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Bachelor Thesis

CoCo Bonds - What drives their yields compared to benchmarks and on a standalone basis?

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Management Summary

The need for uniform banking regulations was recognized in the mid nineteen thirties by several countries. The global financial crisis beginning in 2007 was the trigger event for the third and as of today last Basel accord. In 2009 the first draft of Basel III was already submitted, featuring stricter capital rules and marking the first incentive to issue CoCo bonds by the regulator. The combination of a young market and the lack of comparable securities leads to a shortage in statistical evaluations, analysing the drivers of the CoCo market. The high importance of such data is explainable by the big market size and the investors need for transparency, to evaluate potential risks when deciding to invest in CoCo bonds.

The drivers of CoCo bonds are analysed over the last 3.5 years and compared to benchmark indices. The impact the factors have will be displayed and discussed for all indicators, macro, market and bond-specific indicators subsequently.

The first part gives a qualitative overview on the banking regulation history, explains how CoCo bonds work and what the important features are. In the quantitative part, a bond sample of 14 bonds with daily yields was extracted. The traced time frame was between the 30.09.2015 and the 05.04.2019. To determine the influence every factor has on CoCo yields a single and multi-regression analysis was performed based on OLS.

It was found that equity markets influence CoCo markets in a strong manner. Specifically, equity indices like EURO STOXX 50 and EURO STOXX banks can explain relevant parts of the variance of the yield. Also, non-bank related indices have an even bigger explanatory factor for yields variance in a single regression analysis. On the other hand, the influence of the single equity price of the issuing banks is rather small, underlining reaction on systemic events and market movements. Stating the influence of equity markets on CoCo bonds, an unexplainable detachment of both markets was detected, which took place over the last six months. Separately, a clear relation between distance to trigger and yields was established with a linear and non-linear model.

In conclusion, the distance to trigger will gain relevance in accessing CoCo bonds as an investment, taking into consideration that regulators decide not to use PONV triggers in

an early stage. Also, global equity markets are even stronger recognized as drivers of CoCo bonds, compared to their benchmarks. Single equities will remain important within the set of drivers for CoCo bonds, but for rather company-specific events. This conclusion shall be seen as universally applicable and is a gain for the understanding of CoCo bonds and especially for quantifying CoCo drivers.

To further enhance statistical models, an ongoing analysis of the market is proposed. Bigger sample groups will become available and analysis during sharply contrasting economic cycles shall be made. Also, an additional paper could investigate the reasons behind the shrinking correlation of CoCo bonds and equity markets. Furthermore, additional trigger events shall be awaited to gather further precedent cases.

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List of abbreviations

CoCo	Contingent Convertible
U.S.	United States of America
RWA	Risk-weighted assets
AT1	Additional tier-1
Bn.	Billion
USD	United States Dollar
CHF	Swiss Franc
EUR	Euro
GBP	Pound sterling
IDR	Indonesian rupiah
CNY	Renminbi
NOK	Norwegian krone
CET1	Common Equity Tier 1
ADI	Available Distributable Items
V.G. model	Variance Gamma model
PONV	Point of non-viability
CDS	Credit Default Swap
RWA	Risk-Weighted Assets
OECD	Organisation for Economic Co-operation and Development
AMA	Advanced Measurement Approach
ECB	European Central Bank
EU	European Union
G-SIB	Global systemically important banks
D-SIB	Domestic systemically important banks
LCR	Liquidity Coverage Ratio
HQLA	High-quality liquid assets
NSFR	Net Stable Funding Ratio
SIFI	Systemically Important Financial Institution
FINMA	Swiss Financial Market Supervisory Authority
NPL	Non-Performing Loans
YTC	Yield to call

YTM	Yield to maturity
Mio.	Million
SEC	United States Securities and Exchange Commission
ISIN	International Securities Identification Number
SST	Swiss Solvency Test
GDP	Gross domestic product
DIP	Down-And-In-Put

1 Introduction

Once the banking crisis hit the global markets during the years of 2007-2009, global capital markets became highly complex and interdependent on each other. In addition, it became obvious that current bank capital was at a historical low and hence unable to absorb losses (Martynova & Perotti, 2018, p. 1). When the U.S. mortgage market collapsed, losses started to add up to amounts even threatening bankruptcy to certain financial institutions, marking the moment the too-big-to-fail debate started to get traction among regulators and politicians (Erismann, 2015, p. 1). Accepting the fact that certain banks and insurances are simply too big and therefore too heavily intertwined with the corporate world and private investors, governments had to step in. Numerous banks, including Swiss-based UBS, had to be rescued with government aid, as damage to the national and global system was seen as a bigger issue than the rescue cost.

During the analysis of the crisis, one of the most stressed topics was expectedly bank capital. To address the issue new regulations were put in place. Eventually, this led to the implementation of the third Basel framework in 2014, called Basel III. The new framework can be split up into three main pillars, which will be explained in detail in the third chapter. One pillar essentially stresses a rise in minimum common equity requirements from 2% to 4.5% of RWAs. A promoted way to ramp up capital is the CoCo bond. After gaining popularity among fixed-income investors and banks to increase their AT1 capital, CoCo's have become an increasingly complex and regulatory driven market.

Gradually coming into force, the implementation of the new framework was finished on the first of January 2019 (Deutsche Bundesbank, 2011, p. 26). A pick-up in issuance of CoCo bonds was already noticeable in 2014, when issuance almost tripled to 123bn USD compared to 2013, when issuance was standing at 41.85bn USD (Bloomberg L.P.).

This thesis will first explain the current state of the literature in a dedicated part. Relevant papers will be presented, theories developed, and directions outlined. Thereafter, the regulatory context of banking regulations will be explained in detail, in order to understand how CoCo bonds developed. The world before Basel, and the Basel accords Basel I, Basel II and Basel III will all be addressed separately. Relevant parts for the structure of banking

capital will be presented and explained. Also, the Swiss finish will be touched and briefly summarized at the end of the section.
The next chapter will focus on the function of CoCo bonds and their design features, illustrating the functionality of the paper, explaining relevant design specifications.
A quantitative part will clarify and analyse the drivers of CoCo bonds based on a sample group of CoCo bonds. The influence of several factors will be examined and, where possible, compared to benchmark indices. Thereafter, the results will be analysed, and a conclusion will be drawn.

The research question can be formulated as follows: What drives yields of CoCo bonds compared to benchmarks and on a standalone basis?

2 Literature Review

Even before the first CoCo bond was issued in 2009, literature started covering the topic and has evolved since then. Merton (1974) has laid the foundation stone when publishing an article on pricing corporate debt in 1974. The value of the bank V_t is defined by the equity value E_t and the outstanding risky debt value D_t at time *t* (Partanen, 2016, p. 16):

$$V_t = E_t + D_t.$$

As the bank is modelled with only equity and debt, the debt gets paid back if the total value of the company V_t is bigger than the outstanding risky debt D_t at time *t*. When at maturity total risky debt D_t is bigger than the total value of the company V_t, the shareholders will choose to walk away with the equity value E_t at zero, rather than making extra cash injections (Merton, 1974, p. 453). Hence, the equity can be priced using the Black-Scholes-Merton model, designing a call option, as only the upside is unlimited, whereas downside risk is floored at the default level (Partanen, 2016, p. 16). Rearranging the formula and solving it for the value of the risky debt, we get the following formula (Partanen, 2016, p. 16):

$$D_t = V_t - E_t$$

Now, risky debt D_t can be priced, showing one of the first possibilities to price a CoCo bond, not yet existing at that time. Since then, the literature has evolved, and major events have even accelerated the number of publications.

Subsequent to the financial crisis of 2007-2009, we saw a massive pickup in the publication of papers related to CoCo's. As of today, they do not solely have a theoretical focus but concentrate on a variety of practical topics. In addition, as a consequence of the implementation process of CoCo bonds within the banking regulation and the promotion of the security by banking regulators into national law, one could observe another player stepping in as a publisher, the local and international regulators.

Generally speaking, we can categorize all related publications related into two main categories. The main direction is related to pricing. We can split this area into two subdivisions, derivative models and credit models. De Spiegeleer and Schoutens (2012, p. 1) have their derivate pricing approach split into two parts, credit derivatives and equity derivatives. A so-called default parameter is used to determine credit spreads. De Spiegeleer and Schoutens (2012) determine λ as the probability of bankruptcy. To convert λ into a suitable variable to price a CoCo bonds credit spread, De Spiegeleer and Schoutens propose a λ corrected by the trigger intensity (De Spiegeleer & Schoutens, 2012, p. 14). When valuing the CoCo bond with its equity derivative model, the approach is more related to derivatives. The fixed income structure is replicated by a zero-coupon bond. The share conversion, triggered once the respective CET1 ratio is touched, is reproduced by a knock-in forward. Potential coupon cancellation in case of a trigger event is considered in the model with short positions on every coupon date in binary down and in options (De Spiegeleer & Schoutens, 2012, p. 22). Corcuera et al. (2013) work with an advanced pricing model and try to take into account an "exponential Lévy process incorporating jumps and heavy tails". While some pricing models focus on the normal distribution, Corcuera et al. (2013) price CoCo's while using the Variance Gamma (V.G. model) model. The V.G. model uses longer tails than the normal distribution. Over time, as longer data sets are added, V.G. approaches normality (Madan & Seneta, 1990, p. 522). Himmelberg and Tsyplakov (2012) combine a dynamic pricing model with the incentives CoCo bonds should have on issuers. It puts the possibility of dilution when raising new equity into perspective regarding a possible dilution from a conversion of the CoCo bond into equity.

The model takes two parameters into consideration to calculate the optimal equilibrium, conversion price and relative CoCo bond size (Himmelberg & Tsyplakov, 2012, p. 15). A more recent publication dealing with pricing is Leung and Kwok (2017). Making use of the Fortet method, the authors designed a numerical algorithm to determine the fair value of CoCo bonds. The Fortet method was extended by two additional input values. At first, the possibility to add two barriers to the equation was incorporated, considering the mechanical CET1 trigger and also the higher warning threshold (Leung & Kwok, 2017, p. 4). In addition, a Parisian state variable is implemented (Leung & Kwok, 2017, p. 4). Parisian options are knocked-in or -out only after the underlying price has broken a level and stayed there for a predefined time (Haber, Schönbucher, & Wilmott, 1997, p. 1). The second feature is especially crucial, as the PONV was implemented in Basel III, which the Parisian model helps to simulate (Avdjiev, Kartasheva, & Bogdanova, 2013, p. 47).

The second major pillar, when it comes to literature on CoCo bonds, is focused on the regulatory design of the securities, in order to fulfil their regulatory mission best. Important here are specific features the bonds have, as well as the legal framework to support their proper loss absorption effects and incentive for bank management. Flannery and Perotti (2011) focus on the design of the implemented trigger, suggesting a market-based trigger such as share prices over accounting triggers. A benefit is the absence of delay when basing conversion on equity prices, as they are transparently quoted every day on the exchange. On the other hand, regulatory ratios are only published on a quarterly basis. Furthermore, "risk information discovery" should be reflected in equity prices, making bondholders activists at some point (Flannery & Perotti, 2011, p. 7). Other supporters of market-based triggers are Calomiris and Herring (2013). Here, instead of taking simple equity prices as a trigger, a "moving average of a quasi-market-value-of-equity ratio" is proposed (Calomiris & Herring, 2013, p. 83). Conversion into equity is favoured over principal write-down. When converting in to equity, a dilution for current shareholders is proposed. It is stated that once a conversion occurs, the dilution to current shareholders should be bigger than a stock offering, encouraging banks to raise new equity and keeping the order between bondholder and shareholders (Calomiris & Herring, 2013, p. 72). McDonald (2013) expands the simple equity price-based trigger model with a second price trigger, related to the industry health. To convert debt into equity, the share price needs to fall below a certain level. In addition, an equity index representing the health of

the banking industry will be used as a second trigger. Only once both triggers are reached conversion takes place (McDonald, 2013, p. 4). Hart and Zigales (2010) classify CET1 triggers as not useful when set at current levels, mentioning the absence of any trigger event during the crisis of 2007-2009, as the trigger level of 5% is too low. On the other hand, triggers linked to equity prices are rejected, identifying risks of market manipulation by a management interested in conversion. The proposed solution is a market-based trigger, linked to CDS levels that are compared to last month's levels. It is stated that CDS levels would have predicted the riskiest financial institutions during the credit crisis. Also, CDS triggers would have forced banks to issue equity already in the autumn of 2007 for the first time (Hart & Zingales, 2010). The Squam Lake Working Group (2009) suggests an accounting and a regulatory trigger to convert. The regulatory trigger is met once the regulator declares "that the financial system is suffering from a systemic crisis" (Squam Lake Working Group on Financial Regulation, 2009, p. 4). Furthermore, the accounting trigger tier 1 compared to RWAs is proposed (Squam Lake Working Group on Financial Regulation, 2009, p. 4). It is also recommended to issue long term debt, which later manifested in the dominant issuance of perpetual CoCo's (Squam Lake Working Group on Financial Regulation, 2009, p. 3). Furthermore, the phenomenon of the death spiral is explained and put forward to underpin arguments in favour of accounting triggers versus market-based triggers. The death spiral describes a situation in which the threat of dilution pushes an already falling share price even lower. This, in consequence, leads to even more dilution and an even lower stock price in consequence again (Squam Lake Working Group on Financial Regulation, 2009, p. 5).

Due to the relatively young age of the market, a statistical evaluation of multiple bonds over a longer time period was not possible until now. This thesis will focus on statistical data of the last 3.5 years, determining the drivers of the CoCo market and their impact. It should be the first interpretation of several variables possibly impacting bond yields, which should be followed by more statistic reviews as the CoCo market is maturing.

