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The Information Content in Contingent Convertible Bond Prices

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Abstract

Credit institutions are to an increasing extent using Contingent Convertible Bonds (CoCos) to meet part of their capital requirements, which could suggest that the market for CoCos contains useful information on the robustness of the issuer. This paper gives a thorough introduction to CoCos – the product, its use in capital regulation, the market and the specific risks faced by investors. To illustrate which information potentially can be extracted from the price level and change in prices of CoCos, we introduce models which incorporate most of the characteristics and risks of CoCos. The models illustrate how the complexity of CoCos makes them difficult to use when assessing the soundness of the issuer; in addition to this the many CoCo-specific risks make it questionable whether the cost of CoCos constitutes a lower bound for the cost of equity.

Resume

Kreditinstitutter benytter i stigende omfang Contingent Convertible Bonds (CoCo'er) til at opfylde en andel af deres kapitalkrav, hvilket kan gøre markedet for CoCo'er interessant i forhold til at udlede information om institutternes robusthed. Denne artikel giver en grundig introduktion til CoCo'er – produktet, dets brug i reguleringen, markedet og de specifikke risici, som investorerne står overfor. Til at illustrere, hvilken information der potentielt kan udledes af CoCo'ernes prisniveau og -ændringer, benytter vi modeller, som inkorporerer de fleste af CoCo'ernes karakteristika og indbyggede risici. Modellerne illustrerer, hvordan kompleksiteten i produktet gør det svært at bruge CoCo'er til at udlede information om udstederens finansielle tilstand, ligesom de mange CoCo-specifikke risici gør det usikkert, om prisen på CoCo'er udgør en nedre grænse for prisen på egenkapital.

Key words
Financial regulation; Financial stability; Financial sector; Financial risks; Models

JEL classification
G01; G12; G21; G23; G28; G32

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The Information Content in Contingent Convertible Bond Prices

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Abstract

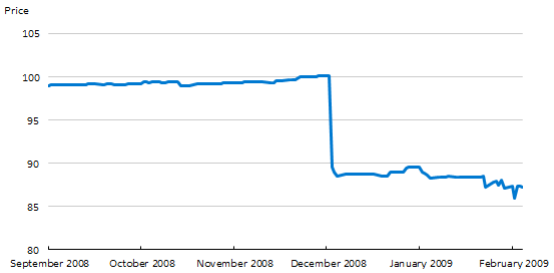
Contingent Convertible Bonds (CoCos) can potentially contain valuable information on the soundness of the issuer - this makes them interesting from a monitoring perspective. To extract information from CoCos we go above and beyond many papers in the literature and use pricing models that incorporate many of the risks embedded in CoCos traded in the market. However, we show that the information extraction is rather difficult due to the complexity of the product, liquidity issues, and an unstandardised market. Further, we question whether the cost of CoCos constitutes a lower bound for the cost of equity. As a starting point, the paper provides an introduction to Contingent Convertible Bonds with illustrations using CoCos issued by European banks.

1 Why CoCos are interesting

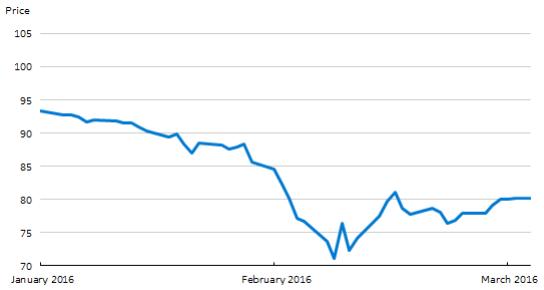
One important lesson from the financial crisis was that banks needed to use both more capital and capital of a higher quality to fund their assets.[1] Much of the regulation that followed the crisis, e.g. CRD IV in Europe, has sought to address this. One aspect of the new regulation is that European banks are now allowed to fulfil part of their capital requirements with so-called Additional Tier 1 (AT1) instruments. AT1 instruments are meant to be loss-absorbing when the bank is going concern and are synonymous with Contingent Convertible bonds (CoCos) if these satisfy certain requirements (to be expanded on later). A CoCo is a hybrid debt instrument with a principal that can be written down or converted into equity as well as discretionary coupons and no fixed maturity. CoCos reduce the probability of a bankruptcy and the need for a public bail-out if a bank becomes distressed but can also change incentives, see e.g. Pennacchi (2010), Berg and Kaserer (2015) and Chan and Van Wijnbergen (2016).

[1] Quality refers to the states of the world where the capital can absorb losses. High-quality capital, such as equity, can absorb losses in a going-concern situation, i.e. before the bank defaults.

Figure 1.1: Deutsche Bank Contingent Convertible Bonds.



(a) Tier 2 paper that did not get called at first call date.



(b) AT1 CoCo when investors feared for a cancellation of coupon payments.

Note: Subordinated (ISIN: DE0003933511) and jr. subordinated (ISIN: DE000DB7XHP3) debt issued by Deutsche Bank.
Source: Bloomberg.

This paper investigates the information which potentially can be derived from the market prices of CoCos. As CoCos are complex products and their prices can be affected by features such as conversion of the principal, cancellation of the coupons and extension of the maturity, we go above and beyond many papers in the literature and model CoCo prices using pricing models that incorporate these features.[2] The hybrid nature of CoCos and the growing market of more than 120 billion euro in 2016 imply that, in principle, useful information concerning financial market participants' views on the soundness of banks can be extracted from CoCo prices. As an example, one can consider the price evolution of two CoCos issued by Deutsche Bank in Figure 1.1. In December 2008, the extension of an outstanding CoCo led to a sharp price decrease (left chart), while fears over whether or not coupons would be paid during early 2016 also led to a major price correction in the price of Deutsche Bank's outstanding CoCos (right chart). An additional advantage of CoCos is that they can provide a market view on unlisted banks. However, given the complexity and heterogeneity of CoCos, one must have a good understanding of CoCo-specific features before trying to extract this information. This paper first gives an introduction to CoCos: What is a CoCo, why are banks issuing these complicated contracts and who is buying them? Then different approaches are used to illustrate the difficulties in information gathering from CoCos. Last, we look into whether or not the cost of CoCos can be used as a lower bound for the cost of equity.

[2]Other papers that consider the pricing of CoCos typically focus on specific parts of the contract, see e.g. Spiegeleer and Schoutens (2012), De Spiegeleer and Schoutens (2014), Corcuera et al. (2013) and Corcuera et al. (2014). Note that the literature often focuses on CoCos with stock price triggers, but that such a thing does not exist and it would not qualify as AT1 capital under the current regulation.

2 The defining characteristics and embedded risks of CoCos

A CoCo is a hybrid debt instrument that can absorb losses in certain states of the world. CoCos can qualify as AT1 capital if they meet certain criteria which enables them to absorb losses even in a going-concern situation.[3] Since the implementation of CRD IV in 2014, almost all CoCo issuances have been on a form that made them eligible for AT1 capital.[4] For this reason, the rest of the paper will only focus on AT1-eligible CoCos, and therefore we use the terms AT1 instruments and CoCos interchangeably for the remainder of the paper.

The three most important CoCo features are:

- **Loss-absorbing capabilities of the principal**: If the capitalisation of the issuer reaches a certain level (the "trigger level"), the principal will either be converted into equity[5] or written-down[6]. For a CoCo to qualify as an AT1 instrument, it must have a trigger when CET1 reaches 5.125 per cent of risk-weighted assets (or higher). In addition to this, conversion or write-down can also take place when the regulator deems that the issuer has reached the "point of non-viability" (PONV) where AT1 instruments are subject to bail-in. In principle, the PONV can be reached before the trigger.[7] From an investor perspective, the relevant risks relate to the probability of conversion/write-down and the loss upon conversion/write-down - which can be rather difficult to pin down as there is some regulatory discretion attached to whether or not these risks will materialise.

- **Treatment of the coupons**: The coupon payments of AT1 instruments are fully discretionary, and issuers are only allowed to pay coupons in full if they have available distributable items (ADI) and surplus capital relative to the buffer requirements (maximum distributable amount, MDA[8]). From an investor perspective, the relevant risks relate to whether an issuer will be forced to suspend coupon payments (i.e. the level of ADI and/or MDA) as well as discretionary incidents such as an issuer deciding to voluntarily suspend coupon payments.

