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The Determinants of European Coco Spreads

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Abstract

Contingent Convertible (Coco) bonds are hybrid capital securities that absorb losses when the capital of the issuing bank falls below a certain level. Previous research has mainly been focusing on the pricing of such instruments and this paper contributes to the field by empirically examining the determinants of Coco bond spreads for European banks. By examining different samples, this study will search for differences between Cocos with different characteristics such as rating and regulatory capital designation. The sample covers a set of 71 currently traded Cocos issued by listed European banks, accounting for over 30,000 panel observations. Firm specific credit risk variables, initially identified by Merton (1974), are found to explain the largest part of the variations in Coco spreads. Individual bond liquidity and market wide variables are shown to complement the Merton variables in explaining Coco spread movements.

Keywords: Contingent Convertible bonds, Cocos, Coco spreads, Hybrid Securities, Basel III, Additional Tier 1, Tier 2, Banks

JEL Classifications: G01, G21

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1 Introduction

This paper empirically addresses the determinants of Contingent Convertible (Coco) spread changes for bonds issued by European banks. Coco bonds are hybrid capital securities intended to strengthen a bank's finances in times of financial distress. With loss absorption capacity and a pre-determined trigger mechanism, these bonds can quickly be converted into equity or be written down in order to provide a boost of the capital levels of the issuer. The first Coco was issued in 2009 after the outbreak of the Global Financial Crisis (GFC) and the market for Cocos has grown rapidly since then (Avdjiev *et al.*, 2013). Considering the hybrid nature of Coco bonds, they can serve as equity under some circumstances, and may therefore qualify as regulatory capital under Basel III. Coco capital has come to represent a notable proportion of the issuing banks' regulatory capital (see Nordal and Stefano, 2014). On average, the Coco size relative to common equity capital is almost 8% for European issuers (Bloomberg, 2016-05-24). As the market for Cocos grows, the need for knowledge and understanding of this rather new instrument increases, and this has contributed to the topic has become more prominent in financial literature during the last years.

Many previous studies have so far been concentrating on developing theoretical models for the pricing of Cocos and empirically testing such models. A comprehensive overview of existing pricing models is presented in a recent paper by Wilkens and Bethke (2014). The pricing methods so far proposed in academia can be grouped into three main categories; *Equity Derivative Models*, *Credit Derivatives Models* and *Structural models*. Regarding equity derivatives models as well as the credit derivatives models, De Spiegeleer and Schoutens (2012) are generally considered to have been the first to apply these models for the pricing of Cocos. An equity derivatives model assumes that the share price of the issuer to be the main price driver. Credit derivatives models, on the other hand, relate the Coco price to the financial health and default probability of the issuing institution (Wilkens and Bethke, 2014). Earlier papers, applying the credit derivative approach (see *e.g.* Serjantov, 2011 and De Spiegeleer and Shoutens, 2012), proposed pricing frameworks based on credit default swaps. The third approach of pricing Coco bonds is to apply a structural model, also referred to as the Merton approach. Structural models are considered to be economically fundamental since they model the bank's assets and liabilities, where the difference represents the bank's capital (Wilkens and Bethke, 2014). In structural models the firm's assets are assumed to follow a random process, such as a geometric Brownian motion, and impose a contingent capital conversion when the critical capital ratio threshold has been breached. Most outstanding Cocos have their trigger threshold defined in terms of capital ratios, and therefore structural models can provide a natural pricing framework that considers the bank's balance sheet structure as the main price driver (Wilkens and Bethke, 2014). Structural models have been proposed in several earlier papers (see *e.g.* Pennacchi, 2011; Albul *et al.*, 2010; Hilscher and Raviv, 2012).

Previous literature has also put focus on whether Cocos play a vital role in strengthening the financial stability of financial institutions. Ammann *et al.* (2015) found significant negative abnormal CDS spread changes in the immediate period following the Coco announcement date. The authors explain these negative reactions in CDS spreads by the provision of an additional layer of protection that Cocos offer to senior creditors through their ability to absorb losses. Avdjiev *et al.* (2015) also conducts a comprehensive empirical study of Cocos, examining how Coco bond issuance announcement affect stock price as well as CDS spreads of the issuing bank. Similar to Ammann *et al.* (2015) they found that Coco issuance leads to a drop in the issuers' CDS spreads, indicating that Coco issuance reduces banks' credit risk. However, no significant impact on equity prices of Coco issuance was found.

Interestingly, little attention has been given to assess the determinants of Coco spreads. There are however several reasons for examining potential determinants and the behaviour of Coco spreads. In addition to the fact that the Coco market has been growing rapidly during the last years and research on driving factors of Coco spread is still absent, it is of great importance to gain knowledge about the causes of Coco spread variations in order to improve the so far developed pricing models. Several other studies, among them Collin-Dufresne *et al.* (2001), Annaert *et al.* (2013) and Galil *et al.* (2014), have explored the determinants of corporate bond credit spreads and CDS spreads in order to propose models that can be used as an analysis tool for such spread changes. The aim of this thesis is to propose models that can be used to assess Coco spread variations, and therefore determinants of changes in Coco spreads are examined by conducting first-difference estimator regressions. The sample covers a data set of 71 currently traded Cocos issued by European banks. The set ranges from July 2010 until March 2016 and comprises of daily observations. Since the loss absorption mechanism of a Coco bond is intended to take place in times of distress, the occurrence of such can be closely linked to the financial health of the issuing institution. Thus, widely recognized firm-specific credit risk variables, purposed by structural pricing models, will form a base of explanatory variables of Coco spreads. Following previous papers on determinants of credit spreads and CDS spreads (*e.g.* Collin-Dufresne *et al.*, 2001 and Annaert *et al.*, 2013) variables that are proposed to capture the current market climate, business cycle and individual liquidity will also be included to complement the issuer specific credit risk variables.

Furthermore, the European Securities and Markets Authority (2014) has in a public statement pointed out potential risks associated with Coco bonds and argues that the structure of Cocos is highly complex and heterogeneous across issues. That is, Coco bonds often differ in trigger level or loss absorption mechanism and comparability across bonds can therefore be difficult. However, during the last years there has been a movement towards consistency in terms and conditions due to the new capital regulations in Basel III. By fulfilling certain criteria Coco bonds can be designated to different elements of the issuer's regulatory capital. Still, depending on which element of regulatory capital Cocos belong to, their features differ in a number of ways, and therefore they have different risk profiles. In order to assess and compare the determinants of Cocos with different characteristics, the sample in this study will be decomposed into subgroups based on Basel III designation as well as individual Coco bond rating.

The remaining parts of this paper are structured as follows. The remainder of Section 1 provides a short overview of the background and history of Cocos. Section 2 will give a brief introduction of the regulatory framework defined in Basel III. Section 3 will provide a description of the structure and features of Cocos. Section 4 presents the explanatory variables and their theoretical relation to Coco spread changes. Section 5 initially specifies the calibration methodology, describing the estimation technique and regression tests. Section 5 will also present the results. Finally, Section 6 concludes the paper.

1.1 Background

The recent GFC of 2007-2009 clearly revealed the fragility of the financial system, pointing out weaknesses in both national and international regulatory frameworks. Since many banks were unable to raise capital during this period, authorities in certain countries had to provide financial support, indirectly financed by taxpayers, in order to protect the financial stability and limit the consequences of the crisis (Avdjiev *et al.*, 2013). The crisis further revealed that hybrid securities existing at the time were not able to absorb the losses as they were supposed to (European Securities and Markets Authority, 2014). The governmental interventions did therefore contribute to a significant increase in sovereign exposures and worsening moral hazard (Pazarbasioglu *et al.*, 2011). Furthermore, the government rescue of several large banks also brought the issue of so-called "too big to fail" banks to the attention of regulators as well as the public (Buergi, 2013), implying that many financial institutions are so large and so interconnected that a failure of such institution would be disastrous to the modern economic system. The GFC also made it clear that financial institutions around the world had built up concentrated credit and liquidity risks from their investments (Calomiris and Herring, 2013) and thus one important outcome has been a call for better capitalization of such financial institutions (Buergi, 2013). To address the capitalization issue, the moral hazard and the problem that banks could be too big to fail, proposals for new types of hybrid capital was gaining ground (Pazarbasioglu *et al.*, 2011).