3 Regulatory context

3.1 The world before Basel regulations

Before financial regulations were applied globally and comprehensive capital requirements were invented, banking regulations were a national topic. The most commonly used

measurement technique to determine if a bank's capital cushion was sufficient was the ratio between equity and total assets (Hull, 2018, p. 369).

3.1.1 Germany

In Europe, Germany decided to introduce the country's first national banking regulation in September 1931. The law was based on the constitution of the Weimar Republic and an emergency decree. The law was a reaction to the bankruptcy of the Danat-Bank on the 31.07.1931, triggered by low equity and insufficiency liquidity. On the 05.12.1934, the base for today's banking supervision was laid when the law for credit was implemented. At first, the topics of equity, liquidity and credit business were mentioned, and relevant rules implemented (Lessenich, 2014, p. 15).

3.1.2 Switzerland

Switzerland faced similar issues as Germany before implementing a national banking regulation. After Swiss banks started to generate huge revenues when opening credit lines to Germany, the boom was abruptly stopped by a sharp economic downturn in the then German Reich. Facing losses, national pressure for a regulatory solution started to mount up. Before a national law was applied, banks refused to obey a law regulating their business. Even after the crisis, the 1934 Swiss Bankers Association report mentioned the threat of banking regulation as "bank police legislation". Switzerland ultimately followed through in 1935, implementing the federal Law on Banks and Savings Banks as a national solution (Vogler, 2012).

3.1.3 Global issues

Differences in banking regulations and inexistent global minimum capital requirements were not only an issue for systemic stability. In an increasingly complex and competitive world, banks started to compete for business internationally. In consequence, banks operating from countries with looser capital requirements had a competitive advantage (Hull, 2018, p. 369). In addition, complex derivative transactions further impacted credit risks. Banks did not consider arising counterparty risks from these transactions, as the regulatory framework did not foresee these developments on the product side. Hence, the need for a global framework was recognized. In 1974, the Basel Committee on Banking

Supervision was founded by twelve countries, Switzerland being among them (Hull, 2018, p. 370).

3.2 Basel I

In 1988, the first of today's three Basel accords was passed by the Basel Committee on Banking Supervision. It was directed at banks involved in international business. The voluntary status was made compulsory when regulators started to implement the recommendations into its framework and passed them into national law (Lessenich, 2014, p. 16).

Two major goals are stated by the Basel committee. Firstly, an enhancement of the creditworthiness and stability of the international banking system should be reached. Secondly, the framework should be uniformly applicable to banks operating from different countries to avoid competitive distortion (Basel Committee on banking supervision, 1988, p. 1). Terms such as the RWA were first implemented combined with the Cooke-Ratio, measuring the total capital compared to the RWA. One of the main outputs were the static risk weightings in table 1 below, to value balance sheet positions and calculate the resulting RWA (Basle Committee on Banking Supervision, 1996):

Risk weight in %	Asset category
0	Cash, gold bars, government OECD-Bonds
20	Claims against OECD-Banks and public OECD-Institutions
50	Unsecured mortgage claims
100	Other claims including corporate bonds, government bonds from non-OECD countries, non-OECD banks credits, commercial premises and factories

Table 1: Risk weights for balance sheet positions Basel I (Hull, 2018, p. 371)

The committee came to the conclusion that total equity should be standing at a minimum of 8% compared to the total RWA (Basel Committee on banking supervision, 1988, p.

15). At least 4% of those should be covered by core equity tier 1 capital, hence by share capital and reported reserves. The focus on both share capital and reported reserves was mainly justified by the fact that these two parts of the balance sheet were the only common part in capital structure across international legislation (Basel Committee on banking supervision, 1988, pp. 3-4). The other 4% could be covered by tier 2 capital, including undisclosed reserves, asset revaluation reserves, general loan-loss reserves, hybrid capital instruments and subordinated debt. Furthermore, tier 2 capital was ruled not to exceed the tier 1 capital (Basel Committee on banking supervision, 1988, p. 17). The 1996 amendment was mainly focused on market risks, arising from trading activities banks were involved in (Hull, 2018, p. 377). A third capital type, tier 3, was invented subsequently to absorb parts of the risk arising from market exposure. Tier 3 capital had to be unsecured, subordinated, not repayable before maturity and could waive coupon payments if they would lower the bank's capital below a certain level (Basle Committee on Banking Supervision, 1996, pp. 7-8).

3.3 Basel II

In 1999, the Basel committee already proposed new regulations, in the form of Basel II. In June 2004, the final version was published and began to be implemented in 2007 (Hull, 2018, pp. 379-380). Accord number two was based on a three-pillar principle, consisting of the following pillars: minimum capital requirement, supervisory review process and market discipline (Lessenich, 2014, p. 22). This paper will focus on pillar one and three, which relate the closest to capital requirements and market mechanisms important for CoCo bonds.

3.3.1 Minimum capital requirements

When designing capital requirements in Basel II, the original 8% threshold was kept unchanged. Also, the minimum capital requirement for market-risk was not changed from the 1996 amendment. An addition to already existing market-risk and credit-risk was the newly implemented operational risk (Hull, 2018, p. 380). To capture those risks, banks are enabled to pick different systems. The main distinction is made between the standard approach and the AMA (Lessenich, 2014, p. 23). When deciding for the AMA, an approval from the regulator must be obtained for the respective model (Lessenich, 2014, p. 28). Commitment to the more sophisticated and complicated AMA leads to a discharge

of equity compared to the standard approach (Lessenich, 2014, p. 27). The Basel committee thereby tries to incentivize banks towards AMA. A tailor-made solution should lead to a better understanding of internal risks, better risk management and improved risk measurement systems (Lubbe & Snyman, 2010, p. 142). Still, it seems too complicated or unfavourable for the bigger part of the banks to implement AMA. While 1579 credit institutions were licensed to do business in Germany in the year of 2017, only 13 institutions had an AMA implemented and were using this method to determine their capital requirement (Bundesanstalt für Finanzdienstleistungsaufsicht (BaFin), 2017, p. 176/178). On the other hand, the more popular standard-approach was updated. In Basel I, the creditworthiness of the counterparty was not reflected at all when weighing the credit. The main focus was on the membership in the OECD. In Basel II, the distinctive point when valuing credit weightings was the credit rating. Below, table 2 reflects different rating classes and their respective weighting:

	AAA to AA-	A+ to A-	BBB+ - BBB-	BB+ to BB-	B+ to B-	Below B-	Not rated
Country	0%	20%	50%	100%	100%	150%	100%
Banks	20%	50%	50%	100%	100%	150%	50%
Corporates	20%	50%	100%	100%	150%	150%	100%

Table 2: Risk weights for credit positions Basel II (Hull, 2018, p. 381)

A few specialities should be mentioned. First, completely unrated clients will be rated less risky than clients who obtained a rating of B- or lower (Hull, 2018, pp. 381-382). Also, some flexibility was left to national regulators on the implementation of the risk weightings. When the debt owed is in local currency and refinanced in the same currency, risk weightings could be adjusted for central banks and for the country in which the banks operate (Basler Ausschuss für Bankenaufsicht, 2006, p. 23). This special rule was applied for countries of the European Union and the ECB by the European Union (Europäische Union, 2006, p. 81). This move essentially erases rating differences within the EU, mirroring the Basel I approach.

A newly implemented obligation to measure operational risk was presented with three possibilities. The base indicator approach focuses on gross net income. Necessary equity

is calculated by multiplying gross net income by the static factor of 0.15 (Hull, 2018, p. 390). The standard approach has the same mechanism as the basis indicator approach. The only difference is the variety of factors applied, ranging from 0.12 to 0.18, depending on the business area and the risk it bears. The third approach is again the AMA, based on internal bank models and is subject to regulatory approval (Lessenich, 2014, p. 28).

3.3.2 Market discipline

The third pillar focuses on market discipline, in essence boosting transparency towards market participants (Hull, 2018, p. 391). Market participants should be able to get insight into bank's common equity and major risk positions. In consequence, they should be able to derive if the bank equity is sufficient (Basler Ausschuss für Bankenaufsicht, 2006, p. 256). All major international banks have to disclose their CET1 ratios on a quarterly basis (Basler Ausschuss für Bankenaufsicht, 2006, p. 258). These steps should lead to more transparent pricing of debt and equity markets of those banks, giving banks with good capital bolsters better refinancing conditions (Lessenich, 2014, p. 32).

3.4 Basel III

Following the global economic crisis that started in 2007, the Basel committee, national banking regulators and national politics were pushing towards stricter minimum capital rules. Basel III is, therefore, the direct reaction to the crisis and addresses the lessons learned from the credit crunch and the accords before (Rüdlinger, 2015, p. 12). The first draft was already submitted in December 2009, while the final version was presented in 2010 (Hull, 2018, p. 404).

3.4.1 Common equity structure

Basel III has its main focus placed on the evolution of the capital structure. Before the financial crisis took place, a pick-up in hybrid capital was observed, which is not as useful for loss absorption (Deutsche Bundesbank, 2011, p. 7). Addressing this problem, the Basel III accord amended the capital structure, eliminated certain capital classes and changed the weightings within the buckets. Below, figure 1 displays how the structure was changed from Basel II to Basel III:

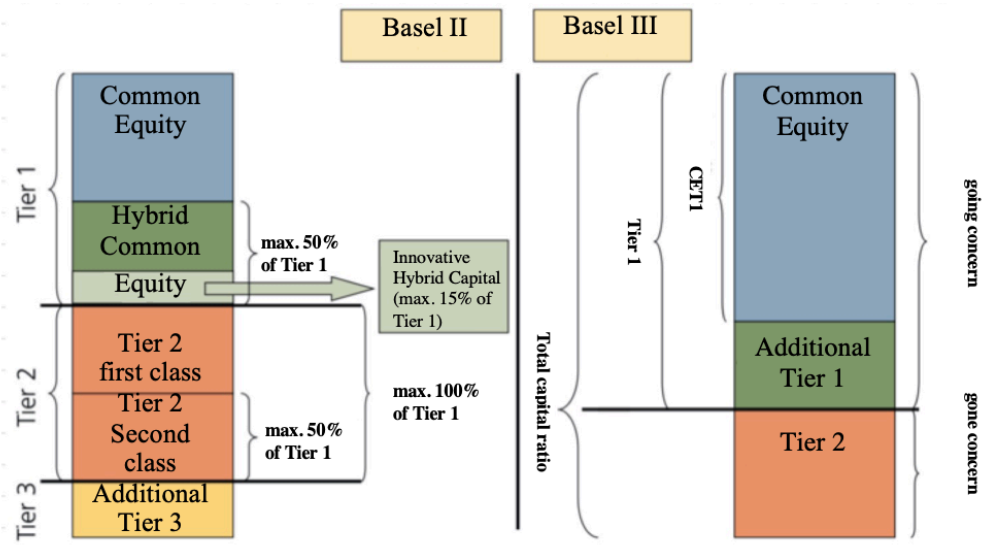

Figure 1: Capital structure evolution in Basel III (Deutsche Bundesbank, 2011, p. 10)

At first, the third capital bucket covering market risk was eliminated completely (Basel Committee on Banking Supervision, 2011, p. 2). Total minimum capital still remains at 8% compared to the RWA. After a transition period that ended in 2015, banks are now required to hold at least 6% of the total 8% in tier 1 capital, compared to 4% in Basel II. Also, a distinction is made for the first time between CET1 and AT1 capital. Of the 6%, 4.5% have to be CET1 eligible capital, which in fact is mostly share capital (Lessenich, 2014, p. 39). There were 14 points defined to determine whether capital qualifies as CET1, two of which are the non-callability and the last payment rank in the case of bankruptcy (Basel Committee on Banking Supervision, 2011, pp. 15-16). Up to 1.5% are eligible to come from the new bucket, AT1, which has the covenants displayed in the table 1 in the attachment (Lessenich, 2014, p. 39).