[3] See Table A.1 in the Appendix for an overview of the most important of the minimum requirements that CoCos will need to meet in order to qualify as AT1 instruments.

[4] According to data from Bloomberg, around 94 per cent of all European CoCo issuances have qualified for Tier 1 capital since 2014.

[5] The equity conversion can be at a contract specific ratio or use the prevailing market price of equity.

[6] The write-down can be either permanent or temporary, full or partial.

[7] In support of this is the fact that the ECB is using 5.5 per cent of RWA as a hurdle rate for their stress tests and that the minimal CET1 requirement is in fact 7 per cent of RWA (the sum of the Pillar 1 CET1 requirement of 4.5 per cent and the CCB-requirement of 2.5 per cent).

[8] If the combined buffer requirement is not satisfied, MDA sets a limit on how much profits in a particular year may be distributed as dividends, AT1 coupons and bonuses.

Table 2.1: Main risks faced by CoCo investors.

Risk	**When does the risk materialise?**	**Type of product if the risk materialises**
Principal absorbs loss	• If CET1-ratio hits trigger or • if supervisor deems that PONV has been reached	• Principal write-down: Bond with haircut • Equity conversion: Equity
Coupon cancellation	• If MDA or ADI restriction binds, • if issuer decides not to pay coupons, or • if supervisor restricts issuer from paying coupons	• Zero-coupon bond
Extension	• If issuer decides not to call, or • if supervisor does not allow issuer to call	• Bond with longer maturity (potentially infinite)

- **Maturity**: AT1 instruments are required to be perpetual, but - conditional on regulatory approval - they are allowed to be called by the issuer from 5 years after issue.[9] The issuer must have no incentive to redeem, and redemption can only take place after regulatory approval. On the call date, the CoCo coupons are reset to the original spread, and therefore the issuer will only have an incentive to extend the CoCo if they would have to pay a higher spread on a new issue than the one already outstanding or is unable to attract new funding. This implies that investors typically prefer the CoCo to be called at the first call date, cf. the sharp price reaction in Figure 1.1(a). In practice, there is also some reputational risk. If a bank has voluntarily extended a CoCo in the past, it is also likely to do so in the future, and therefore any new issues would be at a higher cost.

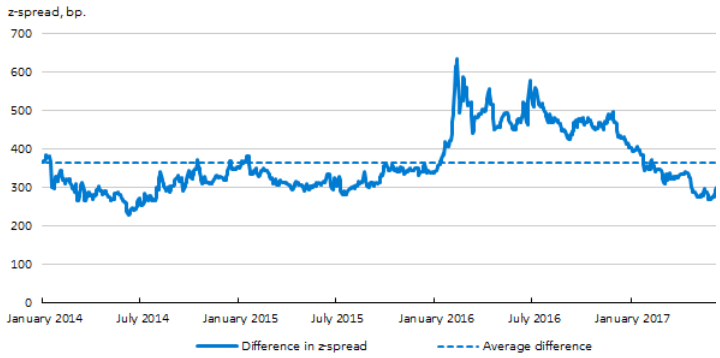
These main features are summarized in Table 2.1 and imply that AT1 instruments, unlike other types of (bail-inable) debt, can absorb losses in a going-concern state of the world as coupon payments can be suspended and the principal can absorb losses before the issuer reaches the point of non-viability. Therefore, AT1 instruments are more risky than e.g. Tier 2 capital, and investors price CoCos with a substantial premium compared to Tier 2 instruments, cf. Figure 2.1.

This premium should (besides the seniority order) reflect the CoCo-specific risks relating to the contractual features described above and can be summarized as:

- Will the coupon payments be suspended?

[9] Contracts may also include a possibility to call if the regulation or tax treatment is changed, e.g. if the instrument no longer qualifies as AT1.

Figure 2.1: Difference in z-spread between CoCos and Tier 2 bonds.



Note: The chart shows the average difference in z-spread between AT1 CoCos and Tier 2 bonds issued by Danske Bank, Nykredit Realkredit, Deutsche Bank, Swedbank, Barclays, Lloyds, HSBC and Societe Generale.
Source: Bloomberg and own calculations.

- Will the principal be converted or written down and what will the loss be upon conversion/write-down?

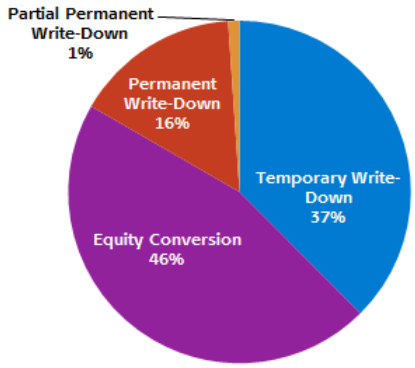
- Will the CoCo be called at the first call-date or be extended?

2.1 One must be aware of contractual and legal differences

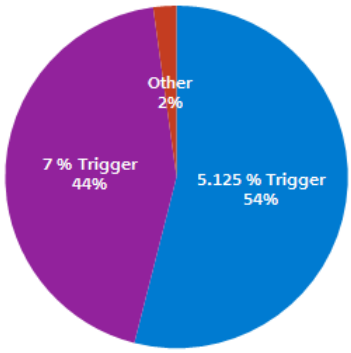
When investors are buying a CoCo, they are essentially buying a bond that risks conversion, where coupon payments may be cancelled and the maturity might be perpetual. The probability of these risks materializing depends on many factors, among others the actions of the national regulators as they ultimately can decide whether or not the point of non-viability has been reached and whether or not a bank is allowed to call a CoCo issue or pay coupons. That is, investors are buying a product with many embedded options and some regulatory discretion, which makes their pricing very complex. Consequently, it is difficult to determine what gives rise to a change in the price of a CoCo. In addition to this, there are currently no market standards for how to set the trigger level and what will happen upon hitting the trigger, which have resulted in a market for CoCos that is far from standardised, cf. Figure 2.2. From an investor's perspective, this adds to the complexity of CoCos as each CoCo should be evaluated considering its specific characteristics.[10] To add even more complexity, there can also be differences between jurisdictions on how e.g. the available distributable items (ADI) or the maximum distributable amount (MDA) are calculated,

[10] In line with this, many investors call for a standardisation of the market according to Gallo et al. (2014). Standardisation and simplicity are also highlighted by the European Banking Authority as desirable features of CoCo issuances in their 2016 report on AT1 instruments of EU institutions.

Figure 2.2: The outstanding AT1 CoCos by loss mechanism and trigger.



(a) AT1 market by loss mechanism, value-weighted



(b) AT1 Market by group trigger, value-weighted

Note: The sample contains issues of AT1 CoCos by European banks from 2012 to 2016.
Source: Bloomberg.

which will have an impact on when a bank is allowed to pay CoCo coupons.[11]

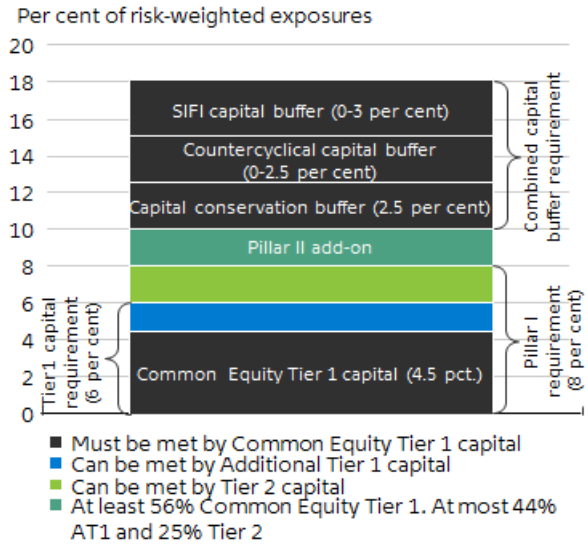
The point is that before interpreting changes and the level of yields on CoCos one needs to have a good understanding of the legal framework as well as the contractual features (that can differ greatly, cf. Figure 2.2) of the exact CoCo in question.

