UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

# Pricing Contingent Convertibles

*in an intensity based model*

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## Abstract

As a result of the recent years financial instability, governments have developed new regulatory frameworks for bank capital adequacy. Authorities have become more aware of keeping capital as a buffer to absorb potential losses. Due to this, a new financial instrument, so-called Contingent convertibles (CoCos) have become more interesting. A CoCo bond converts automatically or suffers a write-down when the financial institution is facing a though time and can therefore strength the banks capital structure before the point of non-viability is reached. Currently, only a few CoCos have been issued but at the moment, several financial institutions are waiting for regulatory frameworks to be implemented, in order to issue CoCos. As CoCos are relatively new there is naturally an interest of how to price CoCos. We will in this thesis analyze one pricing model, namely the Credit Derivative approach on how to price CoCos. Further, applications with fictive data and real data from Swedish banks will be made.

## Key words

*Convertible bonds, Contingent convertibles (CoCos), Credit Default Swaps (CDS), CDS Spread, Credit Derivative approach*

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# 1. Introduction

The financial crisis 2008-2009 proved that the current regulatory framework, Basel II was not sufficiently effective. Basel III, developed by the Basel Committee, is a new regulatory framework for banks to identify the banking risks better. The new regulatory framework implies stricter requirements on the bank's capital to withstand losses and to avoid other financial crises. In short, banks capital has to be more liquid and of a better quality. Basel III will be implemented during the coming years, 2013-2019 (Riksbanken [1], 2013).

Contingent convertibles (CoCos) are one way to achieve the requirements of Basel III and were issued for the first time 2009. CoCos are bonds that in case of a trigger event automatically can be converted into shares or be written down by a preset percentage of the face value, i.e. decrease debts and increase equity. The trigger event will appear e.g. if the share price of the issuing company drops below a predetermined level. In this way the CoCo could help to strengthen the capital structure of the company in times of distressed economic environment. As it is a relatively new financial instrument we can assume an interesting development. At the moment, many countries are facing a though time, e.g. the financial situation in Cyprus is highly topical in time. The republic of Cyprus is facing a financial crisis that hits the Cypriot banks hard. In March 2013, The Irish Times published an article stated that the second biggest bank, Cypriot Popular Bank, agreed to close down in return of a €10 billion bailout. Bailouts, such as loans, bonds, stocks and cash create highly costs for banks and CoCos may be an alternative solution. By issuing CoCos banks can generate equity and decrease their debts without taking any loan. The interesting fact is that the biggest bank in Cyprus, Bank of Cyprus, still managed to continue their activities during the unstable economic situation. They are also the only bank in Cyprus that have issued CoCos. It is therefore very interesting to follow and to see if the closing of Cypriot Popular Bank causes a spillover effect on other banks in Cyprus as well.

Furthermore, in Sweden there has up to the writing moment been no issuing of CoCos but some of the biggest banks have showed interest to issue such bonds. In March 2012, Swedbank was the first bank to announce its interest in issuing CoCos. At the annual general meeting in March 2013, the board of Swedbank was decided to have mandate in issuing CoCos. The condition for making Swedbank eligible for using this mandate is that there must be a clear and good working regulation system for CoCos, something that the Swedish Financial authorities have not yet declared.  Swedbank is thereby waiting for these regulations so that they can issue their first CoCos (Swedbank, 2012).

In February 2013, another Swedish bank, Nordea, announced that they were going to ask their shareholders for permission to have mandatory right to issue CoCos. In a report from January 2013, Nordea said that the purpose of issuing CoCos was to "enable a flexible and cost-effective adaptation of Nordeas capital structure to the new capital adequacy rules and related new instruments" (Realtid, 2013).

As described above, there is an interesting development to follow. The Swedish finance minister, Anders Borg, has recently declared his positive sight for Swedish banks to issue CoCos (Di, 2013).

As CoCos are relatively new instruments there is naturally an interest of how to price CoCos. Both the issuer and the investor of this kind of bond want to deal with a fair price. There are several pricing models to deal with in this problem. In Spiegeleer & Schoutens (2011) two of them are presented, namely the Credit Derivative approach and the Equity Derivative approach. Further, these pricing models and a third one, the Merton approach are exanimated in a master thesis by Alvemar and Ericsson (2012). We will in this bachelor thesis focus on the Credit Derivative approach. We will investigate and analyze the Credit Derivative approach much more than in the previous mentioned papers. The reason why we have chosen to only focus on the Credit Derivative model is primarily because it offers quantitative theory that is fairly easy to understand and investigate, but also because we find it the most interesting. Besides the papers written by Spiegeleer & Schoutens (2011) and Alvemar and Ericsson (2012) there are additional papers about CoCos. For instance, Campolongo, Girolamo, Spiegeleer and Schoutens (2012) and Brigo, Garcia and Pede (2013).

In the last part of the thesis we will calculate the price of a CoCo, both with fictive data and data from the Swedish banks Nordea and Handelsbanken. We are going to investigate the sensitivity by letting some variables vary while others are set constant. Moreover, we chose to use data from Nordea because they recently announced that they are interested to issue CoCos. We have also chosen data from Handelsbanken to see if there is any difference. The purpose is to see which price the banks would set the CoCo to, if they would issue them.

The rest of this thesis is organized as follows. In Section 2 we will present the background. A description of a CoCo bond will be presented in Subsection 2.1 following by Subsection 2.2 explaining the regulatory frameworks such as Basel II and Basel III. In Subsection 2.3 the structure of a CoCo will be presented. In Subsection 2.4 issued CoCos are presented and in

Second, in Section 3 we will explain how to price CoCos by using the Credit Derivative approach. In Subsection 3.1 the Credit Derivative approach is described. In Subsection 3.2, the intensity-based credit risk model is presented. In Subsection 3.3 credit default swaps are described. Further, in Subsection 3.4 the premium leg is presented and in Subsection 3.5 the default leg is described. The CDS spread is presented in Subsection 3.6 and in Subsection 3.7 we will describe how the CDS spread can be connected with the CoCo. Finally, in Subsection 3.8 we will intimate describe the process of how to price a CoCo using the Credit Derivative approach.

Furthermore, in Section 4 we will investigate the Credit Derivative approach, Subsection 4.1 will investigate the model by using fictive data and in Subsection 4.2 and 4.3 we will use data from Nordea and Handelsbanken to illustrate what the price of a CoCo could be set to, if the banks would issue them. Finally, in Section 5 we are discussing the result and in Section 6 a conclusion will be drawn.

## 2. Background

In this section we will discuss the background. In the subsections we will present what a CoCo is and how it works as a financial instrument. Subsection 2.1 defines what a CoCo bond is and Subsection 2.2 contains information about regulatory frameworks. In Subsection 2.3 we present the structure of the CoCo bond. Furthermore, in Subsection 2.4 CoCos issued by different banks will be presented.

### 2.1 What is a CoCo?

First, to be able to describe a CoCo we have to remind the reader of what a traditional convertible bond is. In short, a convertible bond is a bond that can be converted into a predefined amount of equity at a certain time during its maturity (Investopedia [1], 2013).

In the chase for a more stable bank system, and especially after the latest financial crisis, some of the regulations of Basel III have resulted in the creation of a new class of convertible bonds, namely the CoCo bond or “CoCo”. A CoCo is a debt instrument that, in case of a trigger event, automatically converts into equity or suffers a write down. If there is a risk for insolvency of the issuing bank, the CoCo will work as a buffer by helping the equity to absorb losses. When the conversion occurs due to a trigger event, the CoCo bonds will be converted into shares of the issuing bank. The conversion price and numbers of shares can either be pre defined or calculated due to pre specified preferences at the day of the conversion (Spiegeleer and Schoutens, 2011).

Due to the conversion at the moment of trigger event, banks capital structure will be strengthen. Banks can generate equity quick and easy and decrease their debts, which will lead to a change in their balance sheet. This is very attractive for the banks, as they do not need to search for new investors in order to raise their capital.

If the CoCo does not get trigged during its maturity time, it will work and mature just as a regular bond with ordinary coupon payments (Spiegeleer and Schoutens, 2011).