Analysing the covenants, it can be concluded that these terms mark the first incentive to issue CoCo bonds by the regulator. First, point 11 mentions the possibility of a conversion feature to classify as AT1. Distributable items are introduced as a pool from which coupon payments must be made, making sure banks will not pay out money they do not have to bondholders. Also, coupon step-ups after the mandatory 5-year non-call period were banned, avoiding incentives to call at the first date. The pick-up in the issuance of CoCo bonds can also be explained by the implementation of additional capital buffers. A so-called capital conservation buffer consisting of 2.5% tier 1 is implemented. This buffer

should be built up under normal market conditions, serving as a cushion during economic stress (Hull, 2018, pp. 405-406). Furthermore, a countercyclical capital buffer of up to 2.5% tier 1 can be implemented at the local regulator's discretion (Hull, 2018, p. 406). Switzerland for example implemented a sectoral countercyclical capital buffer of 1% for the first time in September 2013, targeting "mortgage loans financing residential property located in Switzerland". The buffer was subsequently revised upwards and is now standing at 2% (Swiss National Bank, 2019, p. 1). Non-compliance in either one, countercyclical capital buffer and capital conservation buffer, leads to punishment in the form of dividend pay-out restrictions. Below, table 3 shows how a breach of tier 1, including countercyclical capital buffer and capital conservation buffer, affects the bank's ability to pay dividends:

Tier 1 Ratio	Minimum retained profit
4.5% - 5.75	100%
5.75% - 7.00%	80%
7% - 8.25%	60%
8.25% - 9.50%	40%
>9.50%	0%

Table 3: Dividend pay-out restrictions considering capital conservation buffer and countercyclical capital buffer (Hull, 2018, p. 407)

All measures concerning the capital structure and the relevant ratios were implemented gradually. When looking at the detailed figure 2 below, one can link the pick-up in CoCo bond issuance in 2014 with the rising capital requirements from this year on:

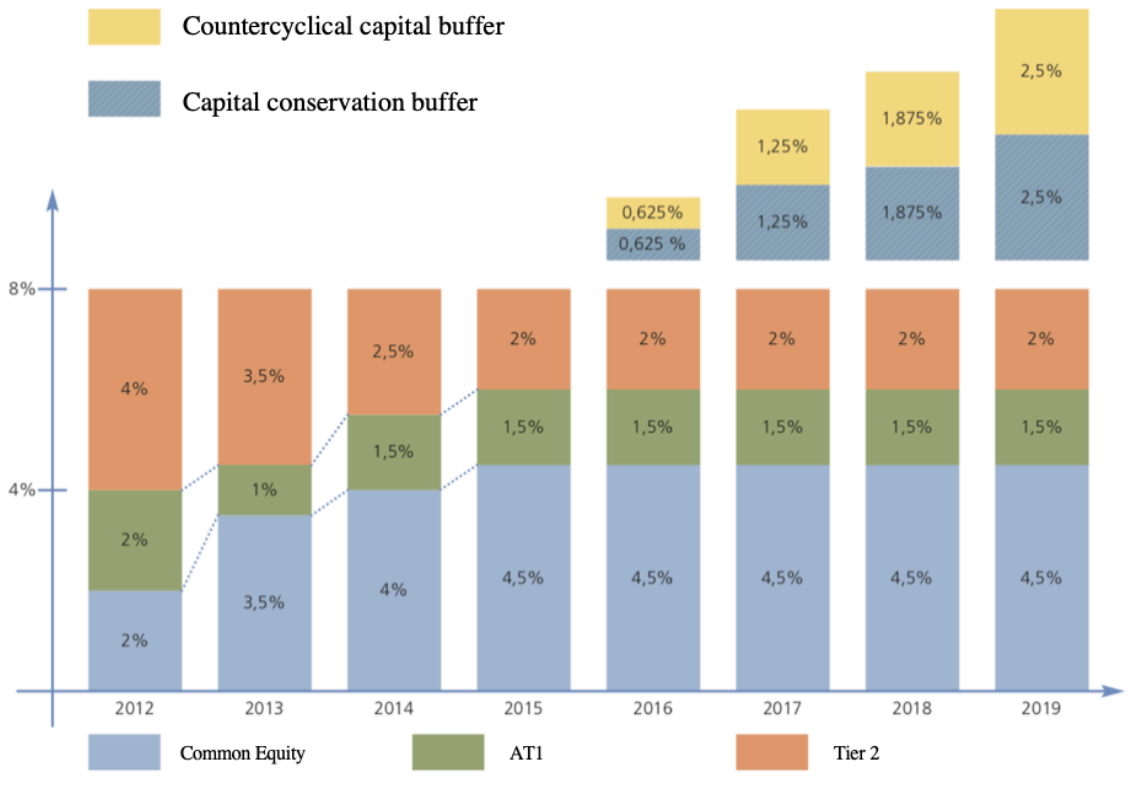

Figure 2: Implementation time frame for capital requirements and additional buffers (Deutsche Bundesbank, 2011, p. 19)

One of the main catalysts for international anxiety during the financial crisis was the systemic relevance of certain institutions, making it necessary for governments to step in with taxpayers' money to rescue them, also known as the "too big to fail" problem. For banks seen as too important to go bankrupt, special rules were implemented when new regulations were elaborated.

Globally and systemically important banks, G-SIBs, are now rated in a ranking system, ranging from 0 to 629 points. To classify as a G-SIB, a minimum of 130 points must be obtained. The point system is based on twelve different indicators, among them assets under control, payment activity and outstanding securities. Five different buckets were put into place, with the fifth one being empty, as no bank currently reaches the necessary points needed to be deemed a category five bank. Banks included in a certain bucket are obliged to hold an additional percentage of their RWA in CET1, fully applicable from 2019 on (Basel Committee on Banking Supervision, 2014, p. 4). Below, table 4 shows the respective top-ups and an example bank for each bucket:

Bucket	Example	Score	Additional CET1
5	n/a	530-629	3.5%
4	JP Morgan Chase	430-529	2.5%
3	Citigroup	330-429	2%
2	Goldman Sachs	230-329	1.5%
1	Credit Suisse	130-229	1%

Table 4: G-SIB classification buckets and additional CET1 levels (Basel Committee on Banking Supervision, 2014, p. 4) / (Financial Stability Board (FSB), 2018, p. 3)

Some regulators decided to put even stricter rules on their G-SIBs. Switzerland has a puffer target of 6.3%, including the 2.5% countercyclical puffer. The global standard is ranging between 3.5% and 5% (Schweizer Bundesrat, 2017, p. 4852). In addition, local regulators are allowed to name D-SIBs, domestically and systemically important banks. Switzerland decided to classify ZKB, PostFinance and Raiffeisen as D-SIB, beside the G-SIBs UBS and Credit Suisse (Schweizer Bundesrat, 2017, p. 4859).

3.4.2 Leverage Ratio

During the financial crisis, it was observed that banks were excessively overleveraged. During the market downturn, fire sales of assets lead to a negative price spiral. To address this issue the leverage ratio was implemented (Basel Committee on Banking Supervision, 2011, p. 61). It measures CET1 capital compared to off-balance and on-balance sheet assets. The ratio calculated should be at least 3%. This 3% mark is revised upwards from various regulators and is also higher for G-SIB institutions (Hull, 2018, p. 407).

3.4.3 Liquidity

Another issue banks were facing during the economic crisis was the lack of liquidity. Also, banks generally tend to refinance their balance sheet activities on the short end of the yield curve. On the other hand, their investments tend to have longer maturities, violating the principle of maturities matching, the so-called golden banking rule. During calm economic times, this behaviour does not pose a significant threat, as refinancing is available to banks on every point of the curve and in almost every size. During an economic crisis, however, trust within the market is barely existing and refinancing becomes somewhat expensive or, in the worst case, impossible. This leads to a balance sheet full

of investments, which the bank is unable to refinance. To avoid scenarios like this, a consistent regulation on liquidity was imposed.

The LCR is implemented to oppose short term liquidity shortage, mainly for 30 days. Scenarios are simulated in which the bank is downgraded multiple notches in its credit rating. It faces bank-run like schemes and a heavy utilisation of its credit lines. HQLA are divided by the calculated net-outflow from the stress scenarios. The value should always be above 100% (Lessenich, 2014, p. 54).

The NSFR tackles the problem of maturities matching. To avoid excessive financing on the short-end, mostly even overnight, the NSFR compares the available stable refinancing to the necessary stable refinancing. Both numbers are extracted to cover a yearly basis; the quotient should always be above 100% (Lessenich, 2014, p. 409).

3.5 Swiss finish

As mentioned before, Switzerland decided to implement rules which are stricter in some areas than Basel III proposed. Market shares are evaluated and segregated into four different buckets. A higher market share results in a surcharge for target leverage-ratio and RWA. Banks with market shares between 22% and 27% have an RWA surcharge of 1.08% and a leverage-ratio surcharge of 0.375%. Total engagement is measured as well, which also leads to certain surcharges, especially for banks with balance sheets bigger than 1050bn CHF, targeting G-SIBs (Der Schweizerische Bundesrat, 2012, p. 73). Both Swiss G-SIBs are entitled to have a CET1 ratio of at least 14.3%, versus 9.5-11% in Basel III, and a leverage ratio of 5%, versus 3% in Basel III. In terms of capital quality, stricter rules apply, too. To reach the leverage ratio, 1.5% can be obtained through CoCo's. To reach the CET1 ratios, 4.3% are allowed to come from CoCo's. It is important to know in both cases that only high-trigger CoCo's are eligible for the two buckets, which have a CET1 trigger not lower than 7% in place (Eidgenössisches Finanzdepartement, 2016, p. 4). The remaining capital requirement needs to be fulfilled by CET1 capital, no tier 2 capital is eligible at all (Eidgenössisches Finanzdepartement, 2016, p. 7). Below, figure 15 shows Swiss requirements compared to standard Basel III rules for normal and for SIFIs:

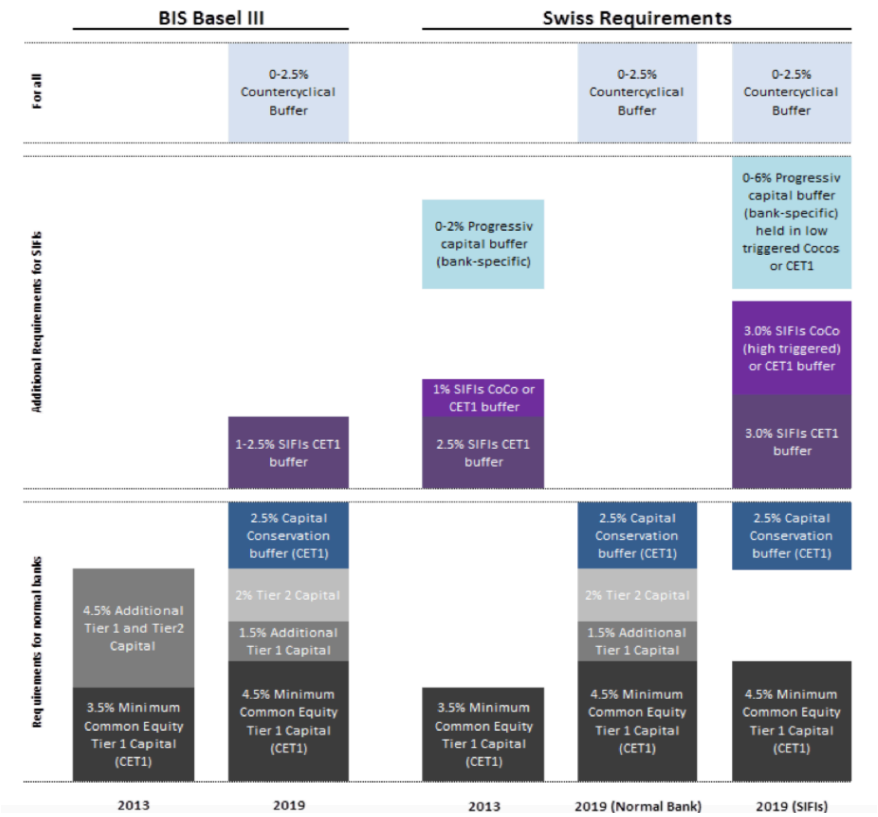

Figure 3: Basel III requirements compared to Swiss implementation (Rüdlinger, 2015, p. 14)

4 What are CoCo bonds and how do they work?

CoCo's, contingent convertibles, can be seen as an evolvement from normal hybrid securities. When issued, they have all the normal characteristics of a straight bond. The regulatory relevance of the paper is gained through a mandatory conversion mechanism. Predefined trigger levels are incorporated, exposing the bondholders to potential capital write-down or equity conversion during economic distress of the bank. Designed to absorb capital losses in banks capital, CoCo bonds are deemed bail-in instruments, helping to prevent banks from going bankrupt. Furthermore, they are classified as going-concern capital, helping the bank in case of financial distress and not only once bankruptcy is announced. Today's CoCo triggers are mainly linked to CET1 ratios.

4.1 Distinction from standard hybrids

A long-known asset class are the hybrids, on a bank and corporate level. Although some similarities between CoCo bonds and hybrid bonds do exist, the main differences and similarities will be outlined in the following.

Even though hybrids are subordinated papers, they are not considered going-concern but rather gone-concern, meaning they are not suitable to absorb losses during distress on the capital side. However, once a bank faces bankruptcy, hybrids will be subordinated to normal debt and are therefore useful gone-concern capital for creditors. In addition, during no time in the life of a hybrid paper, any kind of conversion or write-down can take place, meaning capital will remain on the balance sheet as debt. A similarity among both security types is the ability to defer coupon payments. In both cases, coupon payments can be suspended for undefined time periods. Some hybrid papers are fully congruent with CoCo bonds when it comes to coupon payment. The non-cumulative feature allows issuers to skip coupon payments at their discretion, not having to recover skipped payments at any point later in time, even when coupons are paid again. Also, some hybrids, mirroring CoCo's, have a dividend stopper clause implemented. This clause prohibits issuers from paying out any form of dividend when coupon payments are stopped on bonds.

4.2 Distinction from standard convertible bonds

Convertible bonds are the second structure that needs some clarification. Similar to straight bonds and contrary to CoCo bonds, standard convertible bonds have been invented a long tone time ago. Although similar naming of both security types suggests similarities in the design, this is not really the case.

Convertible bonds get issued as a straight bond, with an embedded call option on the shares of the company. Trading behaviour in the secondary market is very much depended on the share price. If the call option is far out of the money, the product trades as normal straight bond. If the call option is deep in the money, standard convertible bonds are traded very closely to equity or a high delta call option. Once trading just around the strike price, this product is a unique asset class in itself. There is no special going- or gone-concern feature attached to the product. Furthermore, the right to convert the bond into equity lays at the sole discretion of the bondholder, not the issuer. During the last couple of years, the product has lost its attractiveness for issuers, contrary to CoCo bonds. This is mainly due to the very low interest rate-environment, making it superfluous for companies to use the covered call strategy to lower their borrowing cost.

4.3 Trigger type

The trigger type describes the point at which conversion or write-down takes place. Several types have been proposed based on either accounting figures, market levels or regulators discretion. Below, the most common ones are outlined.