3 The market for CoCos

The increase in outstanding CoCos and their hybrid nature make the market for CoCos a good alternative to e.g. the market for equities and more conventional types of debt to gather information on the view that financial market participants have on the CoCo issuers. In the case of non-listed financial institutions, e.g. Nykredit Realkredit a non-listed Danish SIFI, their CoCo issuances are the only publicly traded instruments that can absorb losses in a going-concern situation. This

[11] As an example of this, one can consider the CoCos issued by Deutsche Bank. During the beginning of 2016, where financial markets generally were quite volatile and bank shares in particular performed poorly, the CoCos issued by Deutsche Bank fell far more in value than CoCos issued by big banks in other jurisdictions. One of the reasons for this appears to have been that investors feared that the CoCo coupons had to be cancelled due to strict German accounting standards that results in a more conservative view on cash flows and therefore a lower ADI. That is, the extra price decrease compared to other CoCos was not (necessarily) due to a worsening of the Deutsche Bank outlook, but could be driven by a higher probability of a coupon cancellation due to stricter German accounting standards. Another example involves CoCos issued by Danish banks. According to the implementation of the CRD IV Directive in Denmark, the Pillar 2 add-on should not be taken into account when calculating the MDA. This implies that the level of capitalisation at which automatic restrictions on discretionary payments will occur is lower than in e.g. Eurozone countries. All else equal, this should give a higher probability of a Danish bank being able to pay coupons on a CoCo relative to a Eurozone bank. However, if a Danish bank breaches the combined buffer requirement (including the Pillar 2 add-on), the bank must submit a capital conservation plan for approval by the Danish FSA. On the basis of this, the Danish FSA can choose to restrict discretionary payments, including coupons on AT1 instruments. This suggests that the difference in practice can be rather small.

Figure 3.1: Capital requirements under CRD IV/CRR.



Note: The requirements will only be fully phased in by 2019. There can be minor national differences, e.g. in Denmark, the Pillar II add-on sits on top of the combined buffer requirement, and it is not used in the MDA calculation.

implies that their CoCo issuances can possibly provide market information that is not otherwise accessible.

In this section, the supply, demand and liquidity of CoCos will briefly be introduced, as these are all relevant factors to consider when interpreting the information from CoCo prices.

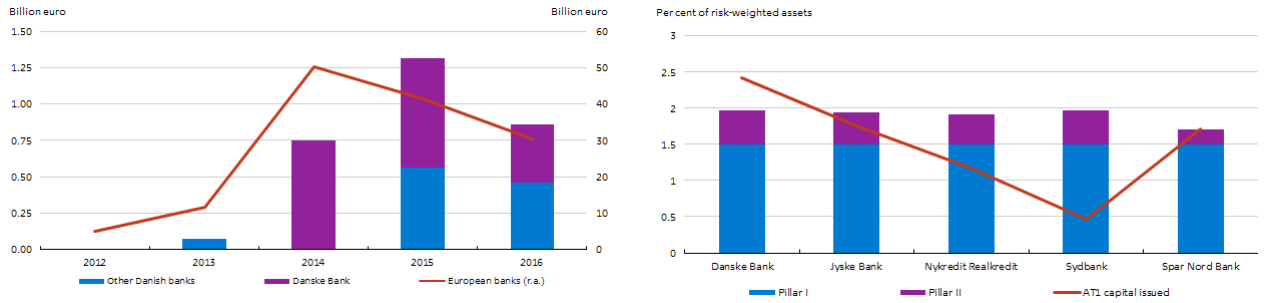
3.1 Supply: Why do banks issue Contingent Convertible Bonds?

When fully phased in by 2019, the requirements in CRD IV / CRR stipulate that credit institutions in the EU will be faced with the capital requirements in Figure 3.1.[12] All parts of the capital requirements in Figure 3.1 can be met with Common Equity Tier 1 (CET1), i.e. mainly equity and retained earnings, which is fully loss-absorbing in a going-concern situation. However, CRD IV / CRR allows for part of the Pillar I and II capital requirements to be met with Additional Tier 1 (AT1) capital. In total, banks are allowed to fulfil up to 44 per cent of their Pillar I and II requirements with AT1, of which 25 percentage points can be met with Tier II capital. Since Tier II is generally cheaper to issue than AT1, cf. Figure 2.1, banks have an incentive to meet up to 19 per cent of their Pillar I and II requirements with AT1 instruments.[13] Since CoCos are

[12] There can, however, be minor national differences relating to e.g. the order of the requirements.

[13] If the difference is only due to Tier II issuances having higher seniority, substituting AT1 instruments for Tier II instruments might not impact the weighted average cost of capital for a bank, cf. Modigliani-Miller theorem.

Figure 3.2: CoCo issuances.



(a) Issuance of AT1 CoCos in Denmark and Europe.

(b) AT1 CoCo issuances of selected Danish banks.

Note: The Pillar I requirement that can be met with AT1 capital constitutes 1.5 per cent of RWA, it can be regarded as a lower limit for the amount of CoCos that Danish banks have an incentive to issue. The sum of the Pillar I and Pillar II bars can be regarded as the amount of AT1 capital Danish banks have an incentive to issue. Note that the Pillar II requirement can fluctuate over time and that banks have an incentive to meet 19 per cent of it with AT1 capital. The Pillar II requirements in the chart are as of 3rd quarter 2017.
Source: SNL and Bloomberg.

fixed-income instruments in good times and equity-like instruments in bad times, they allow issuers to reap both the benefits of coupon tax deductibility and loss absorption. This suggests that banks have a rather strong incentive to use CoCos to meet the part of their capital requirements where they are allowed to use AT1-eligible CoCos.[14] In addition, AT1 instruments can also be used to comply with a possible leverage ratio requirement.[15]

For these reasons, several European banks have in 2014-2016 issued CoCos with a total value of almost 138 billion euros, cf. Figure 3.2(a). Also Danish banks have made sizeable issues of almost 3 billion euros. In Denmark, Danske Bank has by far been the biggest issuer of CoCos. However, other banks, such as Nykredit, Jyske Bank and Spar Nord, have also made sizeable CoCo issuances. In Figure 3.2(b), actual issuances of Danish banks are compared with their capital requirements. As of third quarter 2017, two banks have issued more AT1 capital than the sum of the 1.5 per cent of RWA and 19 per cent of their individual Pillar II requirements, while three banks have issued more AT1 capital than 1.5 per cent of their RWA. It therefore appears that most Danish banks are actively using CoCo issuances to obtain their desired capital structure.[16]

However, other factors, such as liquidity and regulatory discretion, probably imply that the credit risk-adjusted required rate of return on AT1 instruments are higher than Tier II instruments.

[14]The incentives of course depend on whether the required after-tax return on CoCos is lower than the cost of equity. This will be discussed further in Section 4.2.

[15]The European Parliament has proposed a 3 per cent leverage ratio requirement which can be fulfilled with Tier1 capital, i.e. equity and AT1 instruments.

[16]In line with this most Danish banks have in their annual reports stated that their target capital ratios are between 3.5 and 5 percentage points higher than their target CET1 ratio. Assuming that 2 percentage points will be filled with Tier II capital, Danish banks have AT1 targets of around 1.5 to 3 per cent of RWA.

3.2 Demand: Who invests in CoCos and why?

CoCos are OTC products, and information on investors is therefore rather scarce. However, for Danish CoCo issues, it is possible to distinguish between Danish investors as well as some of the foreign investors, although around 40 per cent of the investor base is unaccounted for, cf. Figure 3.3. Although households and non-financial companies own some of the outstanding CoCos, it is primarily large-scale investors as asset managers and, to some extent, insurance firms and pension companies that are the end-investors. This suggests that first-round losses upon the triggering of a CoCo primarily will be placed outside the banking sector, which should be beneficial for financial stability.

In general, it appears that investors primarily buy CoCos due to the relatively high yield they offer. According to a survey from 2014 (see Gallo et al. (2014)) almost 70 per cent of the respondents said they bought CoCos due to the high yield. The respondents also mentioned that they believe conversion is unlikely. In addition, investors mentioned that they are buying CoCos due to a lack of alternatives, which could suggest that the investor interest for CoCos is a "search for yield" phenomenon.