### 2.2 Regulatory frameworks

The Basel Committee is an international organization that frames international standards for bank regulations. The committee provides regulatory frameworks for banking supervision that is not compulsory on an international level but is a part of the legislation in the EU. Anyway, many countries outside the EU have chosen to follow the Basel regulations (Riksbanken [2], 2013).

Due to the latest financial crisis 2008-2009 the Basel Committee has developed a new regulation called Basel III, which will be implemented during the coming years, 2013-2019.

The reason is that the recent years of financial instability proved that the current regulatory framework, Basel II was not sufficiently effective. Basel regulations contain guidelines for banks to increase their capital adequacy, hold capital as a buffer, in purpose to withstand losses in times of crisis (Riksbanken [2], 2013).

The new regulatory framework, Basel III implies stricter requirements on the banks capital to withstand losses and to avoid other financial crises. The regulatory framework contains requirements of increased capital adequacy, composition of the capital base and tightened regulations for calculating risk-weighted assets. The capital requirements will imply a better risk coverage (Riksbanken [1], 2013).

Banks must hold more liquid assets to manage short-term liquidly needs. This regulation consist additionally a minimum level of the total capital banks must hold (Riksbanken [2], 2013).

In the new regulatory framework, stricter requirements of what kind of financial instrument that will be counted as capital base will be implemented. This means that some financial instruments that count as capital right now, e.g. goodwill, hybrids and deferred tax liabilities may not be permitted as regulatory capital any longer. Goodwill reflects the value of a Company's intangible assets and is an intangible asset on the balance sheet, e.g. strong brand name, good customer- and employee relations (Investopedia [3], 2013). Further, hybrids are a combination of two or more financial instruments, generally with both debt and equity characteristics, such as convertible bonds (Investopedia [4], 2013). Instead, a larger part of the capital has to consist of public shares and retained profits, namely Core Tier 1 Capital (Riksbanken [2], 2013).

Further, in order to prevent the banks level of liabilities becoming too high in relation to the banks capital, a leverage ratio or a non risk-weighted capital requirement is proposed.
The leverage ratio is defined as follows

$$Core\ Tier\ 1\ Capital\ Ratio = \frac{Core\ Tier\ 1\ Capital}{Risk - weighted\ assets}$$

The Core Tier 1 capital requirement is the ratio of Core Tier 1 capital in relation to risk-weighted assets. Risk-weighted assets means that assets are weighted by their riskiness, e.g. the more secure an asset is, the less weighted it is. The leverage ratio may not fall below a certain level, i.e. the banks capital may not fall below a fixed limit in relation to its total risk-weighted assets. Basel III consists of a requirement of 7% of Core Tier 1 capital and if this is not obtained the banks dividend will be restricted. Also, in good times, the requirement of Core Tier 1 capital must increase further, namely by up to 2.5% (Riksbanken [1] and [2], 2013).

To meet the requirements of Basel III the banks can issue CoCos. By issuing CoCo bonds banks can be more liquid as the CoCos will convert into equity in financial crisis. When the bank is failing to meet the regulatory requirements of capital level the conversion will strength the banks capital structure. A conversion, which means that the CoCo bond convert into shares or be written down can quickly increase the banks equity and decrease their debts. Hence, it will improve the balance sheet and also the capital adequacy (Riksbanken [2], 2013).

Figure 1 below illustrates the change in the balance sheet after a CoCo has been converted.

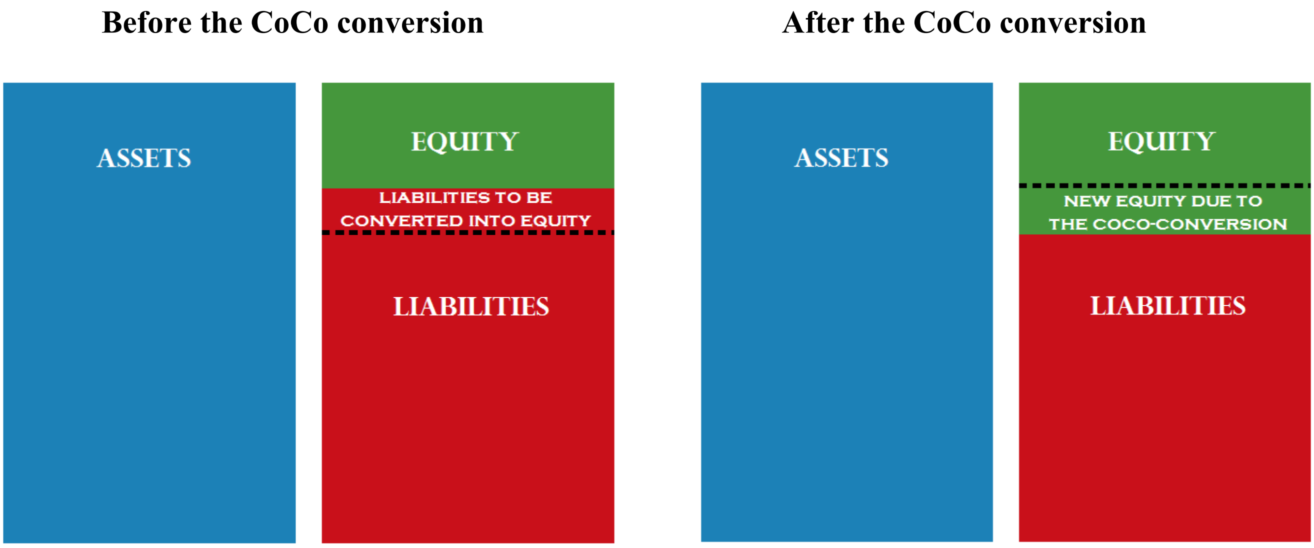


**Figure 1.** The balance sheet before the CoCo bond is converted (left) and the balance sheet after the conversion (right).

Recent years, the European Commission has paid enormous state-aid to financial institutions. This has made authorities realize that if one bank face a problem, it is likely it hits other banks as well. To avoid bank bailouts like this in the future, the European Commission proposed on June 6 2012, stricter EU-regulations for bank recovery and resolution (EU Commission, 2012). The proposed framework includes three tools to deal with this problem, “Prevention”, “Early Intervention” and “Resolution” (EU Commission, 2012).

The first tool “Prevention” consists of requirements on recovery- and resolution plans. In case of financial instability economic groups can help organizations to limit the development of a crisis.

The second tool “Early Prevention” means that supervisory intervention and special managers will detect and prevent problems as soon they arise.

The third tool “Resolution” becomes necessary if the two earlier mentioned tools fail to ensure financial stability. For instance, authorities will have the power to sell a part of the failing bank to another bank. This tool is the one that also relates to contingent capital. The idea is to replace bailout programs, such as loans, with bail-ins, i.e. CoCos. Bail-ins means that banks recapitalize themselves by bonds that converts into equity or suffers a write down once the bank is facing financial instability, i.e. at a trigger event. To manage this, banks will be required to hold a minimum percentage of their total liabilities as bail-in tools.

*Michel Barnier, the International Market Commissioner commented the press release: "The financial crisis has cost taxpayers a lot of money. Today's proposal is the final measure in fulfilling our G20 commitments for better financial regulation. We must equip public authorities so that they can deal adequately with future bank crises. Otherwise citizens will once again be left to pay the bill, while the rescued banks continue as before knowing that they will be bailed out again."* (EU Commission, 2012).

Michel Barnier means that it is the citizens who have paid for the bailouts in terms of taxes, to save the banks from bankruptcy. This new proposal indicates that CoCos, or bail-ins as it also is called will be an important and mandatory financial instrument in the future, in purpose to avoid huge bailouts.

## 2.3 Structure of a CoCo

The anatomy of a CoCo is divided into different parts: conversion type, conversion fraction, conversion ratio, price and trigger event. These factors have an important impact on the value and the dynamics of a CoCo. In Subsection 2.3.1 contains information about when a CoCo transforms depending on which trigger event it is characterized by. Furthermore, in Subsection 2.3.2, we will describe how the different elements interact. Following subsections are based on Spiegeleer and Schoutens (2011).