4.3.1 Regulatory trigger (PONV)

The point of a non-viability trigger (PONV) is mostly implemented together with an accounting or market-based trigger. It gives the national regulator the discretionary right to trigger conversion or write-down in case the bank becomes non-viable. FINMA, the Swiss regulator, will activate the PONV-trigger when either "a bankruptcy can be avoided" or before "assistance from the public sector is needed" (Swiss Financial Market Supervisory Authority (FINMA), 2013, p. 11): The Basel III accord decided to make PONV-triggers mandatory for all new issues of CoCo bonds, otherwise classification as tier 1 capital is not granted. All instruments issued after the first of January 2013 have PONV-triggers implemented, regardless of any other trigger mechanism applied in addition (Bank for International Settlements, 2011, p. 4).

4.3.2 Accounting trigger

Accounting triggers are, combined with PONV-triggers, the most commonly used triggers in today's CoCo bond market. Basel III is mainly focused on the CET1 as a trigger level, as it is also seen as the key health indicator for banks by the committee (De Spiegeleer, Schoutens, & Van Hulle, 2014, p. 84). When setting trigger levels, two main standards have evolved. Low triggers, ranging from 5%-5.125% CET1 ratio and so-called high triggers, ranging from 7-7.125% CET1 ratio. The predefined levels mark the point at which the bond automatically gets converted or written-down. During the last couple of years, the market has evolved towards high-level triggers, making it almost standard to have 7%-7-7.125% triggers. Some regulators decided to fully shift towards high-level CoCo's and are not allowing any low trigger bonds to be considered as tier 1. Switzerland decided that only high trigger CoCo's are eligible in addition to the already stricter capital rules (Eidgenössisches Finanzdepartement, 2016, p. 4).

4.3.3 Market-based trigger

Market-based triggers such as CDS levels or share prices are proposed by various papers, as outlined in the literature review. A certain predefined level of the market traded product would be set as the trigger, nevertheless this kind of trigger was never enforced. Basel III has no focus at all on market-based triggers and focuses solely on capital levels. One of the main reasons could be the possibility of market manipulation by certain participants (De Spiegeleer, Schoutens, & Van Hulle, 2014, p. 85).

4.3.4 Systemic trigger

Systemic triggers focus on the general health of the sector or the economy. The conversion mechanism could be linked to representative health indicators. Some propose to have certain moving averages of bank equity indices as a trigger (McDonald, 2013, p. 4). Another possibility could be the iTraxx CDS index for senior or subordinated bonds, reflecting the financials industries average credit spread. However, like the market-based trigger, systemic triggers were not implemented. One can say that disadvantages overweigh. The trigger is not linked to the specific capital cushion of the bank and therefore erases incentives for the management to enhance the capital base. Also, the lack in differentiation could cause banks to write down or convert bonds which are not in trouble at all, only because the industry as a whole faces difficulties (Pazarbasioglu, Moor, Zhou, & Le Leslé, 2011, p. 25).

4.4 Loss absorption mechanism

The loss absorption mechanism describes the way the bonds get treated after the respective trigger level is reached or the regulator triggers via a regulatory trigger. In general, two main ways of loss absorption can be observed: Equity conversion and principal write-down. Both mechanisms will be outlined below.

4.4.1 Equity conversion

The equity conversion leads to a shift from debt to equity and is therefore dilutive for existing equity holders (De Spiegeleer, Schoutens, & Van Hulle, 2014, p. 2). The shift from debt to equity does not bring any fresh liquidity to the balance sheet but immediately improves the quality from the capital held. Equity conversion incentivises equity holders

to put pressure on the management to avoid a trigger event, in order to avoid dilution of the equity. The degree of dilution is dependent on the way the share price, at which a bondholder receives them, is calculated. One can identify two types of conversion accepted by regulators and applied in the market; both are outlined below.

When the fixed conversion is applied, the conversion price is known from the beginning. Some issues fix a nominal price when issuing directly (De Spiegeleer, Schoutens, & Van Hulle, 2014, p. 80). In some cases, the conversion price is set as a fraction of the price at issuance, logically implying a lower price at conversion (De Spiegeleer, Marquet, & Schoutens, 2019).

When speaking of floating conversion prices, fully floatable prices would theoretically be possible but have never been applied. This has mainly to do with the absence of loss absorption if the conversion would take place at the market level, undermining the use of CoCo's and transferring the complete loss to equity holders (De Spiegeleer, Schoutens, & Van Hulle, 2014, p. 80). To avoid this scenario, a floor is set. Even if the stock price drifts lower than this level, conversion takes place at the floor level, ensuring a loss absorption by bondholders.

4.4.2 Principal full write-down

The principal full write-down is a possible design of the second loss absorption mechanism applied in the market. This mechanism is especially important to banks that do not issue shares, such as Raiffeisen and ZKB in Switzerland or Rabobank in the Netherlands. Once the trigger event is met, the complete capital is subsequently written off, causing bondholders to lose their complete capital.

4.4.3 Principal partial write-down

Partial write-down mechanisms write down a predefined part of the issue immediately, the remaining nominal amount gets thereafter returned to bondholders (Cesaroni, 2017, p. 7). Rabobank issued a partial write-down bond in 2010, calling it a Senior Contingent Note. The paper had a trigger set at 7% CET1, writing down 75% of the nominal immediately after the threshold would have been reached. The remaining capital would subsequently be returned to investors (Buergi, 2013, p. 39).

4.4.4 Principal staggered write-down

Staggered write-down features are more flexible compared to full write-downs (Choudhry, Moskovic, & Wong, 2014, p. 202). They can be seen as a mix between a full write-down and a partial write-down. Here, once the trigger level is reached, the bond is not immediately written down in full but has various write-down levels. An example of this is the 2012-issued ZKB CoCo bond. When the CET1 level would fall below 7%, the bond would be written-down by 25%, 50%, 75% or 99.98%. The final decision on how much will be written down lies with the Swiss regulator FINMA with the main intention being to re-establish the target CET1 level (Buergi, 2013, p. 42).

4.4.5 Market take on different mechanisms and a short history

At first, write-down seems to be the far worse option for bondholders and should be rewarded with higher yields for bonds with the write-down feature implemented. This base-case scenario was correct for some time and can also be easily observed in historical market spreads. The theory got shattered in summer of 2014, when Portuguese lender Banco Espírito Santo got into heavy financial distress. The situation was resolved by a split in to a "bad-" and a "good-bank", taking good assets and credits into the "good-bank" – Novo Banco. All bad assets, including NPLs and subordinated debt, were put into the "bad-bank" and let go bankrupt. A second example is Santander's takeover of troubled Banco Popular. All CET1 and tier 1 was written-off, tier 2 was converted into shares worth 1 EUR in total.

Both cases are seen as a precedent for the market, slowly erasing differences between a write-off and equity conversion, as the financial outcome for CoCo holders is indifferent when accepting equity of the bankrupt "bad bank". In table 5 below, two bonds were chosen to illustrate the tiny difference that loss absorption mechanisms are making to the YTC:

Ticker	Coupon	Next Call	Maturity	CET1 Trigger level	Loss absorption mechanism	Current YTC
SHBASS $	6.25%	01.03.2024	Perp	5.125%	Equity conversion	5.96%
SHBASS $	5.25%	01.03.2021	Perp	5.125%	Write-down	5.617%

Table 5: Econometrics for comparable Svenska Handelsbanken (Bloomberg L.P., 2018)

Looking at the historical yields and the spread below, one can observe that the SHBASS 6.25% with the equity conversion feature yields 34bps more than the SHBASS 5.25% with the write-down feature. This can mostly be explained by the call date, standing at 2024 for the SHBASS 6.25% and at 2021 for the SHBASS 5.25%, giving the SHBASS a duration of roughly 2.5 years more. Interpolating the curve, we can derive a rough premium of 30-40bps for the extension from two years to five years on the yield curve (Bloomberg L.P., 2018). The predominant part of the difference in yield can therefore already be explained by the different call dates. Analyzing below historical spread, it can be observed that both, premiums and discounts, can exist during different times. This can mainly be explained by the episodic investor preference for one or the other bond and the associated excess of supply or demand in the relevant paper. In conclusion, the yield difference related to the loss absorption mechanism is converging towards zero. Even though it is very hard to find a case to compare one-to-one without interpolating, figure 4 shows the exemplary lack of a premium for write-down bonds:

Figure 4: Historical spread SHBASS 6.25 PERP vs. SHBASS 5.25 PERP (Bloomberg L.P.)

4.5 Callability and Step-up

Newly issued CoCo bonds need to be non-callable for at least five years (De Spiegeleer, Marquet, & Schoutens, 2019, p. 7). Also, no incentive to call the paper shall be made. This would normally happen through a coupon step-up, offering a higher coupon to investors after the mandatory five-year non-call period. This contradicts the use of CoCo bonds and also increases debt servicing cost if no refinancing can be made on the market

during market distress, which is normally the case when CoCo's come into action (De Spiegeleer, Schoutens, & Van Hulle, 2014, p. 10).

4.6 Coupon payments

To improve flexibility, the bank needs to have full discretion when paying out coupons, meaning a discretional coupon cancellation can be exercised by the bank. Those missed payments do not trigger a default on either the CoCo or any other bond. In addition, missed coupons are non-cumulative, meaning no missed payments need to be recovered at a later point in time. Other payments can be made from cash that was not paid out as a coupon, except dividend payments. For dividends, a dividend-stopper is applied, prohibiting dividend payment to shareholders when no coupons are paid (Basel Committee on Banking Supervision, 2011, p. 16). However, the European Union decided to implement different rules when it comes to dividend-stopper clauses. These features are fully forbidden for European banks (European Union, 2013, p. 49). Contrary, Switzerland decided to follow the Basel committee and has not banned dividend-stoppers (Oster, 2018, p. 35). The solution of the EU can be seen as a wealth transfer from bondholders to equity holders, but not deriving from an equity conversion point of view (Roggi, Giannozzi, & Mibelli, 2013, S. 4). The wealth transfer occurs as no dividend-stopper is implemented, making it possible not to service the debt while paying out dividends, changing the standard order known. Hence, a coupon deferral could be agreed on the perpetual bond while still paying out dividends to the equity holder (Oster, 2018, p. 21).

Also, CoCo coupons have to be paid out of the ADI (Basel Committee on Banking Supervision, 2011, p. 16). The ADI are defined as "the amount of the profits at the end of the latest financial year plus any profits brought forward and reserves available" by the CRR (European Banking Authority (EBA), 2009).

5 Quantitative Part

This quantitative part should enable readers to get inside the market movements of CoCo bonds and the relevant drivers. As the CoCo bonds issuance size only gained market relevance in 2014, there have been few historical evaluations of the drivers due to the short time frame. This paper uses over 3.5 market years to quantify the impact certain factors have on the yield of CoCo bonds. The whole analysis should lead to an improved

understanding of the CoCo bond market and should enhance the investors understanding when accessing market moves in relevant securities.

5.1 Bond data description

The examined securities had to fulfil specific parameters to be included in the sample group of bonds. The final group contains 14 bonds, which were issued by five different banks. All the market data was extracted between 30.09.2015 and 05.04.2019. For the relevant bonds, the daily closing prices and yields were extracted from Bloomberg. The fixed income search criteria applied in Bloomberg will systematically be outlined and their relevance shall be explained. All related bonds will thereafter be displayed in table 6 below.

5.1.1 Capital Type limitation

The capital type was set to contingent convertible, filtering out every bond classified as CoCo by Bloomberg. Here, bonds not qualified as CoCo bond under Basel III are included as well and hence more precise factors were subsequently added.

5.1.2 Basel designation limitation

As revealed in the regulatory context part, regulations were and still are changing constantly. Certain papers are already grandfathered and do not count as AT1 capital anymore but are still trading in the secondary market. To avoid bonds with no regulatory relevance in the sampling group, only papers with Basel III designation AT1 were allowed.

5.1.3 CET1 trigger limitation

The minimum CET1 trigger was set to 7%. This criterium improves comparability between all selected bonds, as all have a trigger level of 7% except for one standing at 8%. Also, those high trigger bonds satisfy even those regulatory requirements tougher than Basel III, as we can observe in Switzerland (Eidgenössisches Finanzdepartement, 2016, p. 4). This trigger requirement in the statistic makes sure the bonds can also be examined in another statistical evaluation at a later point in time, as they are completely compliant or overcompliant with contemporary rules.

5.1.4 Outstanding Amount limitation

The minimum amount outstanding for each bond was set at a minimum of 200mio in the issued currency. This ensures no real private placement will be in the sample list, as small issues get placed with big shareholders or single investors from time to time. These issues can sometimes have different conditions than they would normally have if being priced in the market, thus distorting the analysis. In addition, solely privately placed bonds usually do not have a secondary market, making it impossible to extract any price data needed to conduct an analysis.

5.1.5 Maturity type limitation

According to Basel III rules, issued CoCo bonds need to be perpetual in order to qualify as AT1 capital (Basel Committee on Banking Supervision, 2011, p. 15). To ensure comparability, only perpetual instruments were taken into account when constructing the sample group.

5.1.6 Tranche 144a limitation

Securities sold in the U.S. need to be registered with the SEC. The exemption rule to sell securities without registration is the so-called rule 144a, making it possible to sell the products under certain conditions but without registration (United States Securities and Exchange Commission, 2013). Bond tranches falling under the 144a rule were excluded from the list, as their inclusion would have triggered several double listings. Most bonds are issued under two different ISINs, one eligible to sell to the U.S. under the 144a rule and one for distribution to the rest of the world. Both tranches have the same econometrics, the difference lies solely in the regulatory context.