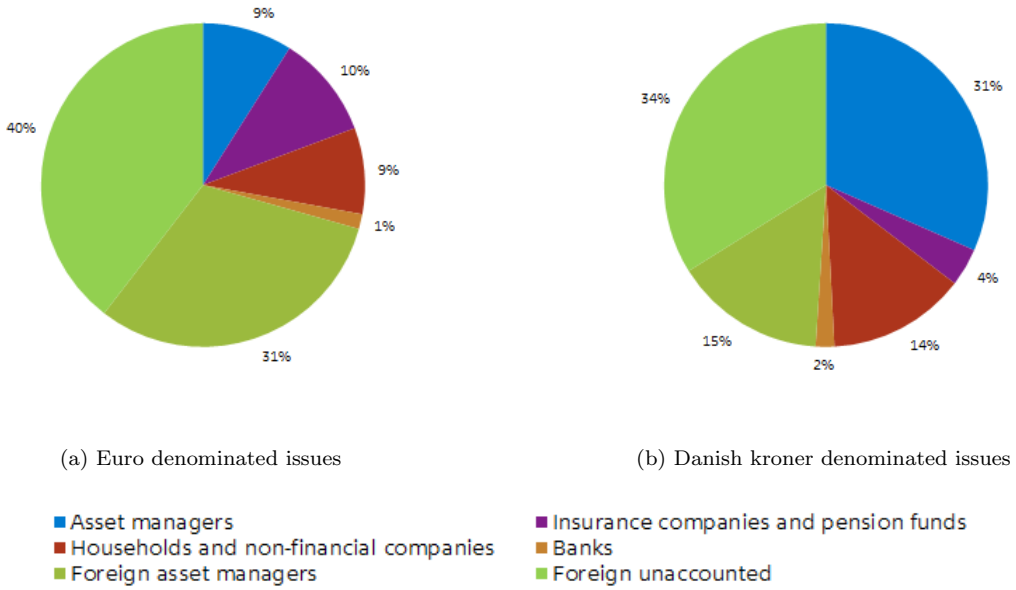
3.3 Liquidity

One of the main caveats (besides the complexity) when it comes to CoCos and the potential for extracting information from their prices is their liquidity. In the first quarter of 2016 CoCo prices experienced large fluctuations, the market basically froze and investors could only sell at a large discount. A lack of liquidity leads to a (possibly time-varying) liquidity premium which is reflected in the price.

The textbook definition of a liquid market is that investors should be able to trade at any time and with a minimum of price impact. An analysis should therefore consider the two dimensions of liquidity: availability and impact. One measure that seeks to take both of these aspects into account is the "liquidity score" from Bloomberg. The measure is relative to the entire bond market, i.e. the score will decrease for a given bond if the liquidity of that bond deteriorates relative to the market, but it will not necessarily decrease if the liquidity of the entire market deteriorates. By looking at five CoCo issuances by Danske Bank (2), Nykredit (1), Deutsche Bank (1) and Nordea (1) as well as three higher ranking debt issuances by Danske Bank (2) and Nordea (1), it appears that the liquidity of CoCos is markedly poorer than that of more senior debt issuances, cf. Figure 3.4(a).[17]

[17] All issuances except one CoCo issuance are in euros and are around 0.5 to 1.5 billion euros, with the exception of a Deutsche Bank issuance of around 3.5 billion euros.

Figure 3.3: Investor base in a sample of CoCos issued by Danish banks.



(a) Euro denominated issues

(b) Danish kroner denominated issues

Note: The figure shows the value-weighted investor base for 5 CoCo issuances by Danske Bank (3), Nykredit (1) and Spar Nord (1) as of November 2016. Based on data from Bloomberg, part of the foreign investors has been categorised as foreign asset managers. In principle, domestic investors (e.g. insurance companies and pension funds) could have invested indirectly in CoCos through these foreign asset managers, something we have not attempted to correct for.
Source: Danmarks Nationalbank, Bloomberg.

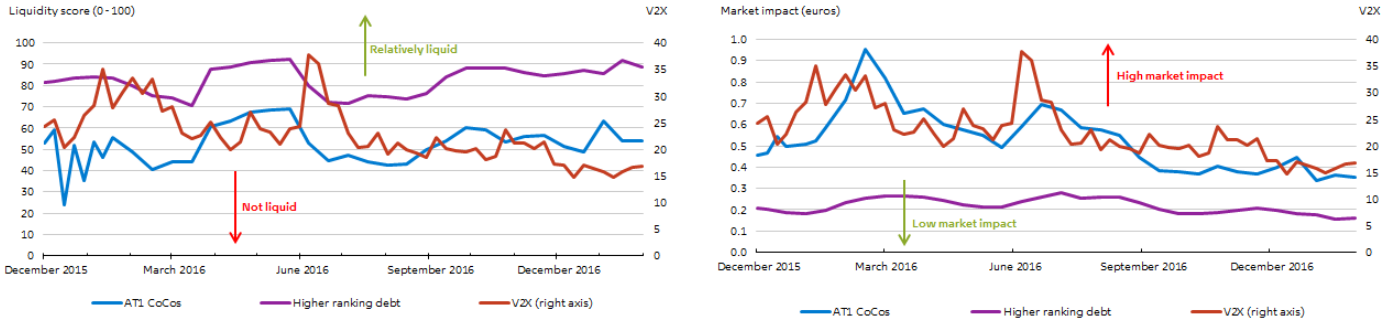
This also applies when looking at liquidity in absolute (and not relative) terms, as measured by the market impact of a given trade, cf. Figure 3.4(b). In addition to this, it also appears that the liquidity of CoCos tends to decrease considerably when market uncertainty is increasing (measured as when the V2X spikes[18]). These findings indicate that a potentially large liquidity premium is embedded in the yield of CoCos and that this liquidity premium will increase when there is financial market turmoil, which is likely to be when one wants to be able to infer how the market perceives the robustness of a given bank.

4 Can information be extracted from the pricing of CoCos? Some simple applications

The previous sections discussed different types of risks embedded in CoCos. First, this section introduces some simple pricing models which embed some of these risks. The purpose is to inves-

[18] V2X is the volatility index of the Stoxx Europe 50, i.e. the Euro area version of the VIX index.

Figure 3.4: Liquidity measures for AT1 instruments and higher ranking debt instruments.



(a) Liquidity (relative liquidity measure)

(b) Market impact (absolute liquidity measure)

Note: Data from Bloombergs "Liquidity assessment" has been used to extract a liquidity score, ranging from 0 to 100, which gives an indication the liquidity of a bond relative to other bonds in Bloombergs sample (with 100 being the most liquid) as well as the estimated trading cost for trading 0.5 million euros of a given bond. Data has been extracted for 5 AT1 instruments issued by Danske Bank (2), Nykredit Realkredit (1), Deutsche Bank (1) and Nordea (1) as well as data for 3 more senior debt issuances (2 senior unsecured and 1 covered bond) from Danske Bank (2) and Nordea (1). Only the mean is illustrated.
Source: Bloomberg.

tigate whether CoCo price *movements* contain useful and easily interpretable information on the market's view of the robustness of the issuer. Secondly, we will discuss whether or not the yield on CoCos (i.e. the price *level*) can be used to approximate a lower bound for the investors' required return on equity for a given bank.

4.1 Interpreting price changes in CoCos

This section serves to illustrate how the complex nature of CoCos, which leads to many embedded risks, makes information extraction difficult. This is first done using an options pricing model, which illustrates how the CoCo price can be expected to react to changes in some specific risks, such as changes in CET1 ratios, asset volatility and when a bank becomes non-viable. Second, a simple simulation approach is used to study the correlation between the prices on a CoCo and shares issued by the same issuer. The idea is that as a bank becomes less capitalized CoCos should become more equity-like, in which case a higher correlation could be observed. Both models illustrate how changes in prices and correlations can be driven by other factors than those directly related to e.g. the robustness of a bank, e.g. illustrating how one should be cautious when interpreting on price movements.