### 2.3.1 Trigger Event

A trigger event is a barrier or incidence that causes another event to take place, in this case the CoCo-conversion. The trigger event occurs when a threshold is breached (Investopedia [2], 2013).

A trigger event should be clear, objective, transparent, fixed and public. The trigger event should be clearly specified before the CoCo is issued to ensure both parties of the conditions for a conversion. It is important that the investor knows under what circumstances the conversion will occur to be able to analyze the risk among the price. When and how the write-down or the conversion of the bond occurs depends on which trigger event the bond is characterized by. There are four different types of trigger events, which are: accounting trigger, market trigger, regulatory trigger and multi-variate trigger (Spiegeleer and Schoutens, 2011).

*Accounting Trigger*

A CoCo with this kind of trigger will convert when an accounting ratio, which indicates the bank's solvability, breaches a certain level. In other words, the conversion is triggered by an accounting measure. For instance, Lloyd's CoCos will convert if their accounting ratio, Core Tier 1 Capital ratio (CT1) breaches 5 % (Spiegeleer and Schoutens, 2011).

Spiegeleer and Schoutens (2011) discuss pros and cons with an accounting trigger. The most common complication with an accounting trigger is that the accounting number, which shows the bank's health, is not always consistent with the economic reality. Moreover, an accounting ratio is not continuously available. This kind of information is only published quarterly or in some cases semi annually. Because of this interval it may be to late to raise the issuing firm's equity and avoid a crisis when the conversion occurs. For instance, Lehmann Brothers went bankrupted even though the reported capital ratios were above 8% after the financial crisis in 2008. Another factor to take into account is the possibility of manipulation through book values in order to force or avoid conversion (Bloomberg, 2009). Further, Haldane (2011) is also critical against the accounting triggers and points out that instead of helping banks in distress, due to lagged data, CoCos issued by profitable banks can be converted even when it is not necessary.

On the other hand, the pros of using an accounting trigger are that the information is public and it is relatively easy to price, understand and implement (IMF 2011).

*Regulatory Trigger*

If a governmental authority, e.g. Financial Supervision Authority (FSA) on own initiative decides when the conversion of a CoCo should happen, then the bond is constructed with a so-called regulatory trigger.  The FSA would trigger the CoCo to be converted if they believe an institution with financial problems could affect the economy in a negative and significant way. In Spiegeleer and Schoutens (2011) article it is expressed that there is a risk of reducing CoCos on the market with this kind of trigger. The reason is that investors may refrain to buy these because of the governmental power. There is no lagged data with this kind of trigger as it is with an accounting trigger, neither any price manipulation as a market trigger may cause.

*Market Trigger*

A market trigger is based on forward-looking measurement and triggered by share prices or CDS spreads. For example, the conversion of a CoCo or a write-down will occur if a credit default swap (CDS) spread on the firm exceeds a certain threshold level or when the issuing firm's share price falls below a predetermined barrier level (Spiegeleer and Schoutens, 2011).

IMF (2011) pointed out that these factors indicate distress earlier than regulatory ratios. Some disadvantages with this trigger event are that it can give misleading signals during times of stress and may convert too early, which may lead to higher funding cost. Further, price manipulation can trig the CoCo.

*Multi-variate Trigger*

A multi-variate trigger, also known as dual trigger, is a combination of different trigger events that all have to be triggered to convert or write-down the bond. It consists of trigger events both on macro level and micro level. The triggers that focus on micro level, for instance on the underlying company, are accounting- and market trigger and the one on a macro level is the regulatory trigger (IMF, 2011). The benefit with this kind of trigger event is that it guarantees recapitalization of problematic banks when the economy is facing a recession (Spiegeleer and Schoutens, 2011). On the other side, it is difficult to interpret mixed signals such as supervisory and lagging effects in the market.

### 2.3.2 Conversion

The anatomy of a CoCo is divided into different parts. Following subsection is based on Spiegeleer and Schoutens (2011).

*Conversion Type*

A CoCo bond can either convert into predetermined number of shares or be written down by a preset percentage of the face value.

*Conversion Fraction* $(\alpha)$

The conversion amount is computed by the conversion fraction $\alpha$ and the face value $F$ and decides what amount that will be converted or written down when the conversion occurs.

$$Conversion\ amount = \alpha F$$

If the conversion fraction is equal to one, $\alpha = 1$, the conversion amount will be equal to the face value and the total amount will be converted into equity, i.e. there is a “full” CoCo.

Another alternative is that the conversion fraction is less than one, $\alpha < 1$, in that case the conversion amount will be less than the face value but convert enough bonds to strength the financial institution.

*Conversion Ratio* $(C_r)$ *and Conversion Price* $(C_p)$

The conversion ratio $C_r$ is the number of shares received per converted bond. It is the ratio of the conversion amount $\alpha F$ in relation to the conversion price $C_p$, that is

$$Conversion\,ratio\colon C_r = \frac{\alpha F}{C_p}. \tag{1}$$

Note that Equation (1) also is used to calculate the conversion price, since it gives the price per share the bonds will be converted into. Hence,

$$Conversion\,price\colon C_p = \frac{\alpha F}{C_r}.$$

Moreover, the conversion price determines the loss of the CoCo when the trigger event occurs. The choice of conversion price has therefore important impact on the value of the CoCo.

Let $S^*$ denote the share price at the moment of the conversion of a full CoCo, i.e. when $\alpha = 1$. Then, with notation as above, the recovery rate R is defined as

$$R = \frac{S^*}{C_p}. \tag{2}$$

The recovery rate tells us how much of the face value of the bond the investor expects to recover when a default occurs.

If the CoCo gets triggered and a conversion occurs, the loss of a full CoCo is defined as

$$Loss = F - C_r S^* = F\left(1 - \frac{S^*}{C_p}\right) = F(1 - R)$$

An investor of a CoCo bond would prefer a low conversion price while the current shareholder would prefer a higher price. Thus, if the price is low, there will be more shares when the conversion occurs and therefore a better investment for the owner of the CoCo. The loss does thereby depend on which conversion price that occurs.

There are three types of conversion prices:

1. Conversion price = Price on trigger, i.e. $C_p = S^*$, where $S^*$is the share price on the trigger moment $\tau^*$.

In this case $S^*$will be low since the trigger only activates when the financial institution facing a tough time. This gives the investor of the bond a high conversion ratio, $C_r$ so the current shareholders have to deal with a dilution of their shareholdings. An investor of this CoCo would not face a loss, as the total value will be equal to the face value.

2. Conversion price = Price on the issue date, i.e. $C_p = S_0$ where $S_0$ is the share price on the issue date of the CoCo bond.

This will normally create a low conversion ratio, $C_r$ and is therefore preferable for the current shareholders, as it does not cause a lot of dilution on their investment. The investor on the other hand, can expect a loss.

3. Conversion price with a floor, which means that $C_p = \text{Max}(S^*, S_F)$ where $S^*$is the share price on the trigger moment $\tau^*$ and $S_F$ is a predefined floor.

This conversion price is a combination of the two previous prices mentioned before. The price the bond has on the trigger moment is the price it is set equal to. At the same time, the conversion price cannot get lower than a certain floor.

## 2.4 Issued CoCos

Even though CoCo bonds are rather new and an unknown financial instrument, there are some banks that already have issued CoCos. In this Subsection a brief summary of CoCos issued by different banks will be given. We have chosen to only describe some of the issued CoCos, namely the one that differs from each other.

### 2.4.1 Lloyds Banking Group

Lloyds Banking Group issued the first CoCo bonds in November 2009. Instead of issuing totally new CoCos to the open market, the bank offered the possibility for existing bondholders to convert their hybrid bonds into CoCo bonds. Many bondholders received the offer positively and the bank issued CoCos for 7 billion GBP. The trigger used for these first CoCos was the accounting trigger. If the capital ratio for Core Tier 1 fell below 5%, it would cause a trigger event. The CoCo bonds would then be converted into a fixed number of ordinary shares. As the holder gets exposed to the extra risk that the bond can be converted into equity results in a higher coupon rate for the CoCo bond than for the original bond. The CoCo coupon rate were thereby increased by 1.5-2.5% units compared to the hybrid bonds the holder exchanged with. The time to maturity, if not converted, differed between 10-20 years (Spiegeleer and Schoutens, 2011).