In the aftermath of the GFC the European Commission has made a move to strengthen bank regulation in Europe and has announced the Capital-Requirements Directive (CRD) IV package, which transposes the Basel III agreement into EU law through regulations and directives. The EU law requires all capital instruments (except common equity) that are included in regulatory capital to have a well-defined loss absorption mechanism, *i.e.* the instrument could be converted into common equity or be fully and permanently written down. Instruments with this kind of loss absorption mechanism are most often referred to as Contingent Convertible capital instruments or simply Contingent Convertible (Coco) bonds. Although the first Coco issues was first seen after the outbreak of the GFC, the idea of similar instruments was discussed already in 2002 in a paper by Flannery, but then under the name of Reverse Convertible Debentures (RCD). In his paper, Flannery discusses the fact that RCD would provide a transparent mechanism for de-levering a firm if the need arises. The idea was that RCDs would resemble a straight long-term debt in good times but would convert into equity as the firm as well as the financial system would be under financial stress. More precise, the RCD would automatically convert into equity if a bank's market capital ratio would fall below a predetermined value. This automatic conversion would instantly transform an insolvent or under-capitalized bank into a well-capitalized bank, and to no cost for tax-payers. Instead the cost would be borne by the investors who had bought the RCDs. Cocos works in a similar way and the financial instrument introduced and discussed by Flannery (2002) is arguably the first proposal of contingent convertible bonds.

2 Basel Framework for Regulatory Capital

Before explaining the design of Coco bonds in detail, a brief description of the development of the current regulatory framework is given together with the latest definition of regulatory capital. The first Basel Accord was introduced in 1988 by the Basel Committee on Banking Supervision, and called for minimum capital requirements for banks. The framework was intended to evolve over time and in 1999 the committee issued a proposal for a new capital adequacy framework to replace the old one. This new revised capital framework got the name Basel II and was released in June 2004. Basel II further developed the first accord in terms of minimum capital requirements, and did also introduce the use of different risk weights on different types of assets as well as a more international approach dealing with bank risks. The current Basel accord, namely Basel III, was introduced in 2011 but has not yet been fully implemented at the time of writing this paper. However, the new definitions of regulatory capital together with increased capital requirement stated in Basel III have been the main drivers of the increase of Coco issuance during recent years (Avdjiev *et al.*, 2013).

Basel III is an extensive set of reform measures developed to strengthen the regulation, supervision and risk management in the banking sector. It was developed as a response to the previously discussed weaknesses in the former regulatory framework revealed during the GFC. The reform measures aim to improve the banking sector's ability to absorb shocks arising from financial and economic stress by increasing capital requirements and impose lower leverage among banks (BCBS, 2011). In extension to this, the measures also aim to improve banks transparency and disclosures since geographical inconsistencies in definitions of regulatory capital led to market players being unable to fairly assess and compare the quality of capital across jurisdictions.

Basel III puts greater focus on the requirements of high quality components of bank's capital, and new definitions enable banks and other financial institutions to raise high quality capital without the need of issuing common shares. In Basel III, the total regulatory capital has been separated into the following elements (BCBS, 2011):

1. Tier 1 Capital (Going-concern capital) (T1)
    (a) Common Equity Tier 1 (CET1)
    (b) Additional Tier 1 (AT1)
2. Tier 2 Capital (Gone-concern capital). (T2)

The regulatory capital proposals in Basel III make a distinction between Tier 1 Capital, which is denoted as "going-concern capital", and Tier 2 Capital, which instead is denoted as "gone-concern capital". The difference between the two capital types is that gone-concern capital acts as support for depositors in bankruptcy or liquidation but has a less important role in preserving the bank as a going concern. Common Equity Tier 1 generally consists only of common equity and retained earnings, while other types of subordinated, perpetual and unsecured capital are included in Additional Tier 1. Tier 2 includes items such as revaluation reserves, undisclosed reserves, hybrid instruments and subordinated term debt. Another central measure in Basel III is the *risk weighed assets*

(RWA), which was initially introduced in earlier accords. The aim of RWA is to provide a straightforward way to assess and compare risks of banks, and to give incentives for banks to hold low risk assets on their balance sheet. RWA is computed by weighting the assets by their riskiness (the higher the risk, the higher the weight), and is used as the denominator when calculating a bank's regulatory capital ratios. The definitions and minimum requirements of all such ratios can be observed in Figure 1. These required levels are the minimum requirements, and national regulators are allowed to set other levels as long as they are at least the size stated in Basel III. Nevertheless, banks have to adjust for the new requirements and maintain these levels at all time.

To be included in any of the above elements of regulatory capital, a debt instrument must fulfill a set of criteria. Cocos can never be included in the CET1 category of a bank's capital and are thereby not labelled as top-quality capital (Avdjiev *et al.*, 2013). Thus, the elements of the regulatory capital to which Cocos may qualify are restricted to Additional Tier 1 and Tier 2. Section 3 will describe the terms and features of Cocos that enable them to satisfy the regulatory capital requirements.

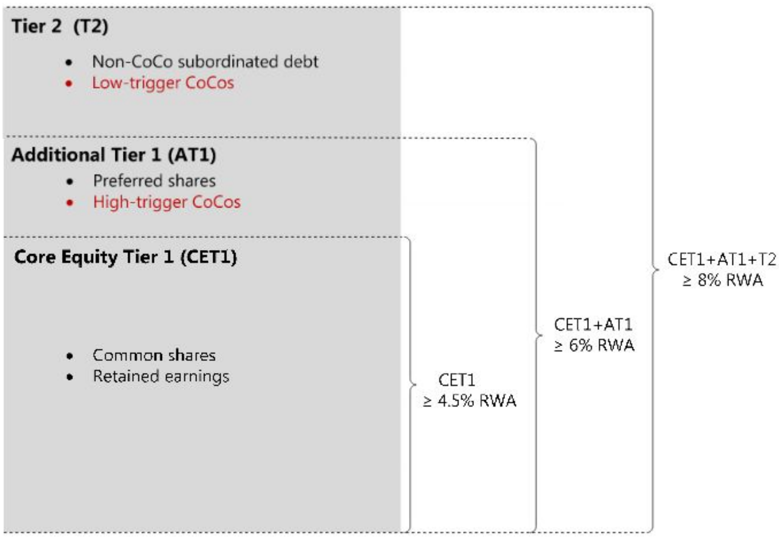

Figure 1: Cocos position in Basel III capital requirements. The graph presents the different elements of total regulatory capital together with the minimum requirements. The list of instruments in this graph is not exhaustive and is included solely for illustrative purposes. For a complete list of instruments and associated criteria for inclusion in each of the three capital buckets, see BCBS (2011). Source: Avdjiev *et al.*, 2013.

3 Contingent Convertible Bond Framework

Contingent Convertible bonds can easily be confused with the concept of regular Convertible bonds, but it is important to remember that despite their similar names, they fulfill completely different purposes. A *convertible bond* is a bond that an investor may convert into equity for a predetermined price when the stock price reaches a certain level. The investor will have downside protection since the convertible bond will behave like a normal corporate bond if the stock price does not reach the level where conversion is possible. However, if the level for conversion is breached, the investor may convert the bond into equity and thus at a lower price than the current market price. This means that the investor has a possible upside gain. A *Contingent Convertible bond* works in the opposite way. Its main purpose is to protect the issuer from defaulting. Holding a Coco, the investor is limited on the upside but is not protected on the downside. As long as the issuer is viable the Coco will reflect a normal corporate bond and pay its coupon to the investor, but if the issuer is facing financial distress the bond can work as loss absorption. In this way, the issuer will get a capital injection and thus hopefully escape default. (De Spiegeleer *et al.*, 2014)

3.1 Loss Absorption

The loss absorption mechanism is the first key characteristic of Coco capital, and it is also one of the main features enabling the instrument to qualify as regulatory capital. The purpose of the loss absorption mechanism is to boost the issuer's capital structure in times of distress. A Coco can absorb losses in one of two ways, where the first alternative is a *conversion into equity*, which strengthens banks' CET1 by converting the Coco bond to a number of common shares. The price a Coco investor then pays per share is called conversion price. The conversion price can either be set to the market price at the time of conversion, or at a predetermined price floor (De Spiegeleer and Schoutens, 2012). The conversion price will then be set to the higher of the two since the idea of such floor is to protect the current shareholders from substantial dilution. That is, the lower the conversion price, the more shares the Coco investor receives at conversion, which leads to higher dilution for current shareholders.

The second alternative is to utilize a *principle write down*, which in contrast raises equity by incurring a write-down of the Coco's face value. The write-down can be either full or partial, and the terms and prospectus will differ depending on country and issuer. The most common loss absorption mechanism for Cocos is full principal write-down since it is a requirement in order to qualify as regulatory capital (Avdjiev *et al.*, 2013). Furthermore, there also exists the possibility of a temporary write-down, implying a "write-up" if the issuer restores its financial health. Both ATI and T2 Cocos have loss absorption features, but according to Basel III this feature is only required for AT1 designation (BCBS, 2011).