5.1.7 Currency limitation

The bond list was limited to bonds issued in CHF, EUR, GBP or USD. The main objection is to eliminate bonds issued in rather exotic currencies for bonds such as NOK, IDR or CNY, as the comparability between those currencies seems to be very low. Furthermore, the CoCo market is globally concentrated in hard currencies, whereas the above-mentioned currencies are the exception, as marketability to investors is lower. Even though the criteria would have allowed bonds denominated in CHF, only bonds in EUR, GBP and USD matched all relevant criteria.

5.1.8 Country limitation

Bonds from the following risk countries were excluded deliberately from the list: China, Russia, Brazil, South Africa and Mexico. All these countries do have outstanding bonds matching with the CoCo definition of Bloomberg. Nevertheless, those countries do have substantially different regulatory standards than the ones examined in the regulatory part of this paper and are therefore not comparable (Goncharenko, Ongena, & Rauf, 2017, p. 4).

5.1.9 Issue Date limitation

Bonds included in the sampling group had to be issued not later than on the 01.01.2015. This ensures that the bonds are outstanding for more than 3.5 years, making it possible to extract pricing data for a longer time frame. In consequence, recently issued bonds were excluded, as the statistical significance is too low when observing only a short period of time. As this is one of the first papers being able to examine longer-term effects and correlations for CoCo bonds, this is one of the most important limitations.

5.1.10 Industry limitation

Certain insurance companies are issuing bonds similar to CoCo bonds. Swiss Re, for example, issued a CoCo bond in 2013 that is maturing in 2024. This bond, similar to a CoCo bond issued by a bank, has a 100% write-down feature linked to the SST (Erismann, 2015, p. 6). This ratio is designed to ensure the proper capitalization of an insurance company in Switzerland, similar to the CET1 used for banks (Swiss Financial Market Supervisory Authority (FINMA), 2018). Here, different regulatory standards apply, hence comparability is given neither for the design of the security nor for the general regulatory standard applied for the industry. Therefore, all other industries, except traditional banks, are excluded from the sample list.

5.1.11 Coupon type limitation

When comparing bond coupons, the main distinction is made between fixed coupons and floating coupons. Today's CoCo bonds are mostly issued with a fixed-to-floating type coupon. The coupon is fixed for the first five years, equivalent to the minimum non-callability requirement of the Basel III accord (Basel Committee on Banking Supervision,

2011, p. 16). If the bond is not called, the coupon gets floating above a predefined benchmark, plus a certain spread. Bonds with a coupon that is completely floating from the issuance on were excluded. This would otherwise undermine the regression analysis, as they are barely sensitive to changes in interest rates. Thus, they would behave differently than fixed-to-floating bonds and yield different results when conducting the regression analysis.

Issuer Name	Coupon	Maturity	Next Call Date	Currency	Amount Outstanding in bn.	CoCo Trigger	Basel III Designation	Loss absorption mechanism
Barclays PLC	6.625	Perp	15.09.2019	USD	1.211	7	Additional Tier 1	Equity Conversion
Barclays PLC	8	Perp	15.12.2020	EUR	1.377	7	Additional Tier 1	Equity Conversion
Barclays PLC	6.5	Perp	15.09.2019	EUR	1.458	7	Additional Tier 1	Equity Conversion
Barclays PLC	7	Perp	15.09.2019	GBP	1.183	7	Additional Tier 1	Equity Conversion
Danske Bank A/S	5.75	Perp	04.06.2020	EUR	1.043	7	Additional Tier 1	Temporary Write-down
HSBC Holdings PLC	6.375	Perp	17.09.2014	USD	2.25	7	Additional Tier 1	Equity Conversion
HSBC Holdings PLC	5.625	Perp	17.01.2020	USD	1.5	7	Additional Tier 1	Equity Conversion
HSBC Holdings PLC	5.25	Perp	16.09.2022	EUR	1.943	7	Additional Tier 1	Equity Conversion
Lloyds Banking Group PLC	7.5	Perp	27.06.2024	USD	1.675	7	Additional Tier 1	Equity Conversion
Lloyds Banking Group PLC	7.625	Perp	27.06.2023	GBP	2.487	7	Additional Tier 1	Equity Conversion
Lloyds Banking Group PLC	6.375	Perp	27.06.2020	EUR	1.035	7	Additional Tier 1	Equity Conversion
Lloyds Banking Group PLC	7	Perp	27.06.2019	GBP	2.465	7	Additional Tier 1	Equity Conversion
Lloyds Banking Group PLC	7.875	Perp	27.06.2029	GBP	1.248	7	Additional Tier 1	Equity Conversion
Nordea Bank Abp	6.125	Perp	23.09.2024	USD	0.5	8	Additional Tier 1	Temporary Write-down

Table 6: Complete CoCo bond sample group (Bloomberg L.P., 2019)

5.2 Additional Data

To perform the regression and multiple regression analysis, a data set of various indicators that could influence bond yields was collected. Some of them are directly linked to the company issuing the CoCo bond or the bond itself, others can be seen as leading indicators for the whole economy. Mirroring bond yields, daily closing prices of every indicator were downloaded from Bloomberg. The observation period, congruent to the bond data set, is set between 30.09.2015 and 05.04.2019. In addition, two indices were added to benchmark the sensitivity of CoCo bonds and have an anchor point when interpreting. Every indicator will be explained, and the relevancy defined.

5.2.1 Relevant interest rate

The relevant interest rate depends on the currency the bond is issued in. Three different benchmarks were identified consequently and linked to the currency of the bond. The constant five-year government bond yield of Great Britain, the United States and Germany, symbolising the euro curve, were chosen. The five-year time to maturity is overlapping with the mostly five-year non-callability of CoCo bonds at issuance. Normal rate sensitivity that straight bonds evince will be examined on CoCo bonds.

5.2.2 Equity Price

The daily equity closing price of every issuer was extracted. The main objective is to capture the interdependence of single equity prices and bond returns if there is any. These two instruments seem to be very closely linked in case of financial distress and hence it seems to be appropriate to analyse their correlation.

5.2.3 Fully loaded CET1 ratio

The fully loaded CET1 ratio of each day was extracted for each bond. The fully loaded CET1 ratio, contrary to the phased-in CET1 ratio, is calculated as if all transitional rules regarding CET1 capital were already expired (Pfingsten, 2016, p. 18). After calculating the distance to the trigger, the effects of changing CET1 ratios on bond yields shall be examined.

5.2.4 Equity indices

Three different equity indices were included in the analysis. The EURO STOXX 50 was included as one of the leading European stock indices currently available. It captures 50 blue-chip stocks leading their sector which are located in the Eurozone (Bloomberg L.P., 2019). This index can be seen as an indicator of the whole equity market in Europe.

The EURO STOXX banks index was the second one included in to the analysis. This sector-specific composite captures the 26 banks operating in the Eurozone with the highest market value (Bloomberg L.P., 2019). This index is used to measure the performance of the whole banking equity market.

The third included index is the EURO STOXX 50 ex Financials. Similar to the EURO STOXX 50, this composite captures 50 super sectoral leaders in the Eurozone, except firms that are active in the financial sector. This index excludes isolated banking issues from the performance and therefore captures all the rest of the equity markets in Europe.

5.2.5 USD interest rate curve shape

To quantify the curve shape of the USD interest rate market, the daily spread between the three-month on the run U.S. Treasury bill and the ten-year on the run U.S. Treasury note was extracted. A negative number implies an inverted yield curve when looking at the three-month and the ten-year points. The shape of the curve is often used as a leading indicator to foresee the macro-economic developments, as an inverted curve is usually seen as a sign for an economic recession. In addition, a steep yield curve is also seen as favourable for bank revenues (Borio, Hofmann, & Gambacorta, 2015, S. 17). Banks tend to finance lending and trading operations at the very short end of the yield curve and invest at the longer end of the curve, ignoring the principle of matching maturities. Once the yield curve gets flatter the gains shrink, turning into a loss when inversion is reached.

5.2.6 U.S. GDP growth

The GDP growth in the U.S. on a quarter on quarter was extracted. This is another indicator from which conclusions regarding the health of the economy as a whole can be drawn. The U.S. is the biggest economy in the world and, therefore, the U.S. GDP can be seen as a global barometer for growth.

5.2.7 CDS global index

To measure the global credit market, a tailor-made CDS index was constructed and daily closing prices extracted. It was deliberately decided not to use a CDS index focused on the banking sector, as the correlations would consequently be large. Instead, the created index symbolises the western CDS markets. It consists to 50% of the Markit CDX North America Investment grade index, which is an index itself, combining 125 five-year single CDS distributed among various industry sectors (Bloomberg L.P., 2019). The remaining 50% consist of the European counterpart, the Itraxx Europe. The composition is again split between 125 different five-year CDS of firms operating in various sectors (Bloomberg L.P., 2019).

5.2.8 Barclays Bloomberg corporate excl. financials price index

To benchmark sensitivity of CoCo bonds towards certain factors, the Barclays Bloomberg corporate index was included. Rate sensitivity or correlation with global CDS markets can be compared amongst other factors. The index includes corporate bonds denominated in EUR and issued by European blue-chips. Financial institutions are excluded deliberately to avoid multicollinearity (Bloomberg L.P., 2019).

5.2.9 Barclays Bloomberg senior financial institutions price index

To benchmark the sensitivity that CoCo bonds have towards certain factors compared to their senior bond peers, the Barclays Bloomberg senior financial institution index was included. The index contains senior bonds denominated in EUR issued by various financial institutions (Bloomberg L.P., 2019).

5.2.10 Barclays Bloomberg European Banks CoCo tier 1 total return index

To analyse the historical correlation of European CoCo bonds, the Barclays Bloomberg European Banks CoCo tier 1 total return index was selected as the benchmark. The index includes 135 CoCo bonds denominated in EUR, issued by European banks (Bloomberg L.P., 2019)

5.3 Methodology

5.3.1 Single regression analysis

At first, an OLS single regression analysis was run for every single independent variable. This was necessary to determine the significance level of each variable on a single basis. In order to avoid too much multicollinearity, the R^2 is analysed separately for every independent variable. This is important to determine the amount of variance that can be explained by every single variable, as some independent variables were expected to move together with others at a high correlation level. The denotation for every single regression OLS is the following:

$$\widehat{Y_i} = \beta_o + \beta_1 X_1 + + \varepsilon_i$$

The variables are named as follows:

$\widehat{Y_i}$: Depended variable (daily bond yield)

β_o: Constant intercept term

β_1: Regression coefficient

X_1: Independent variable

ε_i: Error term

5.3.2 Correlation matrix / Single correlation

To understand the correlations and the existing multicollinearity, a correlation matrix was extracted. It helped to understand where multicollinearity comes from. The goal was to exclude variables from the multiple regression analysis who are highly correlated with others, as it would not help the reliability and accuracy of the model. In addition, a historical correlation analysis was run for a single bond and a CoCo index. The analysis helps to see if any changes in correlation are identified in the last 1.5 years.

5.3.3 Multiple regression analysis

To establish a relationship between daily bond yields and the factors found relevant in the single regression analysis above, a multiple regression model was built, based on OLS. The multiple regression analysis is based on the formula below:

$$\widehat{Y}_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon_i$$

The observation of the depended variable, here the daily bond yield, is denoted as $\widehat{Y}_i$. The constant intercept term is denoted as β_o, independent variables are written as $X_1\ to\ X_8$, symbolising the eight factors applied later in the multiple regression.

The regression coefficient of each relevant independent variable is denoted as β_1 to β_8, as eight different variables factor into the multiple regression analysis. Residuals, also known as random errors, are denoted as ε_i.

P-values are evaluated and tested on their significance level. Also, the coefficients for every independent variable were assessed. How much of the variance in the bond yield can be explained by the independent variables was explained and assessed based on the R^2.

5.3.4 Distance to trigger

The distance to the trigger was initially calculated by simply subtracting the CET1 trigger level from the fully loaded CET1 ratio published by the company. This implies a linear dependence between the distance to trigger and the bond yield, which would be a very theoretical approach. For good reason, this is not the case, as it would imply a change very close to the trigger level, threatening to convert or write off the bond, would have the same impact on yields as a change in trigger distance far away from the trigger. The effect can be observed when checking DIP options, as their sensitivity to underlying changes increases drastically when approaching the barrier.

To abate the linearity, the distance to trigger was squared first, which would turn the relationship between yield and distance to trigger into a positive term, which is wrong. The first step already helped to move away from full linearity. In consequence, the term was raised by the power of three, turning it back into a positive term. The formula created consequently is denoted the following:

$$\widehat{Y}_i = \beta_o + \beta_1 X + \beta_2 X^2 + \beta_3 X^3$$

$\widehat{Y_i}$ represents the observation of the depended variable, here the yield of the bond. β_1 to β_3 stand for each coefficient determined by the regression analysis for each distance to trigger, depending on the power it was raised by. β_0 is defined as the intercept. X is the denotation for the relevant distance to trigger. The linear model is denoted the following:

$$\widehat{Y_i} = \beta_o + \beta_1 X$$

All dependent and independent variables are equivalent to the binominal approach.

5.3.5 Assumptions

When building the model, the normal distribution of the error term will be assumed. Also, no autocorrelation is assumed, hence error terms of different observations should not be correlated. Heteroscedastic errors are also not presumed within the model (The Albert.io Team, 2016).

5.4 Results

5.4.1 Single regression analysis

The single regression results will be outlined in table 7 below. The relevant factors displayed are the coefficient, p-value, R^2 and the statistical significance. The significance is symbolized by asterisks. A p-value below 10% generates one asterisk, a p-value below 5% two and a high significance is given when the p-value is lower than 1% and is valued with three asterisks.