### 2.4.2 Rabobank

The second bank to issue CoCos was the Dutch Rabobank in March 2010. This CoCo bond was a bit different compared to the one Lloyds Banking Group issued. They were issued as totally new bonds and had another trigger contingency and level. In case of the accounting level falling below 7%, this CoCo would instead of facing a conversion into shares, be written down by 75% of the par value. Since Rabobank was not a listed company, write down was the only possible opportunity. This bond is thereof contingent but not convertible. The maturity was 10 years with a coupon of Libor + 3.5% units.  Rabobank issued these CoCos to the amount of 1.25 billion Euros (Spiegeleer and Schoutens, 2011).

### 2.4.3 Credit Suisse

In early 2011, Credit Suisse launched two CoCo bonds. The first one was a pointed issue to two specific investors, Quatar Holding LLC and the Olayan Group. These two companies were since 2008 holders of hybrid Tier 1 debt issued by Credit Suisse that now, under Basel III, was no longer qualifying as Tier 1 debts. Therefor, Credit Suisse offered to exchange these old notes for new CoCos. The two investors adopted the offer and exchanged their old Tier 1 debts into new CoCo bonds. The issue was divided into two parts, one $3.5 billion issue and another $2.5 billion issue. They held the coupon rates of 9.5%, respectively 9%.

A few days later, Credit Suisse announced a public issue, which raised $2 billion in new capital. This second issue had the following anatomy; coupon rate of 7.875%, maturity time of 30 years but callable after 5 years and 6 months. Both the targeted and the public CoCos used a hybrid trigger composed of an accounting trigger at the level of 7%, respectively a regulatory trigger. The Swiss regulator has the power to instantly trigger the regulatory trigger if they believe Credit Suisse is close to insolvency. In this way, the Swiss government can prevent Credit Suisse from becoming insolvent and in a position where they requires public support. In case of a trigger event, the CoCo will convert into a fixed number of ordinary shares. The conversion price will be determined by an average trading price for a specific trading period that has occurred before the conversion date, however whit a conversion price ceiling of $20/share (Spiegeleer and Schoutens, 2011).

### 2.4.4 Bank of Cyprus

Just a few days after Credit Suisse announcement, Bank of Cyprus stated their issue of CoCos (2011). They were going to launch what they called “Convertible Enhanced Capital Securities”. This is a hybrid between a standard convertible bond and a CoCo bond. With this hybrid, the holders can choose to convert the investment into equity whenever they want until May 2016. After that, only compulsory conversion can take place. Like the CoCo issued by Credit Suisse, this CoCo has two trigger contingencies. Either if the Core Tier 1 ratio falls below 5% or by the discretion of the Central Bank of Cyprus. The bank itself can also, in consultation with the Central Bank, decide if they want to convert. The coupon rate will be at 6.5% until May 2016, where after it will float together with the rate of Euribor + 3% units (Spiegeleer and Schoutens, 2011).

# 3. Pricing of CoCos

In this section we will present how to price a CoCo by using the Credit Derivative approach. In Subsection 3.1 the Credit Derivative approach is described. In Subsection 3.2, the intensity-based credit risk model is presented. In Subsection 3.3 credit default swaps are described. Further, in Subsection 3.4 the premium leg is presented and in Subsection 3.5 the default leg is described. The CDS spread is presented in Subsection 3.6 and in Subsection 3.7 we will describe how the CDS spread can be connected with the CoCo. Finally, in Subsection 3.8 we will intimate describe the process of how to price a CoCo using the Credit Derivative approach.

### 3.1 Credit Derivative approach

In Spiegeleer and Schoutens (2011) the Credit Derivative approach is presented. The model is based on the theory of credit risk modeling with credit default swaps (CDS). In short, a CDS is an insurance against losses on a default, which will be explained more in Subsection 3.2. The main idea is to construct a fictive CDS that will default at the trigger moment $\tau^*$, i.e. at the same time the CoCo converts into equity. The model assumes a fixed income investor, which means we need to add an extra yield on the top of the risk free rate to compensate the risk of facing a loss.

## 3.2 Intensity-based credit risk modeling

To be able to start our work with the credit spread we first have to introduce and briefly explain the intensity-based credit risk model by following the work by Herbertsson (2010). Let $\tau$ be the default time for a company, so $\tau$ is a non-negative random variable with distribution function $p(t) = \mathbb{P}[\tau \leq t]$, thus is $p(t)$ the probability of default up to time $t$. Now, we say that the default time $\tau$ has the intensity $\lambda$ if the default time $\tau$ will arrive in the small interval $[t, t + \Delta t]$, conditionally on the fact that $\tau$ has not happened before time $T$, with probability $\lambda\Delta t$. Thus, the following relationship between $\tau$, $t$ and $\lambda$ should hold

$$\mathbb{P}[t < \tau \leq t + \Delta t \,|\tau > t] \approx \lambda\Delta t \tag{3}$$

where $\Delta t$ is small enough. By using the definition of conditionally probability, Equation (3) can be rewritten as

$$\frac{\mathbb{P}[t < \tau \leq t + \Delta t]}{1 - \mathbb{P}[\tau \leq t]} \approx \lambda \Delta t \tag{4}$$

Using the fact $\mathrm{p(t)} = \mathbb{P}[\tau \leq \mathrm{t}]$ then (4) can be rewritten as

$$\frac{p(\mathrm{t} + \Delta t) - p(t)}{1 - p(t)} \approx \lambda \Delta t$$

dividing this equation by $\Delta t$ and letting $\Delta t \to 0$ implies that

$$\frac{p(t + \Delta t) - p(t)}{\Delta t} * \frac{1}{1 - p(t)} \to \lambda \quad as\ \Delta t \to 0. \tag{5}$$

Further, we can by the mathematic rule of the derivative of a function determine that

$$\frac{p(t + \Delta t) - P(t)}{\Delta t} \to \frac{dp(t)}{dt} \quad as\ \Delta t \to 0.$$

From this equation together with Equation (5), we conclude that

$$\frac{\frac{dp(t)}{dt}}{1 - p(t)} = \lambda.$$

Now, since

$$-\frac{d}{dt}\ln\big(1 - p(t)\big) = \frac{\frac{dp(t)}{dt}}{1 - P(t)} \quad and\ due\ to \quad \frac{\frac{dp(t)}{dt}}{1 - P(t)} = \lambda$$

we get the following equation

$$-\frac{d}{dt}\ln\big(1 - p(t)\big) = \lambda.$$

Moreover, using that $p(0) = 0$ and $ln(1) = 0$ then by integrating both left and right hand side we arrive at

$$ln(1 - p(t)) = -\lambda\, \mathrm{t}.$$

Finally, by taking the exponential of this equation and reorder, we end up with

$$p(t) = 1 - e^{-\lambda t} \tag{6}$$

Hence, we conclude that if the default time $\tau$ has constant default intensity $\lambda$, then $\tau$ is exponentially distributed with parameter $\lambda$. The two equations above are identical if $\lambda$ is replaced by $\lambda(t)$, i.e. a function of the time. We now have a formula for the probability of default $p(t)$ that we will need in the upcoming subsections about the CDS (Herbertsson 2010).

## 3.3 Credit Default Swaps (CDS)

This subsection describes what a credit default swap (CDS) is and how it is structured. In short, a credit default swap (CDS) is an insurance against losses due to a default.