3.2 Trigger Event

The second key characteristic of a Coco contract is the trigger event, which determines under which circumstances the loss absorption mechanism is triggered. The trigger event is designed to reflect a situation where the bank moves into turbulent or difficult times, for example through plunging equity prices or low capital coverage ratios. When the trigger is hit and the loss absorption is induced, the bank ends up with a stronger capital structure.

The Basel III framework contains two key contingent elements in terms of trigger event: First, a Point of Non Viability (PONV) requirement, which applies to both ATI and T2 designation; and second, a going-concern contingent capital requirement, which applies only to AT1 classified Cocos (Avdjiev *et al.*, 2013). The requirement of a PONV trigger, namely a *regulatory trigger*, enables a governmental authority, *e.g.* Financial Supervision Authority (FSA), to decide if and when the loss absorption should take place. The trigger is activated if regulators strongly believe that the issuing institution is in such financial distress it will not be able to fulfill its capital requirements. Since the loss absorption mechanism is activated based on regulators judgment, there is no exact trigger level, which complicates the valuation process of Cocos (Avdjiev *et al.*, 2013).

When it comes to the going-concern trigger, which is a requirement only for AT1 Coco bonds, there are several different kinds of trigger events that may determine when a Coco should convert. The first alternative is called *market trigger* and is associated with an underlying market factor such as the share price or CDS spreads of the issuing bank. A market trigger is forward looking since such a trigger reflects the market's current expectation of the bank's health. Several academics advocate market triggers (see *e.g.* Flannery, 2002 and Calomiris and Herring, 2013), as it is a clear and transparent measure for investors, since market factors such as equity prices and CDS spreads are often observable on a daily basis. However, a market trigger is more of a conceptual alternative and no outstanding Coco has such a trigger at the time of writing this thesis (Bloomberg, 2016).

The second and most common trigger alternative is called *accounting trigger*, which implies that the loss absorption is related to hitting a predetermined minimum capital ratio, usually the CET1 ratio. Previous studies have stated that an accounting trigger is the most appropriate to use in order to protect the bank as well as the whole industry. For instance, in IMF (2011) one can find a number of benefits that are associated with the use of an accounting trigger. It is easy to understand and all numbers are fully disclosed by the issuer. However, there are some complications that arise with accounting-based triggers. Accounting measures are not continuously updated and are at best, available for investors on a quarterly or semi-annual basis. This might leave a lot of room for speculation regarding whether the bond will be triggered or not (De Spiegeleer and Schoutens, 2012).

The choice of trigger levels is to a large extent related to the going-concern contingent capital requirement and the trade-off between regulatory capital eligibility and cost of issuance. A lower trigger implies lower risk of conversion, and therefore a Coco with low trigger can be issued with a lower coupon compared to a high trigger Coco, *ceteris paribus*. However, the trigger levels must be high enough in order for the Coco to be classified as going-concern capital. Under Basel III, the minimum trigger level for a Coco to be eligible as AT1 capital is a CET1 ratio equal 5.125 percent. A large part of the recent years' Coco issues has therefore adopted a trigger level set to exactly 5.125 percent. It is an attractive trigger level as it is cheaper to issue compared to Cocos with higher triggers, while still meeting the AT1 requirements (Avdjiev *et al.*, 2013).

Another alternative when designing a Coco is to use a *multivariate trigger*, which means using more than one of the before mentioned trigger types. The idea of such trigger is that one component could focus on the state of the underlying bank and combine that with a universal systemic trigger that acts as a reflection of the condition of the economy (De Spiegeleer and Schoutens, 2012).

3.3 Extension Risk

The choice of maturity is of great importance in terms of regulatory capital eligibility. Under the Basel III framework all AT1 instruments must be perpetual, while T2 Cocos can have a fixed maturity with a minimum of at least five years (BCBS, 2011). For perpetual Coco bonds, a call feature gives the issuer the option to decide when to repay the face value, allowing the issuer to act in terms of refinancing when the cost of borrowing falls. As much as it is an option for issuers, this comes as a risk for the investors. That is, if the creditworthiness of the issuer would deteriorate, and cost of borrowing increases, there is a probability that the issuer will not redeem at the call date and thereby defer the repayment. Both AT1 and T2 Cocos may be callable after a minimum of five years, but there must be no coupon step up at call date or any other incentives to redeem early. Furthermore, to exercise a call option the issuer must receive prior supervisory approval of early redemption (BCBS, 2011).

3.4 Coupon Cancellation Risk

In addition to extension risk, investors holding Cocos also faces the risk of not receiving the promised coupons. According to Basel III the issuing bank of AT1 bonds must have full discretion at all times to cancel coupon payments, and such a cancellation must not be an event of default (BCBS, 2011). However, this does not apply for T2 bonds, as such bonds are classified as gone-concern capital.

3.5 Coco Ratings

The absence of a comprehensive set of credit ratings has for long been a hurdle for the growth of the Coco market (Avdjiev *et al.*, 2013). Approximately half of all outstanding Cocos are not yet rated (Bloomberg, 2016). Avdjiev *et al.* (2013) discusses a number of reasons for this. First, the heterogeneity of Cocos in terms of regulatory treatment across jurisdictions has prevented the development of consistent rating methodologies. However, since the clarity of regulatory treatment has improved with Basel III, it is suggested that more Cocos will be rated in the future. Furthermore, rating agencies are concerned with certain high trigger Cocos that can invert the traditional hierarchy of investors. That is, holder of high trigger Cocos can face losses ahead of equity holders when the loss absorption is triggered. Finally, the fact that Cocos have a PONV trigger hampers the valuation and thereby complicates the rating process. There is also the risk of coupon cancellation that has to be accounted for when rating Cocos.

Considering definitions of Fitch Ratings, Cocos range between BB- to BBB+, where BB rated bonds are considered as "speculative" and BBB rated bonds are labelled with "Good credit quality" (Fitch Ratings, 2016). The bonds in the sample have been subdivided into two groups, bonds with BB (+/-) ratings and bonds with BBB (+/-) ratings. Table I presents three rated Cocos with different features and Basel III designation.

Table I
Examples of different Coco structures

Issuing Bank	Swedbank	Deutsche Bank	Barclays Bank PLC
Bloomberg ID	*EK7432140*	*EK2481985*	*EJ6192706*
Issue Date	*2015-02-19*	*2014-05-27*	*2013-04-10*
Issue Currency	*USD*	*EUR*	*USD*
Maturity	*Perpetual*	*Perpetual*	*2023-04-10*
Next Call Date	*2020-03-17*	*2022-04-30*	*2018-04-10*
Issue Volume	*0.75 billion*	*1.75 billion*	*1.00 billion*
Reg. Capital Designation	*Additional Tier 1*	*Additional Tier 1*	*Tier 2*
Coupon	*5.5%*	*6%*	*7.75%*
Coco price	*98.375*	*81.935*	*105.270*
Yield to next call (YTC)	*5.977%*	*10.185%*	*4.822%*
Trigger	*Core Tier 1 Ratio*	*CET 1 Ratio*	*CET 1 Ratio*
Trigger Size	*5.125%*	*5.125%*	*7%*
Loss absorption	*Equity Conversion*	*Temporary Write Down*	*Permanent Write Down*
Rating (Fitch)	*BBB-*	*BB*	*BBB-*

The table reports the structure of three different Contingent Convertibles. Bloomberg ID is the Bloomberg identification number assigned when issued. The issue date is the date the security is issued. The Issue Currency is the currency in which the security was issued. Maturity is the last day the security is due and payable. Next call date is the next possible date the security can be redeemed, at the option of the issuer. Issue Volume represents the amount issued in the issued currency. Reg. Capital Designation (Regulatory Capital Designation) indicates how the instrument is classified under Basel III. The coupon is the current interest rate of the security. The Coco price is the last clean price for the security. Yield to call is the yield to next possible date the security can be redeemed, it is calculated per 2016-05-10. Trigger is the level or ratio which, when breached, triggers the loss absorption mechanism associated with the contingent conversion security. Trigger size is the pre-specified, issuer specific numerical ratio which, when breached, causes the contingent capital security to either convert into equity or be written down. Loss absorption is the type of conversion action after the trigger is activated. Rating is the issue level rating assigned by Fitch. Source: Bloomberg (2016).