4.1.1 Option model

To illustrate the price reactions from a theoretical perspective, we use the options pricing model by Corcuera et al. (2014). The model takes a starting point in the notion that the CoCo can be approximated by a long position in a default free bond and short positions in barrier options subtracting any cancelled coupons and the principal if the trigger is reached. The stock price is assumed to follow a Geometric Brownian Motion (GBM), and an equity trigger is used, i.e. when the stock price falls to a specific value, the CoCo is converted or written down. The equity trigger makes it possible to price CoCos with a conversion feature since the stock price is known at the trigger point. Unfortunately, no outstanding CoCo has an equity trigger. Therefore, we make a small departure from the original model and let the underlying GBM process be the asset process and likewise define the trigger point as a critical asset value corresponding to a critical CET1 ratio. Consequently, we focus on write-down CoCos. The model incorporates the possibility of cancelled coupons and a trigger event but it does not consider the extension risk (which can be modelled as an additional embedded option as noticed and described in e.g. Corcuera et al. (2016)).

The regulatory discretion and the discontinuous observation of the CET1 ratio make the distance to the trigger and the point of coupon cancellation uncertain. Figure 4.1 illustrates four different scenarios where different input parameters/risks are changed.

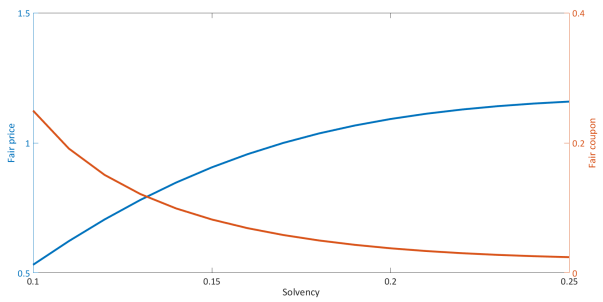
(a) If the *solvency ratio* is changed, the distance to both the trigger and to the point of coupon cancellation will change, which will impact the expected cash-flows and thereby the price (or equivalently the yield-to-call). A higher solvency ratio reduces the probability of a loss of either coupons or principal, which increases the price.

(b) If the *asset volatility* is changed, the probability of a coupon cancellation and trigger event will change. A higher asset volatility increases the risk of a loss of coupon and/or principal, which reduces the price.[19]

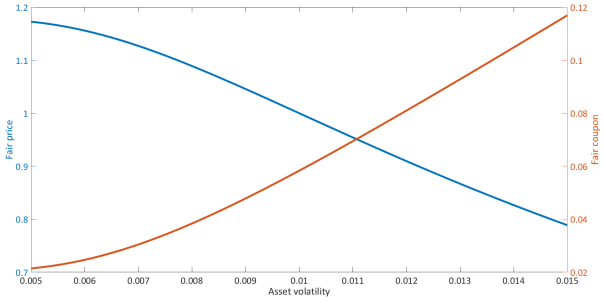
(c) If the *CET1 ratio at which coupons will be cancelled* changes, the probability of coupon cancellation changes. The higher the CET1 ratio at which coupon cancellation is perceived to take place, the lower the expected coupon payments and consequently the lower the price. This scenario is relevant for cases where e.g. the MDA is uncertain, which can be the case in some countries where the Pillar II requirements are not disclosed publicly.

[19] One should note, that the model does not incorporate the extension risk which is likely to increase if the assets become more volatile, i.e. risky, and the fair credit spread therefore increases.

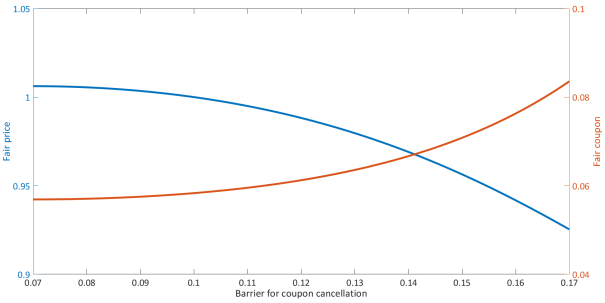
Figure 4.1: Fair CoCo price and coupon as a function of different risk parameters.



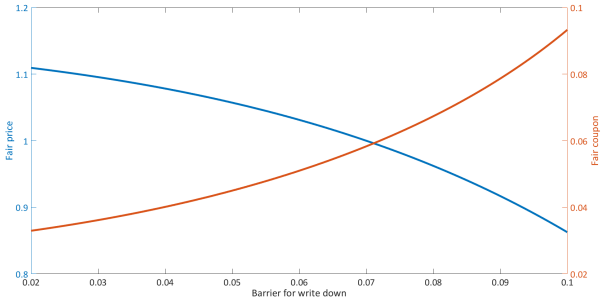
(a) Solvency



(b) Asset volatility



(c) CET1 barrier for coupon cancellation



(d) CET1 barrier for write-down

Note: The fair price is the present value of the expected future payments, given the parameters in Table B.1 and the value of the risk parameter on the x-axis. The fair coupon is the coupon which ensures that the CoCo will trade at par, i.e. it can be interpreted as the yield-to-call.

(d) If the *trigger point* is changed, the probability of losing the principal through a write-down is changed. The scenario of a changing trigger point can be relevant in cases where investors start perceiving the PONV as higher than the contractually specified trigger.

The main take-away from Figure 4.1 is that price reactions can occur due to changes in many different factors, even in a simplified model as ours. This makes it difficult to tell what the underlying driver behind a specific price change is. In some cases, the driver can have different implications from a financial stability point of view; for instance a price reduction due to a lower CET1 ratio will be of interest while uncertainty regarding the MDA due to changing accounting standards would be of lesser concern. This makes the interpretation of price changes difficult.

Further, if the repricing happens when liquidity in the CoCo market is low, which is very likely to be the case when there are financial market turmoil, cf. Section 3.3, the price reaction will most

likely be more extreme than what fundamentals can justify. As a consequence of these issues, CoCo price reactions in themselves are not necessarily a good signal of the financial strength of a bank.

4.1.2 Extracting information from the correlation between equity and CoCo prices

Intuitively one can look at correlations between e.g. equity and CoCo prices to get an indication of when investors fear that a bank will experience trouble (i.e. suspend coupon payments or triggering of the CoCo) as the CoCo should become more "equity-like", which will increase the correlation. In line with this, it has been proposed by e.g. Avdjiev et al. (2015) that the correlation between CoCo, equity and other debt instruments indicate whether or not investors expect (major) losses to the bank. Avdjiev et al. (2015) find theoretical correlations in a two-stage, two-outcome model and compare these predictions to real world estimates to find that investors believe a default is more likely than a trigger event.[20] Inspired by the idea of using correlations to extract information, we set up an (extremely) simple model to estimate how prices on equity and CoCo co-move. The model consists of four elements:

- Credit-risk free debt, i.e. the bank is liquidated if the value of assets reaches the value of debt.
- Asset value which follows a Geometric Brownian Motion (GBM).[21]
- CoCo with a write-down feature and a call-date of five years. The trigger at which coupons will no longer be paid is higher than the trigger at which write-down occurs.
- Equity which receives the payoff after five years.[22]