Consider a company C that has issued a bond with the default time, $\tau$. Another company A wants to buy the bond and at the same time ensure its protection if company C would default within T years, on the nominal amount of N units of currency. Therefore, company A, the protection buyer, signs a contract with a third company B, the protection seller, and pays a CDS premium every third month to company B for taking the risk. The CDS premium is also called the CDS spread $R(T)$ and the quarterly premium is therefore given by $\frac{R(T)N}{4}$ where $R(T)$ is quoted in basis points per annum. Company A pays the premium until the CDS matures and as long as a default does not occur before time T. The structure of a CDS contract is given in Figure 2. The default of a company could for example be that they go bankrupt or fails to pay a coupon on time to some of the investors of its issued bonds. The time at which a company defaults $\tau$, is a random time that is unknown until an eventual default occurs. Even though we are not able to know at what time the company may default, the probability of the company to default before some specific time t could be determined. Thereby, we can get a apprehension of the probability that event $\tau < \mathrm{t}$ strikes for different times t. The probability that the company defaults at time $\tau$ before time $t$, is denoted $p(t)$, where $t \geq 0$. So, formally $p(t) = \mathbb{P}[\tau < \mathrm{t}]$ where $\mathbb{P}$ is a measure of probability. The probability that a firm survives is thus 1- $p(t)$ and is called the survival distribution $s(t)$. If company C defaults before time t, $\tau < \mathrm{t}$, company B pays company A the nominal insured amount multiplied with the credit loss, N$\ell$. The credit loss is defined as $\ell = 1 - \mathrm{R}$ where R is the recovery rate (Herbertsson, 2010).

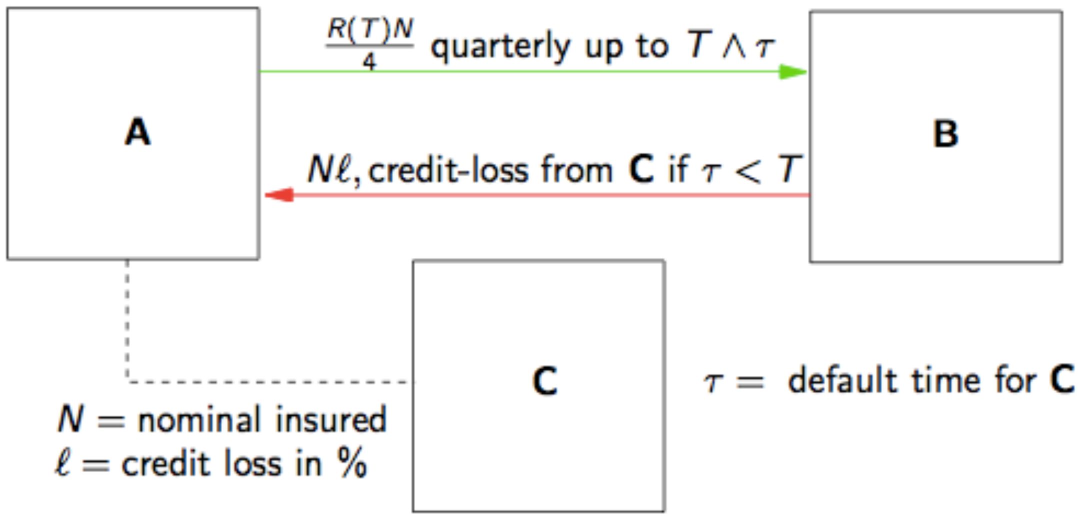


**Figure 2.** Structure of a CDS contract, Herbertsson (2010).

To get a better understanding of how the cash flows between the companies A and B could look, we illustrate the two possible scenarios of how the CDS could mature in Figure 3 and Figure 4.

In Figure 3, we have a scenario where company A pays the premium to company B quarterly until company C defaults at time τ which happens quarter k. Now, company A, the protection buyer, gets their credit loss $\ell$ in company C covered by company B, the protection seller.

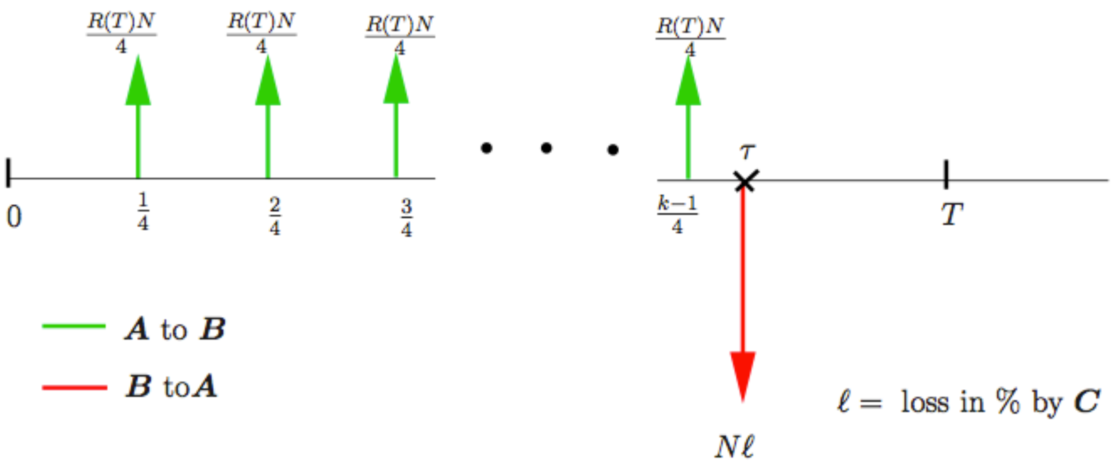


**Figure 3**. Company C defaults in quarter k (counting from t = 0) and τ < T, Herbertsson (2010).

The second scenario, displayed in Figure 4, illustrates how company A pays company B the CDS premium quarterly. Company C does not default on their payments in the time period T, thus $\tau > T$. The cash flows will thereby only be the CDS premium payments from company A to B until the CDS matures.

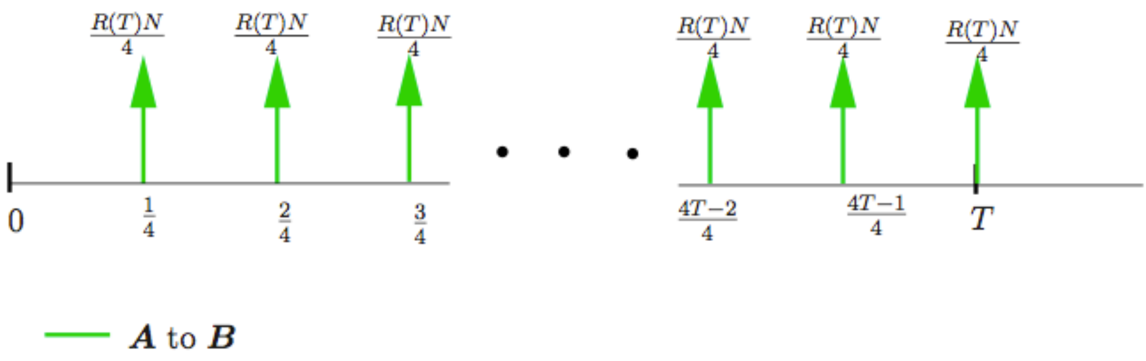


**Figure 4**. Example where there is no default on company C in the time period up to time T. Only cash flows from company A to B, Herbertsson (2010).

The CDS premium R(T) is determined so that the excepted discounted cash flows between A and B are equal at the day of inception $t = 0$. In order to be able to measure R(T) in a general model we have to connect the two different expected discounted legs, namely the premium and default leg. We will in the next three subsections, Subsections 3.3, 3.4 and 3.5, introduce further notations in the topic (Herbertsson, 2010).

## 3.4 The premium leg

Following the outline of Herbertsson (2010), we get formula for the premium leg PL(T), which is the total accumulated expected discounted cash flow from company A to B up to a given time T.

$$\mathrm{PL(T)} = \sum_{n=1}^{4T} e^{-r\frac{n}{4}}\left(1 - p\left(\frac{n}{4}\right)\right)\frac{R(T)N}{4} \tag{7}$$

where $1 - p\left(\frac{n}{4}\right) = s\left(\frac{n}{4}\right)$ is the probability that company C will survive up to time $\frac{n}{4}$. Moreover, 4T are the number of quarterly premium payments up to time T. As an example, if we got $T = 10$, then there would be $4 * 10 = 40$ quarterly payments up to $T = 10$. At last, the interest rate r is set as a constant and this will hold through out this whole section.