4 Model

4.1 Coco Spreads

The total sample consists of 71 currently trading Coco bonds issued by 19 listed banks (see full list in Appendix 9.1). The selection of these Cocos is based on geographical incorporation of the issuing bank, as well as availability of quotes for Coco prices and explanatory variables in Bloomberg. Since the new definitions of regulatory capital stated in Basel III has been transposed into EU law, the sample in this study is limited to

European issuers. Financial institutions, such as insurance companies or financial service providers other than banks, have deliberately been excluded from the sample because regulatory requirements and risk structures of these firms might be different and difficult to compare Ammann *et al.* (2015). Moreover, Cocos with a loss absorption mechanism of either equity conversion or *partial* write down are excluded from the sample due to the high level of heterogeneity in their recovery rate, leading to erroneous conclusions. Both Additional Tier 1 and Tier 2 Cocos are included in the sample.

The analysis uses daily data for a period starting from 14th of July 2010 until 31th of March 2016, which results in a total of 25,661 observed Coco quotes. Due to the fact that some bonds have been relatively illiquid and trades are not always reported on a daily basis, the last-observation-carried-forward principle of interpolation is utilized (max. 5 days back). This increases the data set to 30,688 panel observations. Coco bonds have been issued continuously during the examined period, resulting in an unbalanced data set. Moreover, there exists a possibility of inaccuracies and spurious outliers in the reported data and therefore the sample has been limited in terms of extreme values by truncating outliers in the 0.5 percentiles. All data has been retrieved from Bloomberg.

Since the majority of the Cocos in the sample are perpetual and callable, simplifying assumptions regarding the maturity has to be made when calculating Coco bond yields in order to avoid highly involved Monte-Carlo simulation. As discussed in Subsection 3.3, the event of extending a Coco bond at call date is mainly related to the future refinancing cost of the issuing institution. An improvement in credit quality of the issuer implies a lower refinancing cost and the bond would be called back at par. If the credit quality instead deteriorates, the bond would most likely not be called since a refinancing on the market is then more expensive. Even though information such as forward credit spreads is available in the market, one would need to model the actual evolution of the future refinancing cost, and it cannot be easily extracted from the current bond price (Wilkens and Bethke, 2014). Following Wilkens and Bethke (2014) on this matter, the maturity of the Coco bond will therefore be assumed to be equal to the first call date. Ranneby (2016) takes this discussion further and argues that if a healthy bank are able to call back the Coco, and got supervisory approval, the bank will always exercise the call. The assumption behind this is that due to the fact that Cocos are only a small proportion of banks' total debt, and it is unnecessary to upset the investor base. The assumption of using first call date as maturity when calculating the yields is further strengthened by the fact that only one Coco has so far not been called at the first call date (Bloomberg, 2016).

Bond spreads are generally defined as the difference between the yield of a risky asset and an equivalent risk-free asset. In literature, it is standard to consider government bonds as default free assets and the yield of such is therefore frequently used as risk-free rate (Landschoot, 2004). Thus, the Coco spread is calculated by subtracting a risk-free benchmark with matching maturity from the Coco bond yield. The choice of risk-free rate depends on in which currency the Coco bond is issued, and is approximated using a matching generic government bond.

Figure 2 graphs the evolution of the Coco spreads between July 2010 until March 2016. In the early stages of the period, there are only a few outstanding Cocos. In mid-2013, one can start to distinguish the dispersion in spreads across Cocos, as the number of bonds in the sample is increasing.

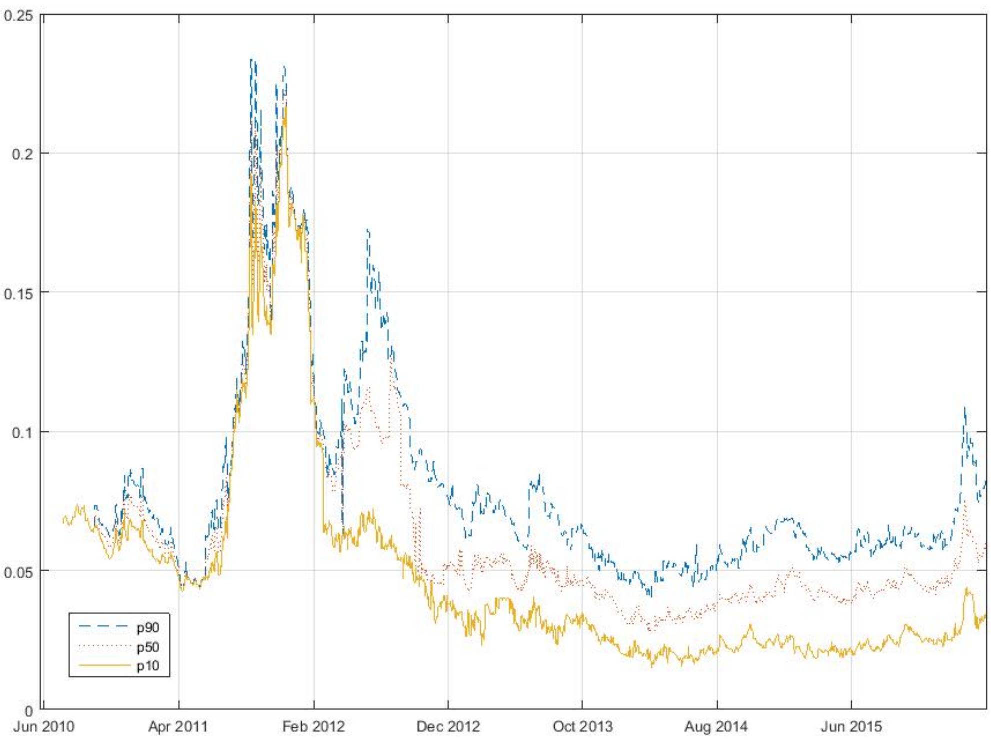

Figure 2: The evolution of Coco spreads in the sample. The full yellow line represents the lower 10th percentile, the pink dotted line represents the median and the dashed blue line represents the upper 90th percentile (levels in percentage points).

4.2 Explanatory Variables

Many theoretical models, based on the findings of Merton (1974), relate credit spreads to default losses. In literature, the Merton model is often referred to as the representative of the structural models since it was one of the first structural credit risk models (Landschoot, 2004). However, over the years several extensions have been made to the Merton model by relaxing certain assumptions, although the main conclusions have not been altered by such modifications. Empirical papers have previously been testing these models when investigating drivers of credit spreads and used proxies for the determinants proposed by these models (see *e.g.* Collin-Dufresne *et al.*, 2001 and Annaert *et al.*, 2013). These variables are firm specific and focus mainly on leverage and asset volatility, which are closely linked to the financial health of the firm. Hence, structural models such as the Merton model will provide an intuitive framework for identifying several theoretical determinants of Coco spreads. Empirically, these firm specific variables have been found to be significantly related to credit spread changes, but their explanatory power is often rather weak (Annaert *et al.*, 2013). In the study of Annaert *et al.* (2013) the authors argue, like some before them (*e.g.* Jarrow and Turnbull, 2000), that adding variables describing the current market condition could improve the fit, as it has been documented that credit spreads (Fama and French, 1989), default probabilities and recovery rates may vary through the business cycle (Pesaran *et al.*, 2006 and Altman *et al.*, 2005). Hence, variables describing the current market condition are added to the explanatory variables in the model of this paper. Annaert *et al.* (2013) finds that changes in such market wide variables play an important role in explaining CDS spreads, which also strengthen the decision to include them as explanatory variables in this study. Finally, Annaert *et al.* (2013) argue that the liquidity of traded contracts impact prices and is therefore also included as an explanatory variable in this study. The explanatory variables are discussed in the subsequent sections and descriptive statistics for each variable are presented in Table II. Furthermore, the explanatory variables are also reported in a Correlation Matrix (Table III), showing the correlation between changes in the explanatory variables.

4.2.1 Credit Risk Variables

The Merton model derives a closed form formula for credit spread of a risky zero coupon bond where leverage, asset volatility and asset growth are used as the key drivers for bankruptcy. Since this study work with daily data over a relatively short period of time, it is difficult to find an accurate measure for financial leverage, as changes in such are reported on a quarterly basis at best. Following previous papers (see *e.g.* Christie, 1982; Collin-Dufresne *et al.*, 2001; Alexander and Kaeck, 2008 and Annaert *et al.*, 2013) the changes in degree of financial leverage is approximated by the *change in market capitalization*, *i.e. stock return* for the issuing bank. If stock return of the issuer is negative, this implies that leverage measured in market values will increase, and thus leading to higher Coco spreads. That is, a negative relation between stock returns and credit spreads is expected.

Although this variable is mainly a proxy for bank specific financial leverage, there is still a possibility that other factors are captured. Annaert *et al.* (2013) argues that, to the extent that equity returns reflect a firm's future prospects, positive returns implies lower default risk and might thus also contribute to lower Coco spreads.