Independent variable	**Coefficient**	**p-value (scientific notation)**	$\boldsymbol{R^2}$	**Significance**
Interest rate	0.421553	1.44e-150	0.051771	***
Equity price	–0.00126959	4.75e-61	0.020925	***
Distance to trigger	–0.443485	0.0000	0.131239	***
EURO STOXX banks	–0.0577174	0.0000	0.256689	***

EURO STOXX non-banks	–0.0119009	0.0000	0.464006	***
EURO STOXX 50	–0.00575055	0.0000	0.469398	***
US 3m vs. 10yr spread	0.00862367	5.18e-138	0.047500	***
US GDP QoQ	–0.811828	0.0000	0.150465	***
CDS global index	0.0950365	0.0000	0.413402	***

Table 7: Single regression analysis results

All regressors are highly significant when performing a single regression. The results will be further discussed in the interpretation section.

5.4.2 Correlation matrix / Single correlation

Some variables are strongly correlated with each other, raising the issue of multicollinearity. To avoid this, a correlation matrix was built which is displayed below as figure 5. In addition, the detailed correlation matrix with the exact numbers can be found in the attachment in figure 12.

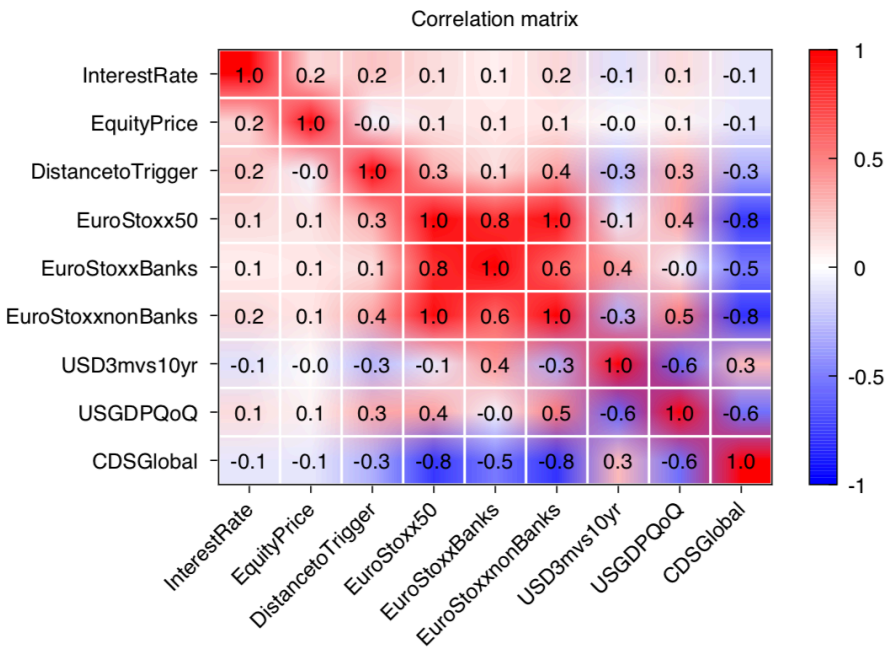

Figure 5: Correlation matrix

The main observation is the logical one, as the three equity indices are highly correlated. Therefore, it was determined to eliminate the EURO STOXX 50 fully from the multiple regression analysis. This due to the fact that generated R^2 is almost the same as for the non-bank index, hence not offering any additional data. Also, one can argue that the non-bank index combined with the isolated bank index is equaling the total EURO STOXX 50. In addition, high correlation can be observed between the US GDP QoQ and two variables, the US Treasury curve and the CDS global Index. No action will be taken, as each of the variables represents another part of the economy and is therefore deemed necessary for the analysis.

The single correlation analysis between the benchmark CoCo index and the EURO STOXX banks equity index showed a trend towards lower correlation. Below, the development of the correlation coefficient over the last 1.5 years can be seen in figure 6:

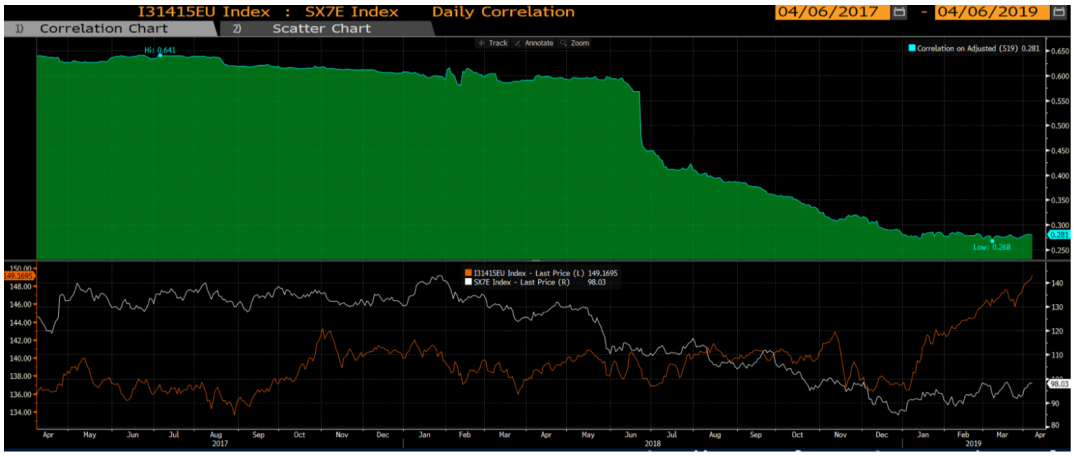

Figure 6: Historical correlation between CoCo index and EURO STOXX banks (Bloomberg L.P., 2019)

The correlation was standing at a high 60% to 65% between April 2017 and June 2018, not showing any significant changes during this time period. However, at the end of June 2018, an abrupt loss of correlation can be noticed. After the correlation coefficient decreased to 40% to 45%, a steady drift towards lower values can be observed. Evaluating the last six months, correlation coefficients of 35% and lower are prevalent.

The same phenomena can be detected when evaluating historical correlation coefficients of single CoCo bonds and the equity of the same bank. HSBC was picked as an example. The historical correlation over the last 1.5 years is displayed below in figure 7:

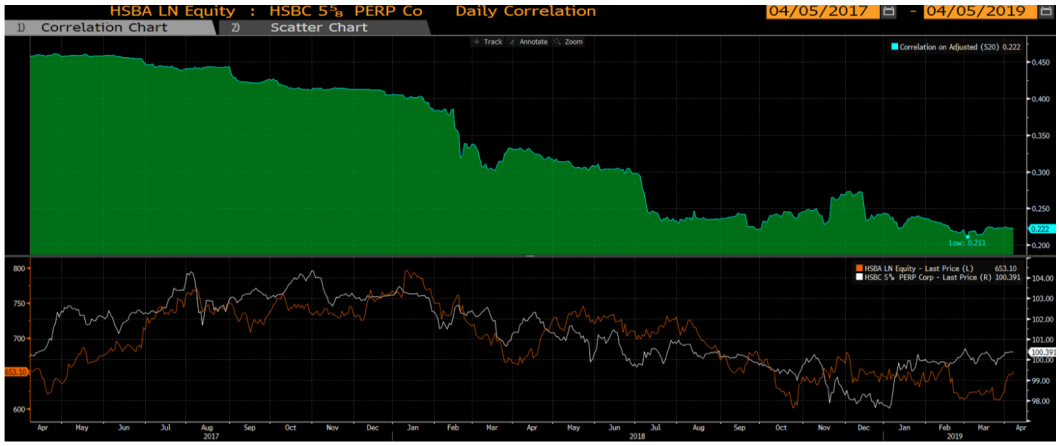

Figure 7: Historical correlation between HSBC equity and HSBC CoCo bond (Bloomberg L.P., 2019)

Here, the first drop in correlation can be detected already in February 2018. Further, the abrupt drop in correlation observed above for the CoCo index and the EURO STOXX banks can also be observed for HSBC. Since the last drop, correlation is remaining at levels between 22% and 30%.

5.4.3 Multiple regression analysis

For the multiple regression, eight independent variables were put in as regressors to explain the change in yield over time. Table 8 below shows the OLS results generated for the coefficients, p-values and the total R^2.

Independent variable	**Coefficient**	**p-value (scientific notation)**	**Significance**
Interest rate	0.752140	0	***
Equity price	–0.00124323	6.93e-170	***
Distance to trigger	–0.258233	6.39e-303	***
EURO STOXX banks	–0.0441627	5.16e-294	***
EURO STOXX non-banks	–0.00383137	8.67e-89	***
US 3m vs. 10yr spread	0.00876245	3.37e-145	***
US GDP QoQ	–0.127875	1.09e-15	***
CDS global index	0.0192846	3.08e-48	***
Total R^2	**0.690920**		

Table 8: Multiple regression analysis results

Also, in the multiple regression analysis, all inputted factors are highly significant within the model. Almost 70% of the variance can be explained by the model.

To check if multicollinearity was decreased by excluding the EURO STOXX 50 from the regression, a test was run, as shown in figure 8 below:

```
Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

     InterestRate    1.103
      EquityPrice    1.048
   EurostoxxBanks    4.411
EurostoxxnonBanks    4.930
       US3mvs10yr    3.016
         USGDPQoQ    2.408
   CDSGlobalIndex    3.293
        Distance1    1.265
```

Figure 8: Multicollinearity test without EURO STOXX 50

The test showed that no or few multicollinearities were detected within the model. The check was performed again with the EURO STOXX 50 included in the multiple regression model. The result is displayed below in figure 9:

```
Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

     InterestRate    1.104
      EquityPrice    1.048
   EurostoxxBanks   89.638
EurostoxxnonBanks  384.771
      Eurostoxx50  678.777
       US3mvs10yr    3.036
         USGDPQoQ    2.820
   CDSGlobalIndex    3.358
        Distance1    1.269
```

Figure 9: Multicollinearity test with EURO STOXX 50

As expected, without the exclusion of the EURO STOXX 50, a massive multicollinearity was detected between the three equity indices.

An additional problem called omitted variable bias was not taken in to consideration. Due to this fact it might be possible that other regressors might be overestimated, as the EURO STOXX 50 was excluded. The EURO STOXX 50 showed high statistically relevant numbers in the single regression analysis, making it almost certain that an overestimation of other regressors will occur. However, the minimized multicollinearity is seen as a highly positive effect, achieved only when leaving out EURO STOXX 50.

To quantify the contribution each variable makes to the R^2, each model was run omitting one variable. In table 9 below, the increase in precision made by each variable is outlined:

Independent variable	**Contribution nominal / percentage of R^2**
Interest Rate	0.149408 / 21.62%
Equity Price	0.019147 / 2.77%
EURO STOXX banks	0.034072 / 4.93%
EURO STOXX non-banks	0.009756 / 1.41%
US 3m vs. 10yr	0.016259 / 2.35%
US GDP QoQ	0.001551 / 0.22%
CDS global index	0.005169 / 0.75%
Distance to trigger	0.035169 / 5.09%
EURO STOXX banks and non-banks combined	0.112508 / 16.28%
EURO STOXX banks, non-banks and CDS global index	0.323551 / 46.83%
Total R^2 of the multi regression:	**0.690920**

Table 9: Contribution to variance explanation multiple regression yield

5.4.4 Benchmarking

In order to have data to compare the output coefficient, p-values and R^2 additional to the multiple and single regression, a separate model was run. Two indices were selected symbolising the corporate bond market without banks and the senior bank bond market respectively. Important to know is the fact that both indices are price-based. Thus, the coefficients have the opposite sign compared to the bond analysis, as that is based on yields. Equity price and distance to the trigger was not regressed in this case, as it would not make sense to regress those variables against an index. The output for the single regression analysis can be seen in table 10 below. Also, table 12 and figures 17 and 18 in the attachment show the multiple regressions for both indices and the contribution made to the R^2 by each regressor.

Independent variable	Coefficient		p-value (scientific notation)		R^2		Significance	
German Bund	–6.5030	–19.6807	3.80e-117	0	0.0404	0.5177	***	***
EURO STOXX banks	–0.0323	–0.0857	5.85e-35	0	0.0118	0.1113	***	***
EURO STOXX non-banks	0.0261	0.0013	0	0.0002	0.3140	0.0011	***	***
EURO STOXX 50	0.0084	–0.0014	0	8.77e-18	0.1399	0.0057	***	***
US 3m vs. 10yr spread	–0.0746	–0.0083	0	2.97e-26	0.4985	0.0087	***	***
US GDP QoQ	4.0324	0.2126	0	3.27e-07	0.5209	0.0020	***	***
CDS global index	–0.2823	0.0062	0	0.0366	0.5119	0.0003	***	**
BB corporate excl. financials index			**Barclays Bloomberg senior financial institutions index**					

Table 10: Benchmark single regression analysis

6 Interpretation

6.1 Single regression CoCo bonds

Generally, the single regression shows that all factors seem to influence the yield of the CoCo sample in a statistically significant manner. The explanation of the variance is over 40% for certain variables, namely EURO STOXX 50, EURO STOXX non-banks and CDS global index. With less than 5% each, interest rate, equity price and US 3m vs. 10yr have rather low explanation power. Some very small coefficients could easily get underestimated, as they relate to a change of one unit of the variable. In consequence, the US Treasury curve coefficient looks small at first sight, leaving aside the very small changes needed to affect the move. On the other hand, the US GDP coefficient looks fairly substantial. Nevertheless, a change by one full unit in the GDP is a somewhat bigger event than the analogical move in the US Treasury curve. Every output for each variable will be interpreted in detail below and compared to the benchmark indices if possible.