## 3.5 The default leg

As in the previous subsection, by following the outline of Herbertsson (2010), we get the total expected discounted cash flow from company B to A up to time T. This, so-called default leg DL(T) is given by

$$\mathrm{DL}(\mathrm{T}) = \sum_{n=1}^{4T} e^{-r\frac{n}{4}}\left(p\left(\frac{n}{4}\right) - p\left(\frac{n-1}{4}\right)\right)\mathrm{N}\ell \tag{8}$$

we have assumed that if a default occurs in the time period $\left[\frac{n-1}{4}, \frac{n}{4}\right]$, the CDS issuer, company B pays the loss $\mathrm{N}\ell$ caused by the default of firm C to company A at time $\frac{n}{4}$ where $\frac{n}{4} \leq \mathrm{T}$.

## 3.6 The CDS spread

As mentioned before, the CDS spread is determined so that the excepted discounted cash flows between company A and B are equal at the day of inception $t = 0$. This means that the premium leg should equal the default leg, $PL(T) = DL(T)$. By connecting Equation (7) and (8) we get

$$R(T) = \frac{(1-R)\sum_{n=1}^{4T} e^{-r\frac{n}{4}}\left(p\left(\frac{n}{4}\right) - p\left(\frac{n-1}{4}\right)\right)}{\sum_{n=1}^{4T} e^{-r\frac{n}{4}}\left(1 - p\left(\frac{n}{4}\right)\right)\frac{1}{4}} \tag{9}$$

where $R$ is the recovery rate, $r$ the risk free interest rate, $p(t_n)$ the probability of default before time $t_n = \frac{n}{4}$. The loss is constant, $\ell = 1 - R$. Also, in case of a default, the loss is paid at the end of the quarter instead of immediately at time τ.

By assuming a constant default intensity $\lambda$ we have that $p(t) = 1 - e^{-\lambda t}$ and by using this in Equation (9) the CDS spread can then be simplified to the following expression

$$R(T) = 4(1-R)(e^{\frac{\lambda}{4}} - 1) \tag{10}$$

For a detailed derivation of Equation (10) see in Herbertsson (2010).

Moreover, if the constant default intensity parameter $\lambda$ is small we can use a Taylor-expansion for $e^x$. A Taylor-expansion is a mathematic method of expressing a function with an infinite sum of term. The terms that are used are values of the functions derivatives at a specific point. The Taylor-expansion for $e^x$ is expressed as follows

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = 1 + x + \frac{x^2}{2} + \frac{x^3}{6} + \cdots$$

When $x$ is small we have $\frac{x^n}{n!} \approx 0$ for $n \geq 2$ which means that when x is small we can use that

$$e^{x} \approx 1 + x\,.$$

Assuming this, $e^{x}$ in Equation (10) will for $x = \frac{\lambda}{4}$ be given by

$$e^{\frac{\lambda}{4}} \approx 1 + \frac{\lambda}{4}$$

and the CDS spread $R(T)$ in Equation (10) can therefore be simplified as follows

$$R(T) \approx (1 - R)\lambda\,. \tag{11}$$

## 3.7 Connecting the CoCo and the CDS spread

Follwing Alvermar and Ericsson, (2012), we are now going to describe how to connect the CoCo and CDS spread.

To prevent a financial institution to default the CoCo-conversion has to occur before the default time τ. This implies that the intensity parameter of conversion $\lambda_{CoCo}$ has to be greater than the default intensity parameter, $\lambda_{CoCo} \geq \lambda$. Which implies that the CoCo-trigger event $\tau^{*}$ always occur before the default time τ, that is $p[\tau^{*} < \tau] = 1$. Reason why is because the CoCo will only be helpful for the company if it converts before the company defaults.

So, by using $\lambda_{CoCo}$ it is possible to create a fictive CDS that default at the random time $\tau^{*}$ if the CoCo converts into equity at $\tau^{*}$.

We will use a CDS CoCo which converts at the random time $\tau^{*}$ where $\tau^{*}$ has arrival-intensity $\lambda_{CoCo}$. The CDS CoCo pays annual premium since CoCos generally pay coupons once a year even that quarterly premium payment are standard for CDS contracts. A CDS CoCo with annual coupon payment and a fixed conversion intensity $\lambda_{CoCo}$ will have a credit spread of $S_{CoCo}(T)$. The credit spread of the CoCo can be calculated from Equation (10) as follow

$$S_{CoCo}(T) = (1 - R_{CoCo})\left(e^{\,\lambda_{CoCo}} - 1\right).$$

With the same assumption as previous mentioned in Equation (11), if $\lambda_{CoCo}$ is small we can use the following formula when calculating the CDS CoCo spread

$$S_{CoCo}(T) = (1 - R_{CoCo})\ \lambda_{CoCo}\,. \tag{12}$$

## 3.8 Pricing by the Credit Derivative approach

We are now going to describe the process of how to price a CoCo using the Credit Derivative approach presented by Spiegeleer and Schoutens (2011).

To calculate the CoCo price with the Credit Derivative approach we are going to use following key formula

$$Price = \sum_{i=1}^{T} CF_i \, e^{(-Y*t_i)} \tag{13}$$

where $CF_i$ is the cash flow at time $t_i$, Y the yield and T the maturity time. This equation is the formula for pricing a normal bond. A normal bond is priced by calculating the present value of all the cash flows that the bond holder will get until the bond matures. We can use this formula for calculating the price of a CoCo too since a CoCo is just like a normal bond if it does not trigger during its maturity (Hull 2012, p80).

To get the price we need to determine the yield, $Y_{CoCo}$ by adding the risk free rate, r and the CoCo credit spread, $S_{CoCo}(T)$. To do this we will use following formula

$$Y_{CoCo} = r + S_{CoCo}(T). \tag{14}$$

The CoCo credit spread can be calculated using Equation (12) derived in Subsection 3.6.
So $S_{CoCo}(T)$ is given by

$$S_{CoCo}(T) = (1 - R_{CoCo})\, \lambda_{CoCo} \,.$$

Secondly, to be able to calculate the $\lambda_{CoCo}$, we need to determine the probability of conversion up to time T which is defined as $p^*(T)$.

It is problematic to determine the probability of conversion for a CoCo with an accounting trigger and a regulatory trigger. Hence, it is difficult to model the behavior of the governmental authority and the movement of an accounting ratio. However, for a CoCo characterized by a market trigger the value of $p^*(T)$ can be easier to determine.

By assuming that the share price follows a continuous time stochastic process, so-called a geometric Brownian motion (GBM) we can calculate $p^*(T)$ by using the Black-Scholes formula for barrier option pricing.

In the Black-Scholes model the log-price of the stock is following a standard normal distribution. Furthermore, in the Black-Scholes model, the probability $p^*(T)$ that a stockprice hits the barrier level $S^*$ before time $T$, is given by

$$p^*(T) = N\left(\frac{ln\left(\frac{S^*}{S_0}\right) - \mu T}{\sigma\sqrt{T}}\right) + \left(\frac{S^*}{S_0}\right)^{\frac{2\mu}{\sigma^2}} N\left(\frac{ln\frac{S^*}{S_0} + \mu T}{\sigma\sqrt{T}}\right) \tag{15}$$

where $S_0$ is the share price at the issue date, σ is the volatility of the stock price, and μ is given by

$$\mu = r - q - \frac{\sigma^2}{2} \tag{16}$$

where $q$ is the continuous dividend yield.

Further, $\lambda_{CoCo}$ can be calibrated by plugging in $p^*(T)$ from Equation (15) into Equation (6), the probability of conversion for a CDS CoCo. Hence,

$$\mathrm{p}^*(\mathrm{T}) = 1 - \mathrm{e}^{(-\lambda_{CoCo}\mathrm{T})}.$$

By solving the equation for $\lambda_{CoCo}$, we get

$$\lambda_{CoCo} = -\frac{\ln(1 - \mathrm{p}^*(\mathrm{T}))}{\mathrm{T}}$$

and this $\lambda_{CoCo}$ tell us at which default intensity grade the CoCo would trigger.