According to previously mentioned theoretical models, higher asset volatility should increase the likelihood of hitting the default threshold and thus also lead to higher credit spreads. Due to the complexity to assess a bank's asset volatility previous papers have used historical equity volatility as a proxy for this determinant (see *e.g.* Covitz and Downing, 2007 and Chen *et al.*, 2007). Following Cao *et al.* (2010) in this matter, who find that implied volatility of individual stock options has a significant explanatory power for CDS spreads, banks' *implied equity volatility* is used as a proxy for asset volatility. All data for individual implied equity volatility is based on options expiring in no less than three month to avoid random movements in implied volatility that may arise close to expiry. As an alternative, historical volatility based on different time periods were also examined, however, these did not improve the results and therefore only results using the implied volatility are reported.

4.2.2 Marketability

Another factor likely to affect the prices of a traded instrument is the liquidity of such. Similar to Annaert *et al.* (2013) this paper follows Longstaff *et al.* (2005) and Chen *et al.* (2007), which argues that individual bond illiquidity is priced and consider liquidity as marketability of a particular bond. Several of the Coco bonds in the sample are traded over the counter, and thus no trading volumes are reported in Bloomberg. Hence, another measure for liquidity must be used as a proxy. There are several ways in which liquidity can be assessed, but following Annaert *et al.* (2013) the bond specific liquidity is measured as the *bid-ask spread* of the Coco bond quotes, *i.e.* the difference between the ask and bid price of the Coco bond. The choice of this variable also relies on the findings of Bongaerts *et al.* (2011) and Tang and Yan (2010), who report substantial correlations between the bid-ask spreads and other liquidity proxies, *e.g.* data on trades or volume of orders.

4.2.3 Market Factors

Many empirical papers examining bond and CDS spreads based on bank specific credit risk variables, have found in their models that the residuals in the model still contain common variation, implying that there might be missing common factors (Collin-Dufresne *et al.*, 2001). In their paper, Collin-Dufresne *et al.* (2001) propose that this common factor might be related to the economic environment, and by including such variables one might capture general market and economic conditions. Collin-Dufresne *et al.* (2005) argues that the business cycle may impact the credit spreads in two ways. First, and most intuitive, credit spreads should reflect that default risk depends on economic circumstances. Second, Berndt *et al.* (2001) provide evidence for risk aversion to vary through the business cycle, which might impact the risk premium investors are requiring to take on credit risk. Based on these two channels through which the Coco spreads might be affected, two different proxies for market and business condition are introduced in the model.

First, the *slope of the term structure*, which is broadly acknowledged for being a good business cycle predictor where a high slope foresees improved economic growth (see *e.g.* Estrella and Mishkin, 1997). An increase in the slope therefore indicates higher expected economic growth, which would lead to lower Coco spreads. Thus, a negative relationship between changes in slope of the term structure and Coco spreads is expected. Annaert et al. (2013), further argues that the slope of the term structure also contains (to some degree) information about future interest rate levels. Again a negative relationship with credit spreads follows as an increase in the slope would indicate higher expectations of future rates which in turn implies lower credit spreads (Annaert *et al.*, 2013). There is really no theoretically correct approach deciding which points on the term structure that should be used to calculate the slope, but based on the findings of Annaert *et al.* (2013) the difference between 10 year and 5 year yield is used. As robustness checks the 10 year minus 2 year yield was also considered, however, since the result is similar but weaker only the first measure is reported.

The next variable introduced to capture the business climate is *market wide volatility*. The underlying assumption here is that a higher volatility would imply a higher uncertainty about the economic prospects. An upturn in volatility would indicate an increase in market uncertainty, which should lead to higher Coco spreads. Thus a positive relationship between market volatility and credit spreads is expected. In addition to this, Annaert *et al.* (2013) argues that market volatility might also be a proxy for market strains that limit the capital mobility across different market segments and therefore sustaining high risk premiums. Following several previous papers (see *e.g.* Berndt *et al.*, 2005; Boss and Scheicher, 2005; González-Hermosillo, 2008; Tang and Yan, 2010 and Annaert *et al.*, 2013) the VSTOXX Index is used to measure market wide implied volatility. The VSTOXX index is developed to capture the implied European market volatility and is based on the EURO STOXX 50 Index. By using a Europe wide index instead of a national index the risk of multicollinearity is reduced, as bank specific equity volatility is included as another explanatory variable. That is, the sample contains large banks that might have an influence on its national market index which volatility might then be correlated with the equity volatility. Finally, based on findings of Pan and Singleton (2008) market wide volatility can also work as an indicator for investors' risk aversion, which might also affect the required spread for credit risk.

Table II
Descriptive Statistics explanatory variables

	Mean	Median	Min.	Max.	St. Dev.	Skew.	Kurt.	Obs.
Equity Volatility	-0.0017	0.0010	-0.9376	0.1912	0.0549	-2.5457	24.4946	31883
Leverage	-0.0010	-0.0050	-0.1089	0.0540	0.0190	-0.4 4	4.7359	31888
Bid-ask spread	0.0000	0.0000	-0.0090	0.0025	0.0007	-4.4123	45.6841	30948
Term structure slope	0.0000	0.0000	-0.0017	0.0007	0.0002	-0.9487	9.5147	32400
Market Volatility	-0.0006	-0.0010	-0.0715	0.0494	0.0156	-0.0346	5.0600	31849

The table reports the mean, the median, the minimum (Min.), the maximum (Max.), the standard deviation (Std. Dev.), the skewness (Skew.), the kurtosis (Kurt.) and the number of observations (Obs.) of the explanatory variables from 14th of July 2010 until 31th of March 2016. The equity volatility is the daily change in implied volatility for the underlying bank (in percentage points). Leverage is the daily bank stock return (in percentage points). The bid-ask spread is the daily change in the difference between the ask and the bid price of the Coco bond (measured in percentage points). The term structure slope is the daily change in the difference between the 10 year and the 5 year government bond in the issuing currency of the Coco (in percentage points). Finally, the market volatility is computed based on the daily change in VSTOXX index (in percentage points).

Table III
Correlation Matrix explanatory variables

	Equity Volatility	Leverage	Bid-ask spread	Term Structure	Market Volatility
Equity Volatility	1.0000				
Leverage	-0.2279	1.0000			
Bid-ask spread	0.0155	-0.0145	1.0000		
Term structure slope	-0.0119	0.1388	0.0154	1.0000	
Market Volatility	0.2998	-0.5967	0.0154	-0.1604	1.0000

The table reports correlation between the changes in explanatory variables from the 14th of July 2010 until 31th of March 2016. The equity volatility is the daily change in implied volatility for the underlying bank (in percentage points). Leverage is the daily bank stock return (in percentage points). The bid-ask spread is the daily change in the difference between the ask and the bid price of the Coco bond (measured in percentage points). The term structure slope is the daily change in the difference between the 10 year and the 5 year government bond in the issuing currency of the Coco (in percentage points). Finally, the market volatility is computed based on the daily change in VSTOXX index (in percentage points).

5 Calibration

5.1 Estimation Technique

The sample in this paper lends itself to panel data estimation techniques. The fundamental advantage of panel data is the capabilities it provides the researcher, such as dealing with the omitted variable bias problem (Schmidheiny, 2015). However, an issue of panel data analysis is the relation between the individual-specific intercept and the explanatory variables. In order to overcome this, the first-difference estimator is used. The advantage with this approach is the efficient removal of the individual-specific intercept regardless if fixed- or random effects estimation is appropriate (Greene, 2012). The basic framework for the first difference estimator regression is as following:

$$y_{it} = c_i + x'_{it}\beta + z'_{it}\gamma + \epsilon_{it}, \quad t = 1, ...T \tag{1}$$

$$y_{it-1} = c_i + x'_{it-1}\beta + z'_{it-1}\gamma + \epsilon_{it-1}, \quad t = 2, ...T \tag{2}$$

$$\Delta y_{it} = y_{it} - y_{it-1} = \Delta x'_{it}\beta + \Delta z'_{it}\gamma + \Delta\epsilon_{it}, \quad t = 2, ...T \tag{3}$$

The equations above demonstrate how the first-difference estimator filters out the individual-specific intercept. By doing so, the only variables left explaining the Coco spread is the time-varying bank-specific explanatory variables (x) and the time-varying common explanatory variables (z), and thus first-difference estimator is a useful technique for analysing instantaneous changes in the dependent variable (Andress *et al.*, 2013).

Note that due to the fact that the sample is differentiated, the model trades the cross-section correlation in the intercept for moving average disturbance, which is serially correlated across one period (Greene, 2012). Even if the coefficients remains unbiased the standard errors is not valid anymore. To adjust for this, the standard errors are clustered. More specifically, a so-called cluster-robust covariance matrix estimator that does not impose any restriction on the form of heteroscedasticity and serial correlation within clusters is used (Schmidheiny, 2015).