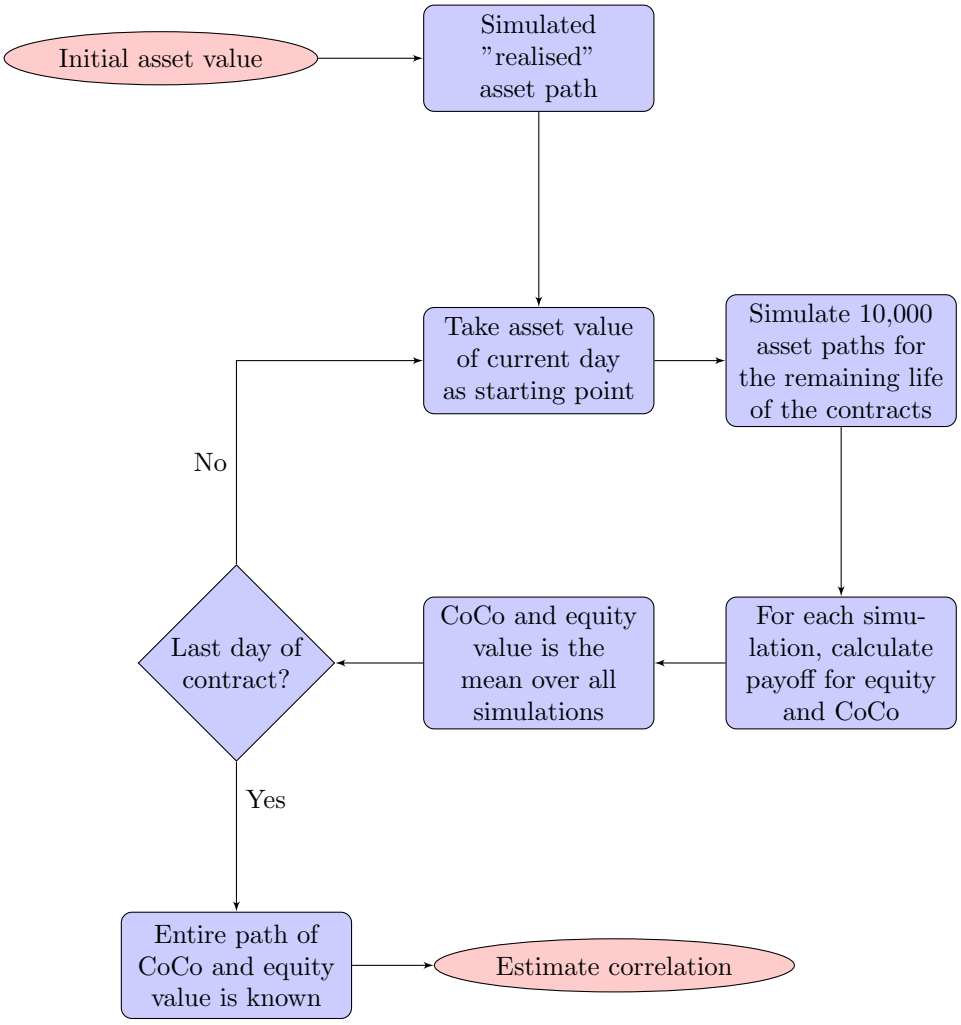
The simulation follows the approach illustrated in Figure 4.2: First one possible path of the asset price is simulated from the proposed GBM distribution for the asset value. In total, five years of asset values are simulated with daily steps and assuming 255 trading days in a year. Then the CoCo and equity value are estimated in each time point as the expected present value of the future cash-flows generated by these products. This is done by assuming that the investors know that the asset value follows a GBM distribution as well as the asset value today (this could be modified to include short-term uncertainty following the lines of Corcuera and Valdivia (2017)). In order

[20] According to their model and correlation estimates investors price the CoCo as if it is most likely to experience a loss at the same time as subordinated debt. I.e. investors do not fear a coupon cancellation or a trigger event but rather a bail-in.

[21] One could potentially expand the model by incorporating a more realistic process, e.g. by adding a jump process, but then the debt would no longer be credit-risk free.

[22] This assumption is a simplification and could of course be changed to e.g. a longer time horizon.

Figure 4.2: Flow diagram for the simulation.



to estimate the investors' expectations towards the future cash flows generated by the CoCo and stock, the asset value is simulated 10,000 times for the remaining life of the contract, and the payoff of equity and CoCo are evaluated for each simulation. Finally the contracts are priced as the discounted expected payoff. The simulation takes account of payments of coupons reducing the asset value, any coupon cancellations, trigger events and default. With the fair values of the CoCo and equity at each time point it is easy to estimate the correlation. It should be noted that we calculate the correlation between total return series for both the CoCo and the stock in order to avoid coupon and dividend payments having any effects on the results.

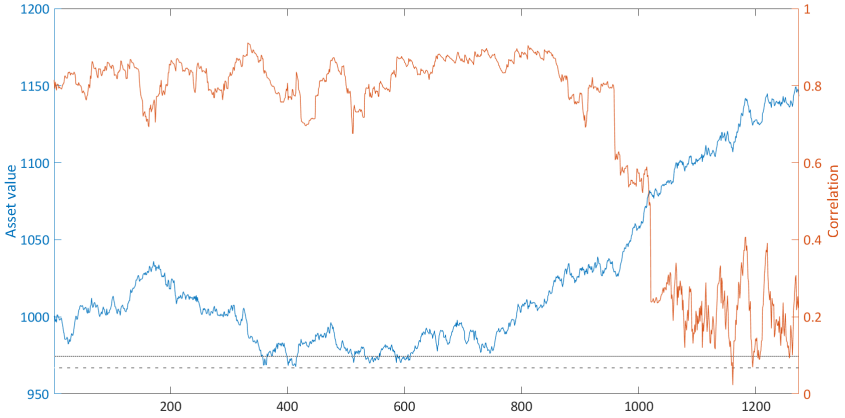
The main idea is to estimate the theoretical correlation between CoCo and equity returns, when we know the asset value of the issuer, i.e. we can link the correlation to what the financial markets

perceive to be the state of the issuer. This way we are able to get an idea of whether or not the correlation is high when the market perceives the issuer to be in a bad shape (the value of assets is low) and the CoCo should be equity-like. The correlation is estimated in a dynamic manner using a Dynamic Conditional Correlation model (DCC), see Engle (2009).[23]

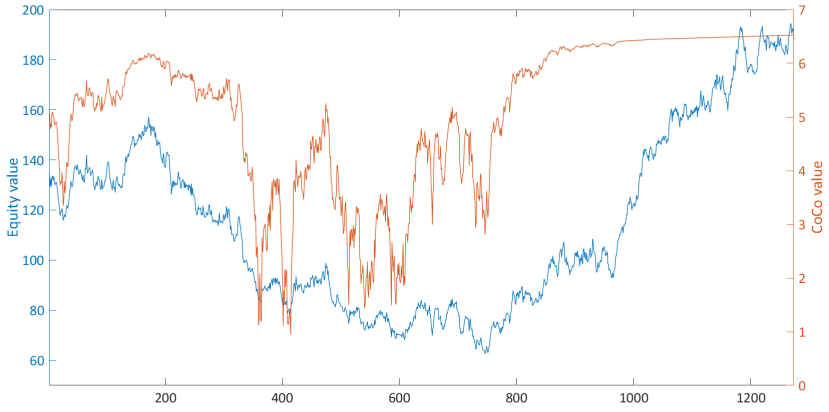
Although the choice of the GBM distribution as the data-generating process allows for basically any path of asset values, we have chosen to focus on two specific - but rather different - outcomes to investigate how the correlation between CoCo and equity returns can change depending on the evolution in the underlying asset value. In the first example we consider the case where the asset price comes close to the coupon cancellation barrier, but no coupons are cancelled nor is the trigger activated. In the second example we consider a simulated path of asset values, where the value decreases so much that a trigger event occurs. This scenario is meant to illustrate the CoCo and equity correlation when the CoCo is not just on the brink of a write-down but actually absorbs losses. It should be noted that the two realised asset paths are generated from the same GBM process and have the same model parameters, i.e. asset volatility, start value, barriers and coupons, c.f. Table B.1. It is only the outcome of the asset process that differs - these are basically two possible paths that could occur and which investors could face when determining the value of equity, CoCo and other financial contracts.

[23]The easy alternative is to use a rolling window but then one must be careful since the window might overlap periods with assets above and below the barriers. However, in this example a rolling window approach does not change the correlation much.

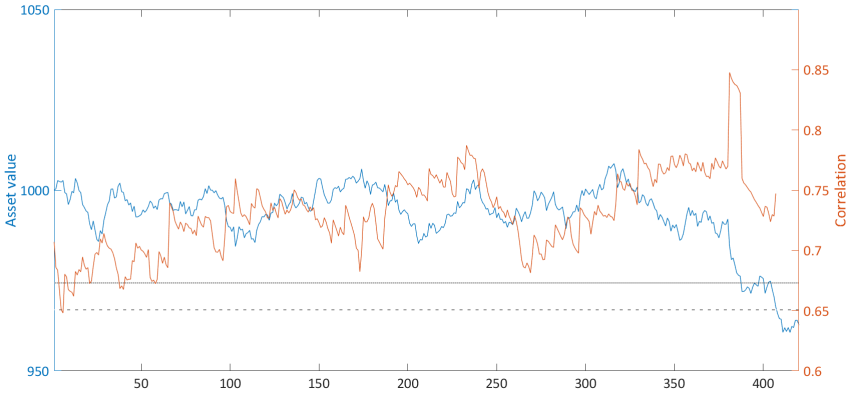
Figure 4.3: Simulated asset values and estimated correlation between equity and CoCo.