6.1.1 Interest Rate

Unsurprisingly, the interest rate influences CoCo bonds, as every fixed income product will have this sensitivity up to a certain degree. The effect is comparatively very low when contrasting it with the results generated by both benchmarks. This can be explained by the higher risk embodied by CoCo bonds. This makes them more dependent on other factors than simple interest rates. On the other hand, normal corporate debt and senior bank debt is closer to a pure rates product and hence is way more sensitive to interest rate changes. The variance explained by the change in interest rate is fairly small, especially compared to the higher notch senior bonds. Corporate bonds also seem to have less overall variance explained by the interest rate, maybe pointing towards more company-specific outlays. Still, interest rates are highly significant for CoCo bonds and both indices.

6.1.2 Equity Price

The impact of the equity price cannot be evaluated together with the benchmark indices, as the indices cannot be assigned to one single share. The coefficient from the single regression shows a statistically high significant relationship, linking a higher equity price of a bank with lower yields on the CoCo bonds. This makes sense, as higher equity prices point towards a better performing company, which can be associated with less credit risk

in general. Still interesting is the very low R^2, which is the lowest among all R^2 of every regressed variable. It can be stated that the own equity price is not an extensive explainer of the variance of the CoCo bonds issued by the same company. The correlation between both, equity price and yield, is standing at -0.14 as per figure 13 in the attachment. This confirms the negative relation but cannot prove a high influence by one factor on the other.

6.1.3 Distance to trigger

The distance to the trigger was analysed based on a linear relationship. Here, an increase in distance by one unit lowers the yield by almost 0.5%. The problem with linearity is that it will not hold true in the market environment. A change in the distance by one unit at a very close level to the trigger will not have the same impact as a distance change by one unit far away from the trigger level. To illustrate the difference between the approaches described in 5.3.4, both will be displayed based on the outputs in figure 14 and 15 in the attachment.

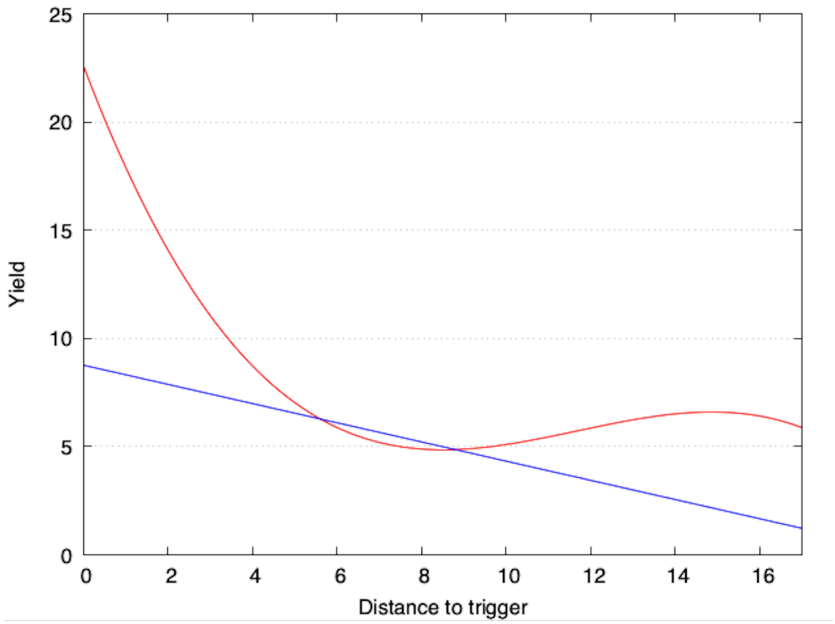

Figure 10: Distance to trigger linear vs. non-linear

The blue line indicates the linear calculation, the red one the non-linear estimation. It is clearly visible that the blue output does not take in to account the proximity to the trigger level. The non-linear approach applied in red is a better fit. As soon as the trigger levels are approached, the yield increases disproportionally. When moving further away from

the trigger level, an additional increase in CET1 ratio does no longer get rewarded with a strong change in yield, as the economic significance is not the same. The distance to the trigger has to be extended largely after reaching the level of six percentage points difference to achieve a positive effect on the yield. When trading between a distance to the trigger of five to nine, the linear model approximates the non-linear model but is not precise when the values are extreme. Still, it can be stated that a clear relationship between yield and distance to the trigger can be observed and plotted. The non-linear model based on the regression output highlights the importance of the distance to the trigger.

6.1.4 EURO STOXX family

The EURO STOXX family holds some surprises and is highly correlated among its members. Therefore, the results are interpreted together.

All three equity indices show a negative relationship towards the yield, which can be explained by the general dependency on the equity markets of CoCo bonds. Interestingly, the R^2, defining how much of the variance can be explained by the regression, is substantially different. Only 25% of the variance of the CoCo sample can be explained by the regressor EURO STOXX banks, which by intuition should have the highest R^2. On the other hand, both EURO STOXX non-banks and EURO STOXX 50 have a substantially higher R^2, standing at 46% each. Also, comparing the correlation coefficient displayed in the figure 16 attached, the lowest correlation coefficient can be observed between yields and the EURO STOXX banks. This leads to the verdict that CoCo yields are, counterintuitively, stronger impacted by the general market and mirror its systematic risk, rather than focusing exclusively on the banking sector.

The benchmark data seems not conclusive. The R^2 is comparably small, indicating that senior banks bonds and corporate bonds do not behave overly similar and do profess a more disconnected assets class. When accessing the correlation matrix attached under figure 16 in the appendix, this fact gets more obvious. The bond yields correlation coefficient is over 65% in two out of three calculations, still being above 50% in the lowest case. Contrary, the correlation coefficients are lower than 40% in five out of six cases. This undermines the statement made above, that both included benchmarks behave differently than the CoCo market.

6.1.5 USD interest rate curve shape

Both the observed CoCo bonds and the benchmarks have the same reaction toward a steeper yield curve, as both react with higher yields or falling cash prices. The mentioned impact on the banks' financing and higher profitability do not impact bonds the way expected. The market seems not to derive higher profitability of banks when the yield curve is steeper, or it just does not regard it as substantial to impact the bond yields. During the last three years, a steeper curve meant raising long end yields, as short-term yields were consequently raised by the central bank in the U.S., excluding the possibility of a steeper curve resulting from falling short term yields. The positive coefficient between CoCo bonds and the steepness indicates the pure dependence on the raise of long-term interest rates.

6.1.6 U.S. GDP QoQ

The GDP influences markets and it does influence CoCo bonds. A high R^2 of 15% can explain a serious amount of variance. A full percent point raises in QoQ GDP, which is a major economic event, lowers the yields of the observed bonds by 0.8%. This supports the information gathered in the interpretation regarding the EURO STOXX family, CoCo bonds are affected by macroeconomic indicators. Also, both benchmarks show the same outputs. Interestingly, the R^2 for the Barclays Bloomberg senior financial institutions price index is rather small compared to the index capturing corporates and excluding banks.

6.1.7 CDS global index

The constructed index can explain the second biggest part of the variance in a single regression compared to all other single factors. Also, once again, it gets confirmed that CoCo bonds very much react to macro factors. It also seems logical that less of the variance can be explained as for the Barclays Bloomberg corporate excl. financials index by the CDS index, as those bonds' benchmark CDS are directly included in the CDS index. CoCo bonds have a separate market which would be useless to include, as correlation would be very close to 100%. Still, CoCo bonds are affected very much by the health of the global credit market and not only by idiosyncratic company risk. Complicated to explain is the very low R^2 toward the senior bank index, which is the only p-value with a significance level not rated highly significant.

6.2 Single correlation

The single correlation analysis provided some highly interesting results, which lead to more questions than answers. The significant drop in correlation observed in June 2018, both when analysing the complete market with indices and on single issuer basis, cannot be explained by an economic event during this time of the year, as there was none. Since the beginning of 2019, the CoCo market saw an incredible rally, compared to a rather weak bank equity market. This trend can be seen in both correlation analyses, as the divergence in pure price development seems the most relevant one during the observed time period. Still, no impact on the correlation coefficient can be observed. Contrary, in June 2018, although no different moves in prices can be observed, the correlation still drops significantly. Currently, it can be stated that CoCo markets and equity markets have detached for the last six months, compared to the last three years.

6.3 Multiple regression CoCo bonds

The multiple regression with its eight regressors can explain 69% of the variance of the CoCo set. A high 14% is attributed to the change in the interest rate market, which is 21.65% of the whole explainable variance. This is more than the variance explained by interest rates of both benchmark indices. This can partially be explained by the longer duration and therefore higher rate sensitivity of CoCo bonds compared to normal bonds. CoCo bonds are not callable for the first five years and are generally designed as perpetual bonds (De Spiegeleer, Marquet, & Schoutens, 2019, p. 7). The multiple regression shows the importance of equity markets for the price movements in CoCo bonds. Together, both included EURO STOXX indices are responsible for 16.28% of the explainable variance. This value is multiple times bigger than in both benchmarks. For normal corporate bonds, the explainable variance by EURO STOXX is standing at 1.01% of the explainable variance, underlining rather disconnected behaviour of corporate bonds when reviewing against equity markets. Senior bank bonds show a slightly higher explainable variance by equity markets, standing at 4.76% of the explainable variance. This supports the higher market beta of the banking sector, even appearing in normal senior bank debt. On the other hand, the CDS explanatory effect is distributed vice versa. Only 0.75% of the CoCo explainable variance can be explained by the CDS global index, whereas the benchmarks have explaining rates of 13.73% to 15.32%. A reason could be the absence of subordinated single CDS in the composition of the CDS global index. Furthermore, one could

mention the completely detached and specialized credit derivatives market for CoCo bonds, as there is even an options market existing on cash bonds. This could potentially lead to a diluted impact in the explanation in variance from the normal CDS side. An important factor is the distance to the trigger, explaining 5.09% of the total 69% explainable. This is the second largest value compared to every independent variable, with only equity markets topping this value when combined with the interest rate. Even though the model used was linear and not approximating perfectly, this still seems an important factor. Given the fact that the average distance to the trigger is standing at 6.72% and extreme values are inexistent, the model still should be able to approximate somewhat correctly. A detailed distribution overview of all distances to the trigger can be found in the attachment under figure 19. Both yield curve steepness and U.S. GDP seem to be rather unimportant although they are still statistically significant. The GDP shows a negative coefficient towards the yield, which would imply lower yields when the economy is stronger. This makes sense in the short term, which we are looking at here, as 3.5 years should not contain several changes in monetary policy within a country. This is a rather long term and slow sphere for developed countries, such as the U.S., whose rates we are looking at. If we would check longer terms, this relation could even change to positive, as high GDP growth could lead the central bank to hike interest rates avoiding economic overheating. The U.S. yield curve as an economic health indicator degenerates towards a pure interest rate substitute and shows similar results as pure rates.

7 Conclusion

The regulatory context of banking regulations has gained much sophistication and complexity since the first Basel accord was published. Today's banks seem better prepared and better capitalized to endure volatile markets than in times before, as banking regulation have paved the way. Evaluating the history of banking regulations extensively, a change in direction towards looser rules is not expected. On the contrary, capital requirements will grow over time, as regulators and countries want to successfully avoid bank rescue programs in the future. Also, economic developments of all kinds will encourage regulators to react and adapt the rules on a learning-by-doing basis. Even though some local rules like the Volcker Rule in the U.S. might be abandoned at some point, as economic rationale seems to disappear or political will is no longer existing, the global trend seems to lead towards stricter rules. To further stabilize and level out the global financial

system, regulators will push more countries to apply the standardized Basel rules. Countries like Russia, Mexico and China will at some point adapt Basel rules, as their growing financial industry might otherwise endanger the economic stability by being too risk-friendly. Some evidence of this thesis can already be found in the market, as these countries, not fully Basel III compliant, already issue CoCo bonds with a 2% low trigger or other non-compliant specifications, underlining their understanding of the importance of bank risk management.
On the other hand, the highly sophisticated Basel approach towards CoCo bonds seems to be set. Alternative approaches when designing CoCo bonds do not seem realistic at the moment, even though numerous design possibilities were proposed by the existing literature. The accounting-based CET1 trigger and the regulatory-based PONV trigger are already established and will unlikely change. Especially CET1 triggers seem to be entrenched by the nature of Basel, focusing on RWA.

The quantitative analysis revealed some helpful facts in understanding CoCo bonds. It can be stated that CoCo bonds have relied on equity markets over the last 3 years. Interestingly, the bonds do not rely so much on the equity issued by the same bank, but rather on the global equity market in the form of indices. Single regression analysis even shows that more of the variance can be explained by the comprehensive EURO STOXX 50 compared to the strongly focused EURO STOXX banks. Nevertheless, a currently unexplainable separation from the equity markets has taken place over the last six months. It can be stated that CoCo bonds seem to react to changes in the mood of cross-sector equity markets. Interest rates combined with distance to trigger are two other main variables explaining the variance of CoCo bonds, as interest rate seems to be the obvious one. Although the distance to the trigger does not seem to be an omnipresent discussion topic in the CoCo market, a significant relationship can be proved. When implementing a simple adjusted system based on the dataset, a clear relation between the yield and the distance can be shown, which even changes the impact depending on the distance to the trigger. Figure 15 proofs this interesting relationship. Further, it was shown that CoCo bonds react stronger to GDP changes compared to benchmark indices, indicating a higher systemic sensitivity of CoCo bonds. Generally speaking, it can be concluded that economically important coefficients can be detected by the distance to the trigger, the EURO STOXX banks, the interest rate and the CDS global index. In addition, U.S. GDP QoQ has a very

high coefficient, losing a bit of its relevance due to the low probability of a 1% GDP move.