Another concern in the sample is the possibility of endogenous data selection. If the missing values in Coco prices are systematically linked to the explanatory variables, the explanatory power could be biased and inconsistent. To explore this possibility we follow a similar approach as Annaert *et al.* (2013) and examine both univariate- and multivariate logit regressions to see if the probability of not having a Coco price is linked to some of the explanatory variables. The results (Appendix 9.2) indicate that neither of the explanatory variables can explain the missing values in Coco spreads on any significant level.

Finally, the correlation matrix in Table III indicates a relationship between some of the explanatory variables. In order for the regression estimates to be valid these variables should not have too high correlation as it may lead to multicollinearity bias. By examining the explanatory variables with a Variance inflation Factor (VIF) test one can see if there is a multicollinearity problem among the explanatory variables. The results (Appendix 9.3) indicate that the mean VIF is not high enough to cause multicollinearity concerns.

5.2 Regression Results

5.2.1 Regression by Group

By conducting multivariate panel regressions for each group of explanatory variables, the relative importance of each group is assessed. The regression models for each group are displayed in Equation 4, 5 and 6 below. The coefficients (with associated t-value) and Adjusted R^2 are reported in Table IV in the following order; *credit risk variables*, *liquidity risk* and *market wide variables*. Regressions are first run for the full sample, and then decomposed by regulatory capital designation as well as individual bond rating.

$$\Delta CoCoSpread_{it} = \beta_1 \Delta EquityVolatility_{it} + \beta_2 \Delta Leverage_{it} + \epsilon_{it} \tag{4}$$

$$\Delta CoCoSpread_{it} = \beta_1 \Delta BidAskspread_{it} + \epsilon_{it} \tag{5}$$

$$\Delta CoCoSpread_{it} = \beta_1 \Delta TermStructureSlope_{it} + \beta_2 \Delta MarketVolatility_{it} + \epsilon_{it} \tag{6}$$

In the full sample, changes in credit risk variables are able to explain up to 6.50% of the variations in Coco spreads, which is the highest explanatory power of the three groups. This is not surprising since Coco spreads are theoretically related to credit risk. Both stock return and implied equity volatility carries the expected sign and are statistically significant at the 0.01 level. The second panel in Table IV shows that changes in bid-ask spreads explains approximately 0.17% on a standalone basis. Although low explanatory power, the coefficient for changes in bid-ask spread carries the expected sign and is also statistically significant at the 0.01 level. The third panel shows that market wide variables are able to explain 6.25%, almost as high as for credit risk variables. Like previous variables, both changes in slope of term structure and market volatility carry the expected sign and are statistically significant (at 0.01 level). Thus, it is suggested from these separate regressions that all variables have a statistically significant impact on Coco spreads, corresponding to the expected sign. The results present relatively high t-values, indicating good accuracy of the coefficient estimates and their sign. This might be due to the large sample (daily observations), enabling estimation of the parameters with high precision.

By observing the sub samples decomposed by regulatory capital designation, one can see that the explanatory power of each group of variables jumps to much lower levels when looking at Tier 2 bonds only, where adjusted R^2 vary between 0.05% (liquidity) and 2.25% (credit risk). For AT1 on the other hand, adjusted R^2 ranges from 0.27% (liquidity) to 8.90% (credit risk). In both of these sub samples, the signs of the estimated coefficients are consistent with those of the full sample and are statistically significant at 0.01 level. The results are in line with the fact that AT1 are riskier than T2 bonds in terms of features and subordination, and imply that AT1 bond spreads are more intimately linked to issuer specific credit risk. The reported results also indicate that changes in the market wide variables as well as bond specific liquidity explain variations in AT1 Coco spreads to a greater extent compared to T2 Coco spreads. The estimated coefficients for changes in market volatility and slope of the term structure indicates that Coco spreads of AT1 bonds are more sensitive to changes in market uncertainty as well as expected economic growth. As the market volatility can also be seen as an indicator for investors' risk aversion (Pan and Singleton, 2008) the estimated coefficient implies that an increase in risk aversion has a greater impact on AT1 bonds. Again, this is consistent with the fact that AT1 Cocos are subordinated to T2 Cocos.

When decomposing the full sample according to individual bond rating, the model shows a somewhat better explanatory power for bonds rated BB(+/-) compared to bonds with BBB(+/-) rating, for each group of variables. Credit risk variables are for instance able to explain 8.90 % of the spread variations for BB(+/-) rated Coco bonds, but only 3.24 % for BBB rated bonds. The same holds for the both liquidity and market wide variables. Also the size of the coefficients indicates a higher impact of credit risk variables on spreads for lower rated Coco bonds. This is consistent with the hypothesis of lower rated bonds are more sensitive to bank specific risk variables. However, this interpretation can be questioned as there are no T2 bond with a BB(+/-) rating, and the results are therefore similar to those where the full sample is broken down by AT1 and T2 designation. This implies that one has to observe the decomposed AT1 sample in order to assess the differences between ratings.

Hence, observing AT1 Coco bonds broken down by rating, the coefficients of credit risk variables once again indicates a higher impact on BB(+/-) rated bonds. Changes in equity volatility, which is a proxy for asset volatility, does not have a statistically significant impact on BBB(+/-) rated AT1 Coco bonds. Although the coefficients indicate that lower rated bonds are more sensitive to the movements in issuer specific credit risk variables, the explanatory power is almost the same for both ratings. The adjusted R^2 for BBB(+/-) is 8.77 % and 8.90 % for BB(+/-).

The conclusion of the separated multivariate regressions by group is that it is clear that Coco spread changes are not solely driven by credit risk variables. Each of the three groups of explanatory variables explains between 0.17% and 6.50 % of the movements in Coco spreads.

Table IV
Regression by group of explanatory variables

	Full Sample			Additional Tier 1			Tier 2		
	All	BBB +/-	BB +/-	All	BBB +/-	BB +/-	All	BBB +/-	BB +/-
I. Credit risk variables									
Equity volatility	0.0017 (8.45)	0.0015 (4.02)	0.0019 (7.73)	0.0016 (7.27)	0.0005 (0.71)	0.0019 (7.73)	0.0018 (4.58)	0.0020 (4.96)	-
Leverage	-0.0205 (-20.07)	-0.0163 (-10.29)	-0.0229 (-17.72)	-0.0223 (-18.61)	-0.0225 (-6.29)	-0.0229 (-17.72)	-0.0141 (-10.33)	-0.0140 (-9.36)	-
Adjusted R^2	**6.50%**	**3.24%**	**8.90%**	**8.75%**	**8.77%**	**8.90%**	**2.25%**	**2.27%**	**-**
II. Liquidity risk variables									
Bid-ask spread	0.1087 (5.66)	0.2551 (6.56)	0.1187 (5.28)	0.1058 (5.52)	0.2541 (4.73)	0.1187 (5.28)	0.2562 (4.33)	0.2562 (4.30)	-
Adjusted R^2	**0.17%**	**0.10%**	**0.27%**	**0.23%**	**0.28%**	**0.27%**	**0.05%**	**0.05%**	**-**
III. Market risk variables									
Term structure slope	-0.5699 (-8.65)	-0.5730 (-4.59)	-0.6099 (-7.96)	-0.6139 (-8.36)	-1.1059 (-9.08)	-0.6099 (-7.96)	-0.3429 (-2.78)	-0.3481 (-2.54)	-
Market volatility	0.0247 (16.45)	0.0181 (12.87)	0.0292 (15.23)	0.0271 (15.37)	0.0201 (6.47)	0.0292 (15.23)	0.0168 (12.54)	0.0166 (11.72)	-
Adjusted R^2	**6.25%**	**3.34%**	**8.51%**	**8.43%**	**10.20%**	**8.51%**	**2.08%**	**2.06%**	**-**

The table reports the results from a first-difference estimator regression on the explanatory variables, divided by group of variables. Robust t-statistics are reported in the parenthesis. The period ranges from 14th of July 2010 until 31th of Mars 2016. The equity volatility is the daily change in implied volatility for the underlying bank (in percentage points). Leverage is the daily bank stock return (in percentage points). The bid-ask spread is the daily change in the difference between the ask and the bid price of the Coco bond (measured in percentage points). The term structure slope is the daily change in the difference between the 10 year and the 5 year government bond in the issuing currency of the Coco (in percentage points). Finally, the market volatility is computed based on the daily change in VSTOXX index (in percentage points). Ratings are from Fitch where BBB +/- represents Coco bonds in the range of minus triple B to plus triple B. Moreover, BB +/- is for minus double B to plus double B.