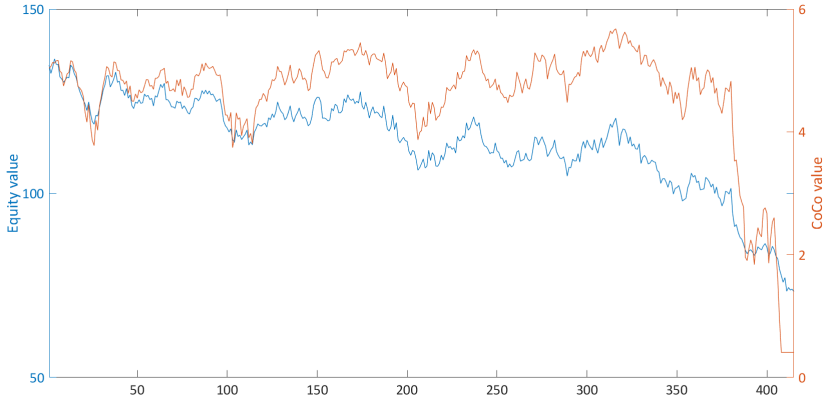
(a) First case: correlation and asset value



(b) First case: value of equity and CoCo



(c) Second case: correlation and asset value



(d) Second case: value of equity and CoCo

Note: The dotted lines represent the barriers where the coupon is cancelled and where the trigger is reached.

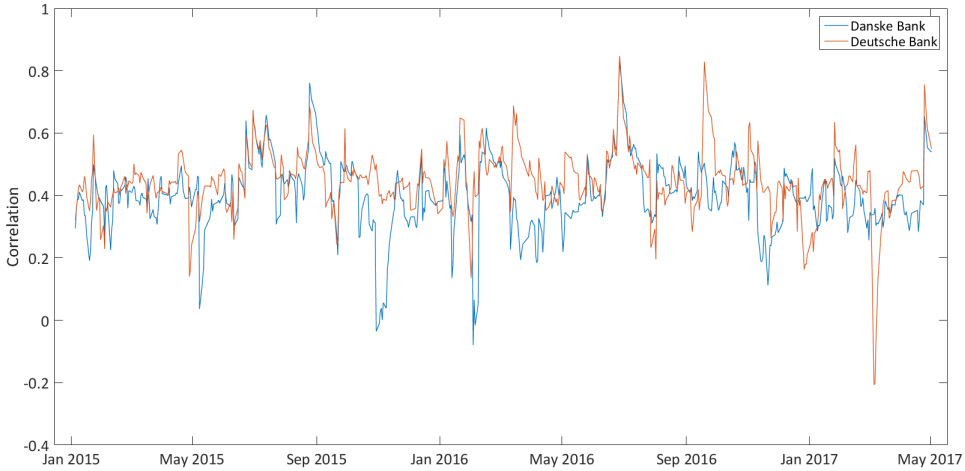
The first case is illustrated in Figure 4.3(a)-4.3(b). The asset value is so low during the first half of the simulation period that the CoCo is on the brink of stopping to pay coupons (in fact the first barrier is hit, but not during the days at which coupons are paid) and being written down. During this period, the correlation is between 0.7 and 0.9 which fits with the intuition of CoCos being equity-like when the asset value is low. Later, when the asset value increases, the probability of getting below the barriers is basically zero, meaning that the CoCo starts to resemble a fixed income instrument and the correlation hovers around 0.2, i.e. it is small and positive. Interestingly, this correlation pattern is somewhat similar to the one observed in Figure 4.4 which shows real correlation estimates between CoCo and stock for both Danske Bank and Deutsche Bank, although there has been periods with quite high correlations (particularly for Deutsche Bank).[24] This suggests that the correlations observed in reality could be a reflection of markets generally attaching a small probability of write-downs and stop of coupon payments on CoCos. This corresponds quite well with the survey results of Gallo et al. (2014) - investors think a trigger event is unlikely.

The second case is illustrated in Figure 4.3(c)-4.3(d) which represents a path for the asset value where the trigger level is actually breached. When the asset value is close to breaching the trigger level, the correlation is again quite high, around 0.7-0.8, while it jumps when the asset value actually crosses the first barrier corresponding to the coupon cancellations. This comes from an abrupt loss of CoCo value as the coupon is to be cancelled, and a trigger event becomes very likely. Following the initial decrease in the price, the correlation decreases but with a little spike just before the trigger event.

Overall, this simulation exercise illustrates how the correlation between CoCos and equity generally is substantially higher when there is some risk of the CoCos being triggered, i.e. the asset value is low, relative to when investors perceive the risk to be negligible. But other than that it was quite difficult to say anything conclusive based on the correlations: In Figure 4.3(c) the correlation increased just before the cancellation of the coupon and then it fell but not, as one might think, because the asset value increased above the point where coupons are cancelled. Consequently, observing a decrease in correlation does not necessarily imply a safer bank.

[24]It should be noted that in Figure 4.3(a) a total return index investing the coupons at the risk-free rate is used, whereas the pure price is used in Figure 4.4.

Figure 4.4: Empiric correlation between stock prices and CoCo price.



Note: Correlation estimated by a DCC model with log returns on prices of equity and CoCo.
Source: Bloomberg and own calculations.

4.2 Can the yield on CoCos be used to infer a bank's cost of equity?

One can think of a CoCo as a hybrid that is something in between a subordinated bond and equity as it absorbs losses before the bond but (possibly) after the equity. Continuing along that line of reasoning, it is therefore natural to conclude that the yield of a CoCo must be higher than the yield of a subordinated bond but lower than the required rate of return on equity. That is, a bank's cost of equity has a lower bound set by the cost of the bank's contingent convertible bonds. However, before drawing that conclusion one needs to consider which systematic risk premia investors require compensation for as well as the risks equities and CoCos are exposed towards.

To frame the discussion, one can start by considering some similarities and differences between CoCos and equity:

- **Both are loss-absorbing, i.e. have downside risk.** In principle, equity is first in the loss absorption order; but with a high trigger, the principal of a write-down CoCo can be wiped out before all equity value is lost. A natural consequence of a CoCo is that it absorbs losses in a certain interval instead of equity. In Figure 4.5(a) and 4.5(b), the values for CoCo and equity are illustrated in a simplified setting. Although the equity is first to absorb losses, it still has some value even after the CoCo is fully written down, cf. Figure 4.5(b). It should be noted that this only applies if the trigger is activated before the point of non-viability.

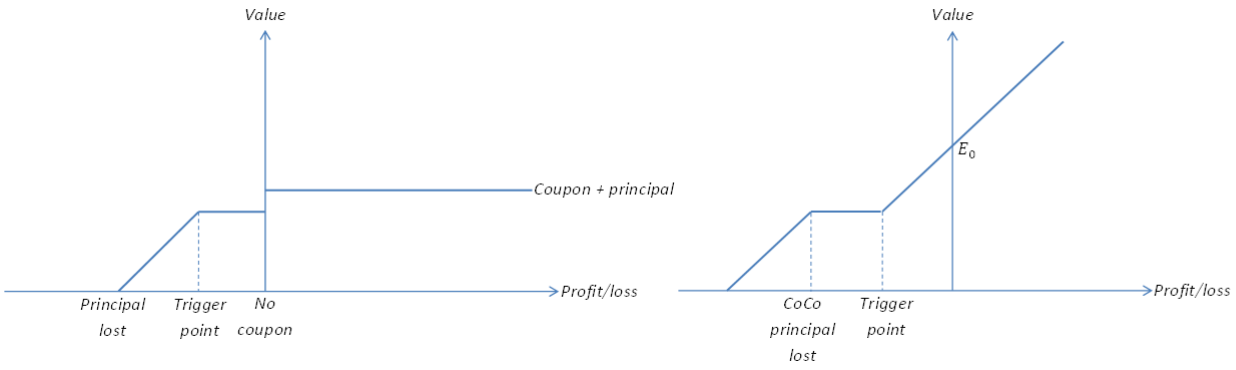
- **Equity has (unlimited) upside, CoCos do not.** While CoCos can absorb losses, the best case for the investor is to receive all coupons and for the CoCo to be called at the first call-date. This implies that there is no upside - either the coupon payments and face value are received or not, cf. Figure 4.5(a). Equity on the other hand has potentially unlimited upside as the equity investor receives a share of the profits. So equity and CoCo share the downside but not the upside.