In the future, more analyses like the ones carried out in this paper shall be done to further understand the drivers of this specific market. Even longer time frames will be available, helping to understand the behaviour of this market during different economic cycles, such as booms and recessions. An additional working paper could potentially be dedicated to the sudden drop in the correlation between equity markets and CoCo markets and try to explain the reason behind this market move. Also, different central bank interest rates cycles will be analysed, which was not possible in this time frame. Additionally, more precedents like Banco Popular or Banco Espírito Santo will emerge to further understand how the full lifecycle of a CoCo bond works in different jurisdictions when applying unequal laws. It will also further enhance the understanding of how the design of CoCo bonds influences the loss-absorption process.

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9 Appendix

1.	Issued and paid-in
2.	Subordinated to depositors, general creditors and subordinated debt of the bank
3.	Is neither secured nor covered by a guarantee of the issuer or related entity or other arrangement that legally or economically enhances the seniority of the claim vis-à-vis bank creditors
4.	Is perpetual, i.e. there is no maturity date and there are no step-ups or other incentives to redeem
5.	May be callable at the initiative of the issuer only after a minimum of five years: To exercise a call option a bank must receive prior supervisory approval; and A bank must not do anything which creates an expectation that the call will be exercised; and Banks must not exercise a call unless: They replace the called instrument with capital of the same or better quality and the replacement of this capital is done at conditions which are sustainable for the income capacity of the bank; or The bank demonstrates that its capital position is well above the minimum capital requirements after the call option is exercised.
6.	Any repayment of principal (through repurchase or redemption) must be with prior supervisory approval and banks should not assume or create market expectations that supervisory approval will be given
7.	Dividend/coupon discretion: the bank must have full discretion at all times to cancel distributions/payments cancellation of discretionary payments must not be an event of default banks must have full access to cancelled payments to meet obligations as they fall due cancellation of distributions/payments must not impose restrictions on the bank except in relation to distributions to common stockholders.
8.	Dividends/coupons must be paid out of distributable items

9.	The instrument cannot have a credit sensitive dividend feature, that is a dividend/coupon that is reset periodically based in whole or in part on the banking organisation's credit standing.
10.	The instrument cannot contribute to liabilities exceeding assets if such a balance sheet test forms part of national insolvency law.
11.	Instruments classified as liabilities for accounting purposes must have principal loss absorption through either (i) conversion to common shares at an objective pre-specified trigger point or (ii) a write-down mechanism which allocates losses to the instrument at a pre-specified trigger point. The write-down will have the following effects: Reduce the claim of the instrument in liquidation; Reduce the amount re-paid when a call is exercised; and Partially or fully reduce coupon/dividend payments on the instrument.
12.	Neither the bank nor a related party over which the bank exercises control or significant influence can have purchased the instrument, nor can the bank directly or indirectly have funded the purchase of the instrument
13.	The instrument cannot have any features that hinder recapitalisation, such as provisions that require the issuer to compensate investors if a new instrument is issued at a lower price during a specified time frame
14.	If the instrument is not issued out of an operating entity or the holding company in the consolidated group (a special purpose vehicle – "SPV"), proceeds must be immediately available without limitation to an operating entity or the holding company in the consolidated group in a form which meets or exceeds all of the other criteria for inclusion in Additional Tier 1 capital

Table 11: Criteria for inclusion in Additional Tier 1 capital (Basel Committee on Banking Supervision, 2011, pp. 15-17)

```
   InterestRate     EquityPrice DistancetoTriger    EuroStoxx50
         1.0000          0.1536          0.2314         0.1384 InterestRate
                         1.0000         -0.0448         0.1099 EquityPrice
                                         1.0000         0.3087 DistancetoTriger
                                                        1.0000 EuroStoxx50

 EuroStoxxBanks EuroStoxxnonBanks   USD3mvs10yr        USGDPQoQ
         0.0666          0.1567         -0.1230         0.1353 InterestRate
         0.0952          0.1018         -0.0011         0.0506 EquityPrice
         0.1259          0.3550         -0.2883         0.3335 DistancetoTriger
         0.8022          0.9552         -0.0876         0.3653 EuroStoxx50
         1.0000          0.5927          0.4024        -0.0496 EuroStoxxBanks
                         1.0000         -0.3161         0.5322 EuroStoxxnonBanks
                                         1.0000        -0.6035 USD3mvs10yr
                                                        1.0000 USGDPQoQ

     CDSGlobal
       -0.0933 InterestRate
       -0.0939 EquityPrice
       -0.3121 DistancetoTriger
       -0.7791 EuroStoxx50
       -0.5224 EuroStoxxBanks
       -0.7965 EuroStoxxnonBanks
        0.2701 USD3mvs10yr
       -0.5602 USGDPQoQ
        1.0000 CDSGlobal
```

Figure 11: Detailed correlation matrix

```
corr(Yield, EquityPrice) = -0.14465601
```

Figure 12: Correlation yield vs. equity price

```
Dependent variable: Yieldtoconvention

             coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------
  const         8.76103     0.0695539    126.0     0.0000  ***
  Distance1    -0.443485    0.0100657    -44.06    0.0000  ***

Mean dependent var   5.777799   S.D. dependent var   1.934956
Sum squared resid    41800.26   S.E. of regression   1.803590
R-squared            0.131239   Adjusted R-squared   0.131172
F(1, 12850)          1941.188   P-value(F)           0.000000
Log-likelihood      -25815.04   Akaike criterion     51634.08
Schwarz criterion    51649.01   Hannan-Quinn         51639.07
rho                  0.996111   Durbin-Watson        0.008309
```

Figure 13: Regression model with distance to trigger

```
Dependent variable: Yieldtoconvention

              coefficient   std. error   t-ratio    p-value
  ------------------------------------------------------------
  const       22.5791       0.767613      29.41    4.18e-184 ***
  Distance1   -5.15333      0.324475     -15.88    2.89e-56  ***
  Distance2    0.476525     0.0437631     10.89    1.72e-27  ***
  Distance3   -0.0136337    0.00187340    -7.278   3.60e-13  ***

Mean dependent var   5.777799   S.D. dependent var   1.934956
Sum squared resid    36228.92   S.E. of regression   1.679229
R-squared            0.247032   Adjusted R-squared   0.246856
F(3, 12848)          1405.047   P-value(F)           0.000000
Log-likelihood      -24895.84   Akaike criterion     49799.67
Schwarz criterion    49829.52   Hannan-Quinn         49809.65
rho                  0.994971   Durbin-Watson        0.010169
```

Figure 14: Regression model with all distances to trigger

```
      BBexFin           BBsnr           Yield     Eurostoxx50
       1.0000          0.2723         -0.4126          0.3741 BBexFin
                       1.0000          0.1779         -0.0757 BBsnr
                                       1.0000         -0.6851 Yield
                                                       1.0000 Eurostoxx50

EurostoxxBanks EurostoxxnonBa~
       -0.1085          0.5604 BBexFin
       -0.3337          0.0331 BBsnr
       -0.5066         -0.6812 Yield
        0.8022          0.9552 Eurostoxx50
        1.0000          0.5927 EurostoxxBanks
                        1.0000 EurostoxxnonBa~
```

Figure 15: Correlation matrix for equity indices, bonds and benchmarks

```
Dependent variable: BBexFin

                    coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------------
  const             254.488       0.465039      547.2   0.0000    ***
  Bund5yr            -7.90508     0.108697      -72.73  0.0000    ***
  EurostoxxBanks     -0.0711638   0.00201928    -35.24  8.53e-260 ***
  EurostoxxnonBanks   0.00304484  0.000267764    11.37  8.06e-30  ***
  US3mvs10yr         -0.0360814   0.000500620   -72.07  0.0000    ***
  USGDPQoQ            0.649628    0.0222814      29.16  5.20e-181 ***
  CDSGlobalIndex     -0.265903    0.00188855   -140.8   0.0000    ***

Mean dependent var   232.3460   S.D. dependent var   5.165504
Sum squared resid    28020.27   S.E. of regression   1.476961
R-squared            0.918283   Adjusted R-squared   0.918245
F(6, 12845)          24057.45   P-value(F)           0.000000
Log-likelihood      -23244.81   Akaike criterion     46503.61
Schwarz criterion    46555.84   Hannan-Quinn         46521.07
rho                  0.943444   Durbin-Watson        0.112574
```

Figure 16: Multiple regression analysis corporate bonds excluding banks index

```
Dependent variable: BBsnr

                    coefficient  std. error   t-ratio   p-value
  ------------------------------------------------------------------
  const               28.9187     0.829319     34.87   1.26e-254 ***
  Bund5yr            -18.3492     0.193843    -94.66   0.0000    ***
  EurostoxxBanks      -0.117731   0.00360105  -32.69   2.85e-225 ***
  EurostoxxnonBanks    0.0280031  0.000477512  58.64   0.0000    ***
  US3mvs10yr           0.0199374  0.000892773  22.33   2.06e-108 ***
  USGDPQoQ            -0.441538   0.0397352   -11.11   1.48e-28  ***
  CDSGlobalIndex       0.0357834  0.00336792   10.62   2.94e-26  ***

Mean dependent var   72.74575   S.D. dependent var   4.364890
Sum squared resid    89112.32   S.E. of regression   2.633915
R-squared            0.636040   Adjusted R-squared   0.635870
F(6, 12845)          3741.215   P-value(F)           0.000000
Log-likelihood      -30679.49   Akaike criterion     61372.99
Schwarz criterion    61425.21   Hannan-Quinn         61390.45
rho                  0.973086   Durbin-Watson        0.056078
```

Figure 17: Multiple regression analysis senior bank bonds index

Independent variable	**Contribution nominal / percentage of**	
Interest Rate	0.033647 / 3.66%	0.103043 / 16.20%
EURO STOXX banks	0.007901 / 0.86%	0.09859 / 15.50%
EURO STOXX non-banks	0.000822 / 0.09%	0.003199 / 0.50%
US 3m vs. 10yr	0.033046 / 3.60%	0.003499 / 0.55 %
US GDP QoQ	0.005407 / 0.59%	0.014132 / 2.22%
CDS global index	0.126114 / 13.73%	0.097447 / 15.32%
EURO STOXX banks and non-banks combined	0.009256 / 1.01%	0.030287 / 4.76%
EURO STOXX banks, non-banks and CDS global index	0.217939 / 23.73%	0.253896 / 39.92%
of the multi regression:	**0.918283 /100%**	**0.63604 / 100%**
BB corporate excl. financials index	**Barclays Bloomberg senior financial institutions index**	

Table 12: Contribution to variance explanation multiple regression benchmark

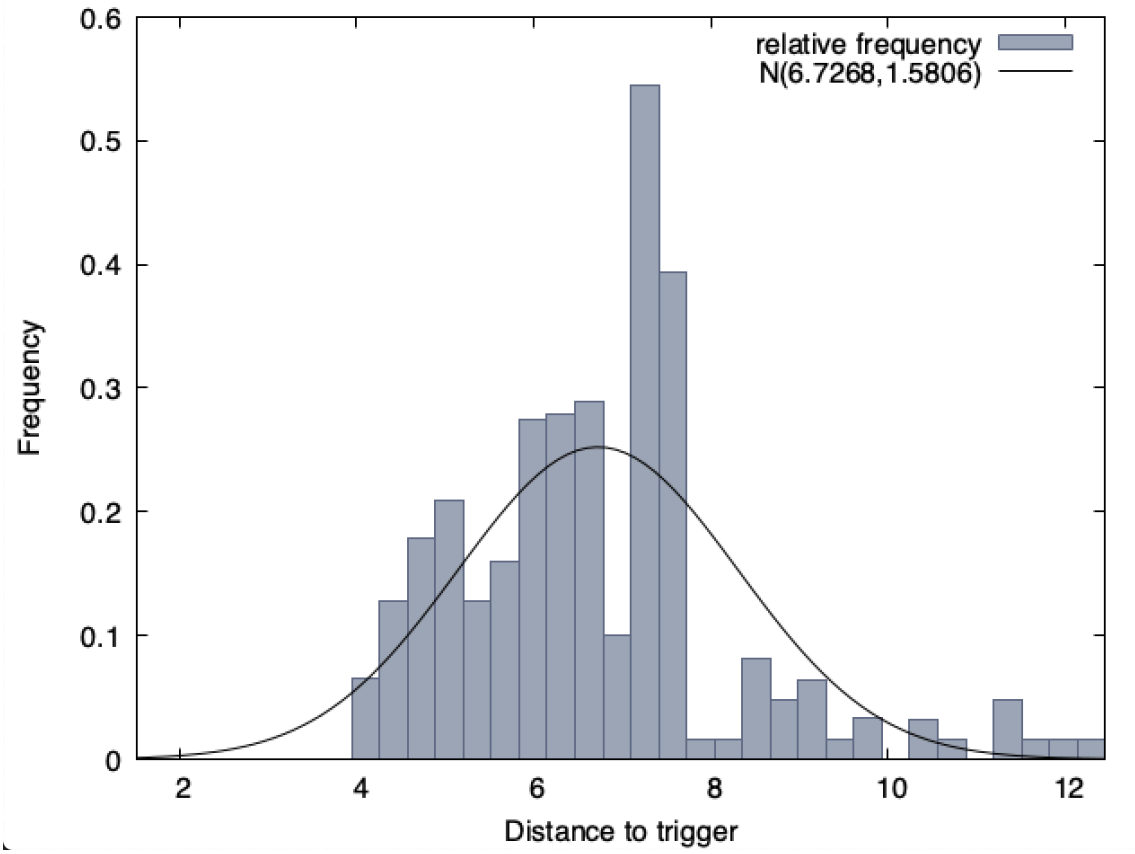

Figure 18: Distance to trigger distribution