5.2.2 Kitchen Sink Regression

In the kitchen sink regression all explanatory variables, regardless of group, are included in the model in order to estimate the effect on Coco spread variations. The main purpose is to investigate if the inclusion of other variables can improve the explanatory power of the model. The regression model can be described by the following equation:

$$\begin{aligned} \Delta CoCoSpread_{it} = \beta_1 \Delta EquityVolatility_{it} + \beta_2 \Delta Leverage_{it} + \beta_3 \Delta BidAskSpread_{it} \\ + \beta_4 \Delta TermStructureSlope_{it} + \beta_5 \Delta MarketVolatility_{it} + \epsilon_{it} \end{aligned} \tag{7}$$

Once again regressions are run for the full sample as well as by Basel III designation and rating. The Kitchen Sink regression, presented in Table V, shows an adjusted R^2 of 7.44% for the full sample. Even though the explanatory power is still rather weak, it is an improvement of the model only including credit risk variables. All estimated coefficients remain statistically significant (at 0.01 level) and with the anticipated sign.

Breaking down the sample according to regulatory capital designation confirms that the model has considerably better explanatory power for AT1 Cocos than for T2 Cocos (10.23% versus 2.53%). All variables carry the same sign as in the regression performed on the full sample. The estimated coefficients for the explanatory variables indicates that AT1 Cocos are more sensitive to changes in firm specific credit risk variables as well as market uncertainty and expected economic growth. Again, this is consistent with the hypothesis that AT1 Cocos should be more sensitive as they are considered to be riskier that T2 Cocos in terms of features and subordination.

Due to the absence of BB(+/-) rated T2 Cocos, one must again look at the AT1 Cocos broken down by rating, in order to investigate such differences. As in the regressions by group of variables, the coefficients of credit risk variables indicates a higher impact on BB(+/-) rated bonds and the effect of equity volatility is not statistically significant for on BBB(+/-) rated AT1 Coco bonds. Although, the coefficients indicates that lower rated bonds are more sensitive to the movements in issuer specific credit risk variables, the explanatory power is again almost the same for both ratings. The adjusted R^2 for BBB(+/-) is 11.18 % and 10.40 % for BB(+/-).

Table V
Multivariate kitchen sink model

	Full Sample			Additional Tier 1			Tier 2		
	All	BBB +/-	BB +/-	All	BBB +/-	BB +/-	All	BBB +/-	BB +/-
I. Credit risk variables									
Equity volatility	0.0011 (5.14)	0.0008 (2.04)	0.0012 (4.42)	0.0011 (4.47)	0.0002 (0.28)	0.0012 (4.42)	0.0011 (2.43)	0.0012 (2.74)	-
Leverage	-0.0131 (-15.49)	-0.0096 (-7.26)	-0.0149 (-12.01)	-0.0143 (-13.54)	-0.0114 (-3.55)	-0.0149 (-12.01)	-0.0089 (-6.68)	-0.0090 (-6.14)	-
II. Liquidity risk variables									
Bid-ask spread	0.0706 (3.46)	0.1552 (4.08)	0.8638 (3.92)	0.0691 (3.39)	0.1467 (2.32)	0.0864 (3.92)	0.1657 (3.49)	0.1660 (3.41)	-
III. Market risk variables									
Term structure slope	-0.5862 (-10.58)	-0.5353 (-4.61)	-0.6154 (-9.65)	-0.6551 (-10.53)	-1.0963 (-9.12)	-0.6154 (-9.65)	-0.2960 (-2.92)	-0.2958 (-2.62)	-
Market volatility	0.0122 (10.06)	0.0103 (9.54)	0.0142 (7.45)	0.0132 (8.34)	0.0111 (6.91)	0.0142 (7.45)	0.0096 (7.69)	0.0091 (6.95)	-
Adjusted R^2	**7.44%**	**3.83%**	**10.40%**	**10.23%**	**11.18%**	**10.40%**	**2.53%**	**2.51%**	**-**
Observations	27045	9446	15660	19318	2423	15660	7727	7023	-

The table reports the kitchen sink regression results from a first-difference estimator regression. Robust t-statistics are reported in the parenthesis. The period ranges from 14th of July 2010 until 31th of Mars 2016. The equity volatility is the daily change in implied volatility for the underlying bank (in percentage points). Leverage is the daily bank stock return (in percentage points). The bid-ask spread is the daily change in the difference between the ask and the bid price of the Coco bond (measured in percentage points). The term structure slope is the daily change in the difference between the 10 year and the 5 year government bond in the issuing currency of the Coco (in percentage points). Finally, the market volatility is computed based on the daily change in VSTOXX index (in percentage points). Ratings are from Fitch where BBB +/- represents Coco bonds in the range of minus triple B to plus triple B. Moreover, BB +/- is for minus double B to plus double B.

6 Conclusion

The main focus of this paper has been the empirical analysis of the determinants of European area banks Coco spread changes on bonds with different characteristics, in particular regulatory capital designation and ratings. Structural models provided guidance on identification of the main driving factors. Furthermore, we have also considered liquidity risk and market wide factors, which have been found to have a significant impact on both CDS spreads and credit spreads in earlier works. As expected, issuer specific credit risk variables (inspired by Merton, 1974), such as leverage and equity volatility, explained the largest part of the variations in Coco spreads. However, individual Coco liquidity and market variables are identified to complement the Merton model and are shown to play a significant role in explaining Coco spread changes. We find a negative relationship between changes in the slope of the term structure and Coco spread changes, and a decrease in implied market volatility reduces the Coco spreads. Additionally, we find that Coco spreads increases with individual bond liquidity risk, approximated with bid-ask spread.

It is shown that the explanatory variables included in this study has a greater impact on Coco spread changes for AT1 bonds compared to T2 Coco bonds. This is consistent with AT1 bonds being subordinated to T2, and investors holding AT1 Coco bonds are more sensitive to changes in risk indicators. Cocos classified as AT1 capital have features that substantially increases the risk of holding such a bond, such as the risk of coupon cancellation and extension risk. Changes in the explanatory variables also has a better explanatory power in explaining variances in AT1 Coco spreads compared to T2 Coco spreads. We have also found that lower rated Coco bonds are to a greater extent affected by credit risk variables, such as firm volatility and leverage.

A general conclusion of this study is that a large portion of the variations in Coco spreads remains unexplained. One can argue that since the examined time period does not contain a financial crisis, Cocos might not yet have been put to the test in their ability to protect banks. This further explains why our variables still have such a low explanatory power, especially in the case of the liquidity premium. Annaert *et al.* (2013) find that there are significant differences in drivers of CDS spreads for a pre-crisis period and a period covering a crisis, but since the first Coco bonds were issued after the recent global financial crisis, such an analysis has not been performed in this paper. A direction for future work could therefore be to assess the time variations in determinants of Coco spreads.

Furthermore, it could be of interest to examine if there are any differences in drivers in terms of which country/jurisdiction the issuer is incorporated in. However, this requires a sample that includes Cocos issued in different countries but with same ratings and regulatory capital designation, so that differences can be correctly identified. This was not the case in our sample, and can therefore be a proposal for future research.

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9 Appendix

9.1 Contingent Convertibles in Sample

Table VI
List of firms issued Cocos (in sample)