- Both equity and CoCos are subject to some degree of **discretion** on the side of issuer and regulator. Coupons on CoCos and equity dividends are both discretionary, and they can only be paid in full if both ADI and MDA are positive. It can be noted that the CoCo coupon payments do not rank higher than dividend payments. That is, the bank is (in theory) allowed to cancel the coupon and continue paying dividends. Further as a part of the lack of upside, the CoCo investor is not allowed to be compensated for lost coupons whereas equity always receives a part of any retained earnings. Finally, there is considerable uncertainty related to whether a regulator will convert the CoCo when the (unknown) point of non-viability is reached, as this potentially can be before the trigger point is reached.

- **The liquidity of CoCos is generally poorer** than that of other capital instruments, particularly during volatile periods where investors might be in need of liquid instruments, cf. section 3.3. In general, stocks are more liquid than bonds which suggests that bank stocks are substantially more liquid than CoCos, cf. that the liquidity of CoCos is generally poorer than that of other bonds. In support of this, the average bid-ask spread for the sample of issues that were used in the liquidity analysis was 0.84 % of the bid-price for CoCos, 0.32 % of the bid-price for other debt instruments and only 0.13 % of the bid-price for bank stocks when using daily data from 2015 to 2017.

Hence, compared to bank stocks CoCos should be more exposed to both liquidity and regulatory risks. All else equal, this should increase the expected return of a CoCo relative to equity. In addition to this, CoCos also have substantial downside risk - but no upside. Following a standard CAPM approach, i.e. by assuming the only systematic market risk compensation investors care about is the *average* covariation with the market (i.e. the average β), this would tend to *decrease* the compensation required by investors to invest in CoCos relative to equity. This is because CoCos only comove with the value of equity (assuming the stock has a positive β) and the market in some states of the world. However, given that the lower β of CoCos primarily is due to a lack of upside, one could argue that CoCos should **not** carry a substantially lower compensation for market risk

Figure 4.5: Value functions in a very simplified setting.



(a) CoCo value

(b) Equity value

Note: Equity has an initial value, E_0, which can increase/decrease according to the profit/loss. To keep things simple, it is assumed that the firm is not allowed to pay coupons if a loss is realised and the CoCo principal is written (permanently) down if the loss is big enough to constitute a trigger event. Notice that we have deliberately not put values on any of the axis - the figure only serves the purpose of illustrating the shapes.

than e.g. bank stocks. This would be in accordance with Lettau et al. (2014) who find that a substantial part of the excess return for currency trades as well as other assets are due to their "downside β", i.e. a crash-premium. Along the same lines, Burnside et al. (2010) find that investors require large excess returns from investment strategies that deliver poor returns in bad states of the world. As a consequence of this, there is a large demand for hedges against tail losses which makes the price of far out-of-the-money put options "too high", see e.g. Bollen and Whaley (2004).

Table 4.1 illustrates the correlation and β between Stoxx Europe 600 (which we consider as the "market") and different capital instruments that have been issued by European banks, such as bank stocks and different types of bank debt (including AT1 CoCos). While the correlation between returns on CoCos and the market are somewhat lower when looking at the entire sample, the correlation is markedly lower when conditioning on days where the market increased considerably (the 5 per cent quantile), and - most interestingly - it is slightly higher when conditioning on days where the market *decreased* substantially. This clearly illustrates the earlier point that investing in a CoCo gives rise to considerable downside while providing no upside, and in that sense it resembles a sold put option which according to the above mentioned studies should generate an excess return.

Table 4.1: Market correlation and beta of bank stock, CoCo, subordinated debt and senior debt.

	Bank stocks	**CoCos**	**Subordinated debt**	**Senior unsecured debt**
Correlation	70.4 %	58.0 %	25.3 %	3.9 %
Conditional on:				
Market decrease	68.0 %	71.6 %	40.2 %	20.4 %
Market increase	35.5 %	19.8 %	−1.4 %	−14.9 %
Beta	1.17	0.25	0.06	0.00
Conditional on:				
Market decrease	1.88	0.62	0.18	0.02
Market increase	1.03	0.33	0.03	−0.05

,

Note: Data consists of daily returns on capital instruments issued by Danske Bank, Deutsche Bank, Nordea Bank AB, Barclays, Lloyds, HSBC and Societe Generale in the period January 2015 to January 2017.
The market is taken to be Stoxx Europe 600, and the market increase (decrease) is when the market return is above (beneath) the 95 (5) per cent quantile.
Source: Bloomberg and own calculations.

Hence, it appears that a liquidity and regulatory premia in combination with the high downside exposure (resembling a sold put) tend to increase the excess return on a CoCo relative to e.g. a stock. This implies that CoCo yields do not necessarily constitute a lower bound for the cost of equity. In practice CoCos are typically trading at a yield to next call of around 5 to 7 per cent.[25] A practical solution would be to estimate the cost of equity, but this leads to different conclusions depending on the metric: historic returns (Damodaran (2016)), implied premium (European Central Bank (2015), Danmarks Nationalbank (2016)) or surveys (Fernandez et al. (2017)).

Despite this ambiguity, it is, however, important to notice that even if investors require the same expected return from CoCos and equity, the firms still have quite an incentive to issue CoCos to fulfil capital requirements. CoCo coupons are tax deductible, and that can make the actual cost of CoCos (for the firm) lower than the traded yield, and in that case CoCos are cheaper for the firm than equity.

[25]The CoCos used in Table 4.1 trade with an average z-spread of 533 basis points.

5 Conclusion

CoCos are highly complex products that regulation gives banks an incentive to use as a part of their funding. The market for CoCos has grown to more than 130 billion euro, but it remains highly non-standardised with different triggers, trigger events, call scheme etc. Perhaps due to this, we find that the market is quite illiquid compared to other debt and capital instruments issued by banks. Besides liquidity investors face different risks such as coupon cancellation, write-down or conversion of the principal and extension. Each of these risks can lead to sizeable price changes, as illustrated in both a theoretic setting and in real world prices.

CoCos are interesting from a supervisory perspective as some major financial institutions are unlisted and their CoCos therefore hold an opportunity to get the investors' view on the institution. However, due to the many embedded risks that can lead to price reactions (for monitoring purposes not all these risks are of interest) and possible liquidity issues, it can be hard to interpret the information and e.g. conclude from a price reduction that the bank is less stable. Likewise, a simple simulation approach indicates that the level of correlation between CoCo and equity returns can be used to get a rough indication of how investors perceive the robustness of the issuer, but that the changes in correlations were hard to interpret. Further, we question whether the cost of CoCos constitutes a lower bound for the cost of equity due to e.g. a lack of liquidity as well as the high exposure towards downside risk embedded in CoCos.

Appendix A

Table A.1: Minimum requirements for AT1 CoCos.

Contract feature	**Minimum requirements**
Maturity	The contract must be perpetual.
Call	The contract may include a call date, but no earlier than five years after issue. The call can only be used with the acceptance of the national competent authority (NCA). There must be no incentive to redeem, and the issuer may not state any intentions to do so.
Coupon	Coupons are fully discretionary by the issuer or the FSA. Coupons are only allowed to be paid in full if available distributable items (ADI) and maximum distributable items (MDA) are positive. The coupon is reset at each call date. Markup or step-up are not allowed.
Trigger	When CET1 reaches 5.125 per cent of RWA (or higher) or PONV.
Event upon trigger	Principal write-down (temporary or permanent) or equity conversion.

Note: See section 2 for a more thorough description of many of the definitions introduced in this table.

Appendix B

Table B.1: Default values for the CoCo pricing.

Model input	**Option model**	**Simulation**
Debt	950	950
CoCo	5	5
Equity	45	45
Assets	1000	1000
Asset volatility	1 per cent	3 per cent
Average Risk Weight	0.25	0.25
Risk-free rate	0 per cent	2 per cent
Time to maturity	5 years	5 years
Coupon rate	4.23 per cent	7.63 per cent
Coupon cancellation	CET1 of 10 per cent of RWA	
Trigger point	CET1 of 7 per cent of RWA	
Trigger event	Full write-down	

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