Further, we need to calculate the recovery rate, $R_{CoCo}$ which will be done using Equation (2).

Now when the values for $\lambda_{CoCo}$ and $R_{CoCo}$ are computed, the next step is to calculate the credit spread by using Equation (12) for $S_{CoCo}(T)$. With the CoCo credit spread we are able to compute the yield to maturity, $Y_{CoCo}$, using Equation (14). Furthermore, the cash flow is the only missing variable in order to be able to calculate the price of a CoCo bond. The total cash flow is the sum of all the cash flows that are going to be made in the future until the CoCo matures The price of the CoCo is computed by adding the present values of the cash flows, i.e. in the same way the value of a bond is calculated. The cash flows are the same from $t_0$ to $t - 1$, namely the face value $F$ multiplied with the coupon rate $c$. The last cash flow at time $t$ consist of the face value multiplied with the coupon rate, plus the face value of the CoCo. Thus, if $CF_i$ is the cash flow at time $t_i$ then the present value $PV\ (CF_i)$ is given by

$$PV\ (CF_i) = CF_i e^{(-Y*t_i)}$$

where $Y$ is the yield that defines the interest rate that makes the total discounted cash flows to reflect the market value of the CoCo today.

Hence, the price of the CoCo is ready to be computed using Equation (13) mentioned in the beginning of this section.

In Table 1 below, all the involved variables in the Credit Derivative approach are defined.

| Variable | Definition |
|---|---|
| $\boldsymbol{Y}$ | Yield |
| $\boldsymbol{CF_i}$ | Cash flow at time $t_i$ |
| $\boldsymbol{S_{CoCo}(T)}$ | CoCo Credit spread in bp/annum |
| $\boldsymbol{r}$ | Risk free rate |
| $\boldsymbol{\lambda_{CoCo}}$ | Intensity parameter of conversion |
| $\boldsymbol{R}$ | Recovery rate |
| $\boldsymbol{p^*(T)}$ | Probability of conversion for a CoCo CDS |
| $\boldsymbol{S^*}$ | Share price when the conversion will occur |
| $\boldsymbol{S_0}$ | Share price at the issue date |
| $\boldsymbol{\sigma}$ | Volatility of a stock-price in the Black-Scholes model |
| $\boldsymbol{\sigma^2}$ | Variance of a stock-price in the Black-Scholes model |
| $\boldsymbol{\mu}$ | See Equation (16) |
| $\boldsymbol{F}$ | Face value of the CoCo bond |
| $\boldsymbol{c}$ | Annual coupon rate |
| $\boldsymbol{q}$ | Dividend yield |
| $\boldsymbol{T}$ | Maturity time |

**Table 1.** Variables in the Credit Derivative approach for pricing CoCos.

# 4. Numerical studies of the Credit Derivative approach

In this section we will price CoCo bonds in the Credit Derivative approach. In Subsection 4.1 we will perform different sensitivity studies of the CoCo price by varying different parameters in the underlying model, which is the Credit Derivative approach. Further, in Subsection 4.2 we will investigate the model by using real data from the Swedish bank Nordea to illustrate what the price of a CoCo could be set to, if Nordea would issue them. Finally, in Subsection 4.3 we will investigate the model by using data from another Swedish bank, Handelsbanken.

## 4.1 Sensitivity analysis of the CoCo prices

In this subsection we will perform different sensitivity studies of the CoCo price by varying different parameters in the underlying model, which is the Credit Derivative approach. The constant variables that we are going to use are presented in Table 2. The risk-free rate is the Swedish short term government bond as of 21/5-13. Moreover, the dividend yield is an approximate average and the coupon rate is set approximate higher than ordinary bonds. We have chosen to set the share price at the issue date equal to the conversion price, which means that the current shareholders do not have to deal with a huge dilution, as the investor of the CoCo bond will bear a part of the loss. We have chosen to set the trigger point, i.e. the moment when the conversion occur at 30 as it seems like a reasonable share price for a company with financial problems. Further, the maturity time for this CoCo is 10 years.

| Variable | $r$ | $T$ | $q$ | $c$ | $S_0$ | $S^*$ | $C_p$ |
|---|---|---|---|---|---|---|---|
| **Value** | 1.5% | 10 | 5% | 7% | 100 | 30 | 100 |

**Table 2.** Fixed variables for the sensitivity analysis in this subsection.

Figure 5 displays the CoCo spread $S_{CoCo}(T)$ as a function of maturity $T$ for different levels of volatility σ. Hence, the maturity time T is not fixed in this investigation Also, as the CoCo spread is analyzed, the coupon $c$ will not be used. We notice a different pattern between the four scenarios of volatility. With a volatility of 10 and 20%, the CoCo spread increases with maturity. With higher levels of volatility (30-40%), the CoCo spread is first increasing then decreasing with maturity. The spread for the lower levels of volatility would probably also start decreasing with maturity if we had longer maturities than 30 years. The CoCo spread is low with short maturities because it implies smaller risk for the investor compared to longer maturities. Our results are in line with results presented in e.g. Alvermar and Ericsson, (2012).

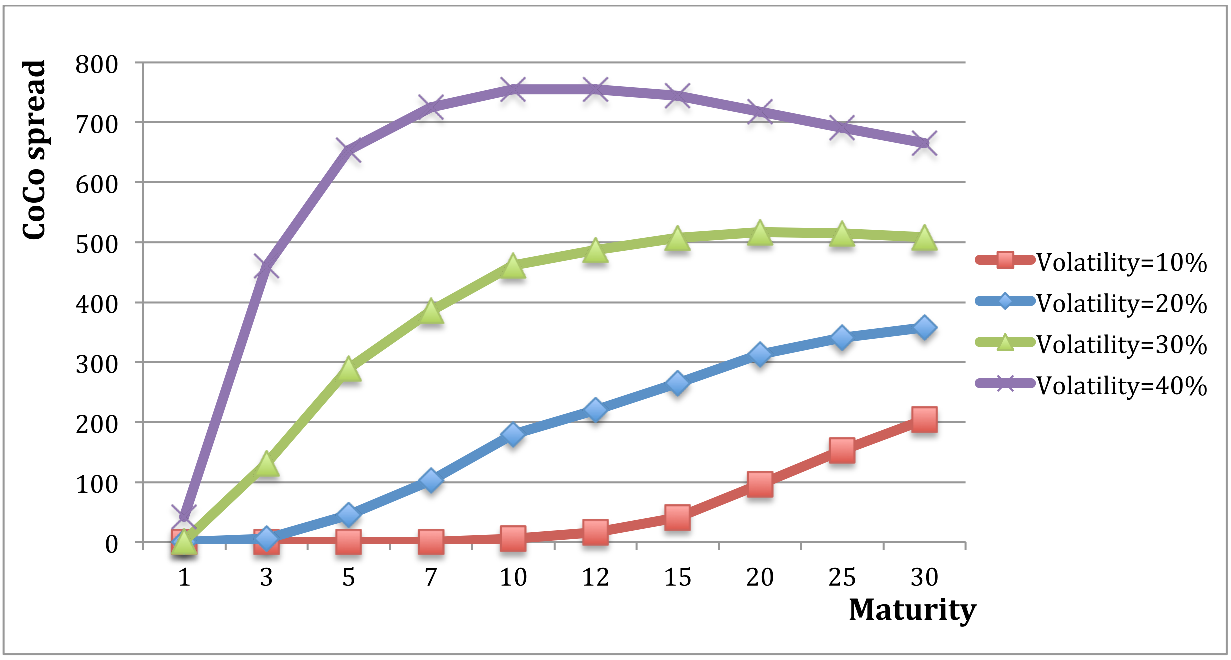


**Figure 5.** CoCo spread $S_{CoCo}(T)$ as a function of maturity time $T$ for different levels of volatility $\sigma$ with parameters given by Table 2.