	Bloomberg ID	ISO	Coupon	Curncy	Loss Mech.	Trigger Type	Rating
Aareal Bank AG	EK6004999	DE	7.625	EUR	Temporary Write Down	Additional Tier 1	BB-
Bank of Ireland	EK9643603	IE	7.375	EUR	Temporary Write Down	Additional Tier 1	N/A
Barclays Bank PLC	EJ4436212	GB	7.625	USD	Permanent Write Down	Tier 2	BBB-
Barclays Bank PLC	EJ6192706	GB	7.75	USD	Permanent Write Down	Tier 2	BBB-
BNP Paribas SA	UV5159024	FR	7.375	USD	Temporary Write Down	Additional Tier 1	BBB-
BNP Paribas SA	EK9617466	FR	6.125	EUR	Temporary Write Down	Additional Tier 1	BBB-
BNP Paribas SA	UV4825039	FR	7.375	USD	Temporary Write Down	Additional Tier 1	BBB-
Credit Agricole SA	JV6342804	FR	8.125	USD	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	EK1579516	FR	6.5	EUR	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	EK0315516	FR	7.875	USD	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	EK4903242	FR	6.625	USD	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	EK1580118	FR	7.5	GBP	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	JV6109195	FR	8.125	USD	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	EK0271495	FR	7.875	USD	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	EK4886967	FR	6.625	USD	Temporary Write Down	Additional Tier 1	BB+
Credit Agricole SA	EJ8346847	FR	8.125	USD	Permanent Write Down	Tier 2	BBB-
Credit Suisse AG	EJ7790151	CH	6.5	USD	Permanent Write Down	Tier 2	BBB+
Credit Suisse AG	EJ8189684	CH	5.75	EUR	Permanent Write Down	Tier 2	BBB+
Credit Suisse AG	EJ7700317	CH	6.5	USD	Permanent Write Down	Tier 2	BBB+
Credit Suisse Group AG	EK3302669	CH	6.25	USD	Permanent Write Down	Additional Tier 1	BB+
Credit Suisse Group AG	EJ9764584	CH	7.5	USD	Permanent Write Down	Additional Tier 1	BB+
Credit Suisse Group AG	EJ8002895	CH	6	CHF	Permanent Write Down	Additional Tier 1	BB+
Credit Suisse Group AG	EK3272664	CH	6.25	USD	Permanent Write Down	Additional Tier 1	BB+
Credit Suisse Group AG	EJ9694864	CH	7.5	USD	Permanent Write Down	Additional Tier 1	BB+
Danske Bank A/S	EK0985227	DK	5.75	EUR	Temporary Write Down	Additional Tier 1	BB+
Danske Bank A/S	EK7502777	DK	5.875	EUR	Temporary Write Down	Additional Tier 1	BB+
Deutsche Bank AG	EK2481985	DE	6	EUR	Temporary Write Down	Additional Tier 1	BB
Deutsche Bank AG	EK5892527	DE	7.5	USD	Temporary Write Down	Additional Tier 1	BB
Deutsche Bank AG	EK2626407	DE	6.25	USD	Temporary Write Down	Additional Tier 1	BB
Deutsche Bank AG	EK2625987	DE	7.125	GBP	Temporary Write Down	Additional Tier 1	BB
DNB Bank ASA	EK8007495	NO	5.75	USD	Temporary Write Down	Additional Tier 1	N/A
DNB Bank ASA	EK7560569	NO	4.32	NOK	Permanent Write Down	Additional Tier 1	N/A
Intesa Sanpaolo SpA	JV5948148	IT	7	EUR	Temporary Write Down	Additional Tier 1	BB-
Intesa Sanpaolo SpA	UV8549403	IT	7.7	USD	Temporary Write Down	Additional Tier 1	BB-
Intesa Sanpaolo SpA	EI4166043	IT	9.5	EUR	Temporary Write Down	Additional Tier 1	BB
Julius Baer Group Ltd	QJ2754621	CH	5.9	SGD	Permanent Write Down	Additional Tier 1	N/A
Julius Baer Group Ltd	EJ3605734	CH	5.375	CHF	Permanent Write Down	Additional Tier 1	N/A
Julius Baer Group Ltd	EK2882950	CH	4.25	CHF	Permanent Write Down	Additional Tier 1	N/A

	Bloomberg ID	ISO	Coupon	Curncy	Loss Mech.	Trigger Type	Rating
KBC Bank NV	EJ5207356	BE	8	USD	Permanent Write Down	Tier 2	N/A
KBC Bank NV	EJ5207356	BE	8	USD	Permanent Write Down	Tier 2	N/A
KBC Groep NV	EK1255174	BE	5.625	EUR	Temporary Write Down	Additional Tier 1	BB
Nordea Bank AB	EK4995529	SE	5.5	USD	Temporary Write Down	Additional Tier 1	BBB
Nordea Bank AB	EK7825129	SE	5.25	USD	Temporary Write Down	Additional Tier 1	BBB
Nordea Bank AB	EK4995644	SE	6.125	USD	Temporary Write Down	Additional Tier 1	BBB
Nordea Bank AB	EK7825665	SE	2.632	SEK	Temporary Write Down	Additional Tier 1	BBB
Nordea Bank AB	EK7826028	SE	4.12	NOK	Temporary Write Down	Additional Tier 1	BBB
Nordea Bank AB	EK4978541	SE	6.125	USD	Temporary Write Down	Additional Tier 1	BBB
Nordea Bank AB	EK4978723	SE	5.5	USD	Temporary Write Down	Additional Tier 1	BBB
Santander UK Group Holdings PLC	EK9552192	ES	7.375	GBP	Permanent Write Down	Additional Tier 1	BB+
Skandinaviska Enskilda Banken AB	EK5793428	SE	5.75	USD	Temporary Write Down	Additional Tier 1	BBB-
Societe Generale SA	EK1447227	FR	6.75	EUR	Temporary Write Down	Additional Tier 1	BB+
Societe Generale SA	EK3458065	FR	6	USD	Temporary Write Down	Additional Tier 1	BB+
Societe Generale SA	EJ7987732	FR	8.25	USD	Temporary Write Down	Additional Tier 1	BB+
Societe Generale SA	UV9578161	FR	8	USD	Temporary Write Down	Additional Tier 1	N/A
Societe Generale SA	EJ9813381	FR	7.875	USD	Temporary Write Down	Additional Tier 1	BB+
Societe Generale SA	UV9429258	FR	8	USD	Temporary Write Down	Additional Tier 1	N/A
Societe Generale SA	EK3444263	FR	6	USD	Temporary Write Down	Additional Tier 1	BB+
Societe Generale SA	EJ9873484	FR	7.875	USD	Temporary Write Down	Additional Tier 1	BB+
Svenska Handelsbanken AB	EK7554448	SE	5.25	USD	Temporary Write Down	Additional Tier 1	BBB
UBS AG	EK2649458	CH	5.125	USD	Permanent Write Down	Tier 2	BBB+
UBS AG	EJ6796167	CH	4.75	USD	Permanent Write Down	Tier 2	BBB+
UBS AG	EK0631110	CH	4.75	EUR	Permanent Write Down	Tier 2	BBB+
UBS AG/Jersey	EJ0327852	CH	7.25	USD	Permanent Write Down	Tier 2	BBB+
UBS AG/Stamford CT	EJ3190901	CH	7.625	USD	Permanent Write Down	Tier 2	BBB+
UBS Group AG	UV4180070	CH	6.875	USD	Permanent Write Down	Additional Tier 1	BB+
UBS Group AG	EK7554505	CH	7.125	USD	Permanent Write Down	Additional Tier 1	BB+
UBS Group AG	EK7554620	CH	7	USD	Permanent Write Down	Additional Tier 1	BB+
UBS Group AG	EK7554927	CH	5.75	EUR	Permanent Write Down	Additional Tier 1	BB+
UniCredit SpA	EK1429340	IT	8.00	USD	Temporary Write Down	Additional Tier 1	BB-
UniCredit SpA	EK4609047	IT	6.75	EUR	Temporary Write Down	Additional Tier 1	BB-
UniCredit SpA	EI3245954	IT	9.375	EUR	Temporary Write Down	Additional Tier 1	BB

9.2 Endogenous test for Selection Bias

Table VII
Logit Regression for selection bias

	Equity Volatility	Leverage	Bid-ask spread	Term structure slope	Market Volatility
(1)	0.0055 (0.10)				
(2)		-0.5163 (-0.93)			
(3)			-1.9659 (-0.16)		
(4)				-49.9640 (-1.06)	
(5)					0.7106 (1.07)
(6)	-0.0050 (-0.08)	-0.1823 (-0.23)	-2.8065 (-0.21)	-18.1131 (-0.33)	0.5103 (0.54)

The table reports the results from univariate logit regressions (1) to (5), and multivariate regression (6). Z-statistics are reported in the parenthesis. The equity volatility is the daily change in implied volatility for the underlying bank (in percentage points). Leverage is the daily bank stock return (in percentage points). The bid-ask spread is the daily change in the difference between the ask and the bid price of the Coco bond (measured in percentage points). The term structure slope is the daily change in the difference between the 10 year and the 5 year government bond in the issuing currency of the Coco (in percentage points). Finally, the market volatility is computed based on the daily change in VSTOXX index (in percentage points).

9.3 Variance Inflation Factor test

Table VIII
Variance Inflation Matrix

	VIF	1/VIF
Equity Volatility	1.63	0.6124
Leverage	1.55	0.6440
Bid-ask spread	1.10	0.9063
Term Structure	1.03	0.9717
Market Volatility	1.00	0.9992
Mean VIF	1.26	

The table reports the Variance inflation factor (VIF) for the explanatory variables. The equity volatility is the daily change in implied volatility for the underlying bank (in percentage points). Leverage is the daily bank stock return (in percentage points). The bid-ask spread is the daily change in the difference between the ask and the bid price of the Coco bond (measured in percentage points). The term structure slope is the daily change in the difference between the 10 year and the 5 year government bond in the issuing currency of the Coco (in percentage points). Finally, the market volatility is computed based on the daily change in VSTOXX index (in percentage points).