In Figure 6 we display the CoCo price as a function of the volatility $\sigma$ at different levels of conversion prices $C_p$ (see Equation 1 about $C_p$). All the variables in Table 2, except the conversion price, are held constant. Figure 6 shows that the price of the CoCo is decreasing with increasing volatility. Hence, there is a negative correlation between the price and volatility. The reason for that is because higher volatility implies increasing probability for the CoCo to be converted and the investor will thereby require a lower price and higher yield. Moreover, we can also observe that for given level of volatility, the price is decreasing in conversion price. As Figure 6 displays, the price of red graph with conversion price=30 is totally uncorrelated with the volatility. Since the recovery ratio, $R$, is determined by the $C_p$

divided by the trigger level $S^*$, this CoCo has a recovery ratio of 1, as $C_p$=$S^*$=30. A recovery of 100% means that an investor in case of conversion, does not loose any money at all since the whole value of the CoCo is only converted into equity. The CoCo is thereby risk free (with respect to conversion into a stock) and has a spread equal to zero, which in this case explains why the price is fixed at 150,59 and totally uncorrelated with the volatility. Thus, in this case the CoCo will be identical to an ordinary bond.

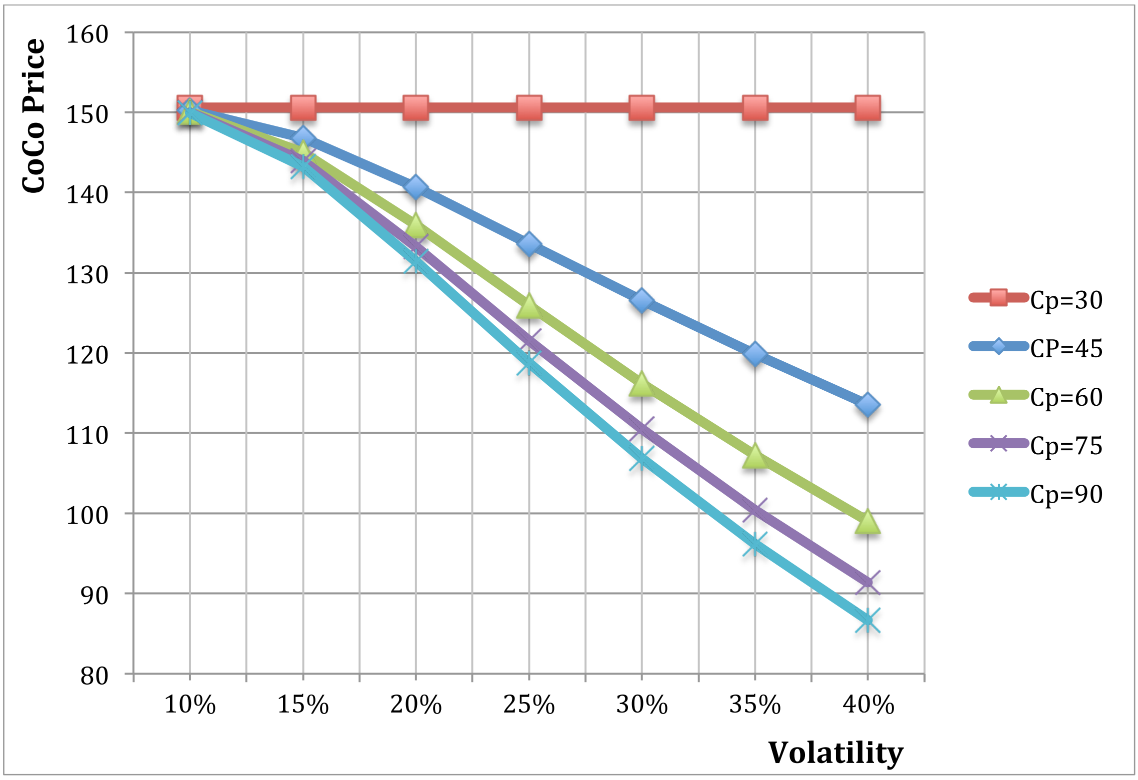


**Figure 6.** CoCo price as a function of volatility $\sigma$ for different conversion prices $C_p$ with parameters given by Table 2.

Investigating how the CoCo price varies with changes in dividend yield $q$ at different levels of volatility $\sigma$ is displayed in Figure 7. So, in this sensitivity analysis, the dividend yield varies. As the figure shows, the CoCo price is decreasing with increasing dividend yield $q$. Therefore, there is a negative relation, but here, between the CoCo price and the dividend yield. If the volatility is high it is more likely that the CoCo will convert into equity. So, for every given dividend yield the price is decreasing in volatility. For instance, looking at the green graph, when the volatility is $\sigma = 30$ and there is no dividend yield, the investor can expect a CoCo price of 100,91. It is intuitive clear that the CoCo prices decreases with increasing dividend yield. The reason for this is that each time there is a dividend, the stocks drops down and comes closer to the conversion barrier. In the case with continuous dividend yield the same intuitive holds since from the formula $\mu = r - q - \frac{\sigma^2}{2}$ we see that the bigger the dividend yield, the smaller is the drift parameter $\mu$.

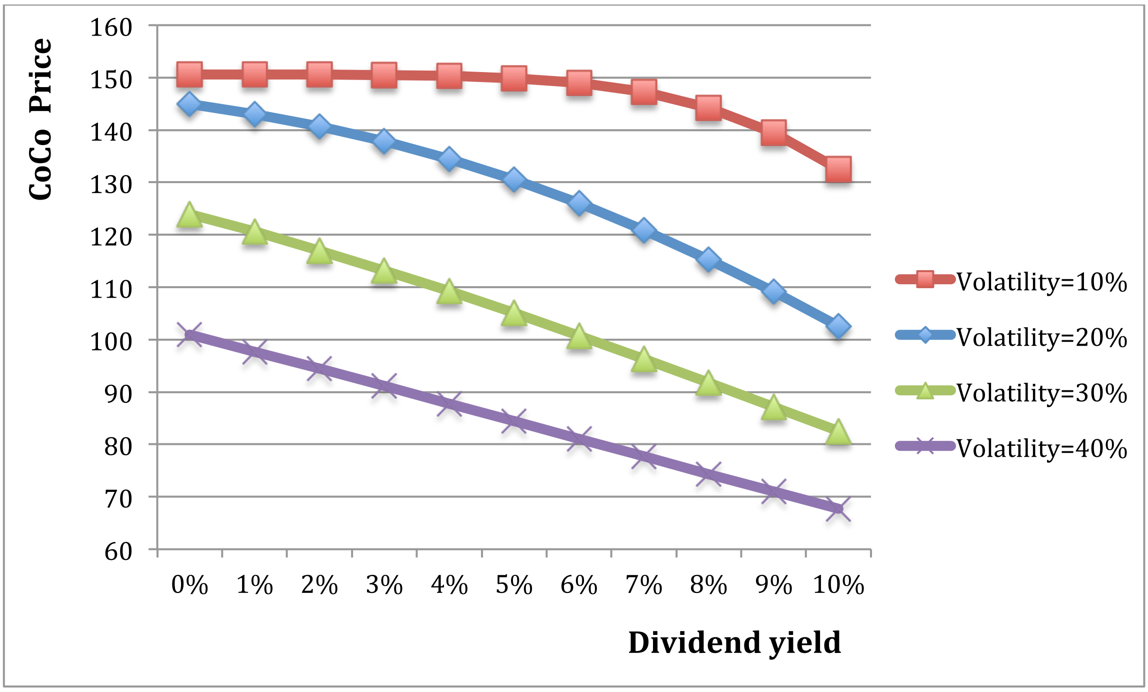


**Figure 7.** CoCo price as a function of dividend yield $q$ for different levels of volatility $\sigma$ with parameters given by Table 2.

In Figure 8 we display the CoCo price as function of the volatility $\sigma$ at different levels of strike prices $S^*$. Hence, the strike price is not constant in this sensitivity analysis. As Figure 8 shows the price is negatively correlated with the volatility. Furthermore, as the strike price increases, the negative correlation between the price and volatility gets reduced. This is explained by the reason that the probability for conversion already is high with high strike prices and the influence of the volatility will thereby decrease with the strike price. Moreover, it is intuitive clear that a low strike price implies a higher price of the CoCo since the investor faces a lower probability for the CoCo to convert and vise versa.

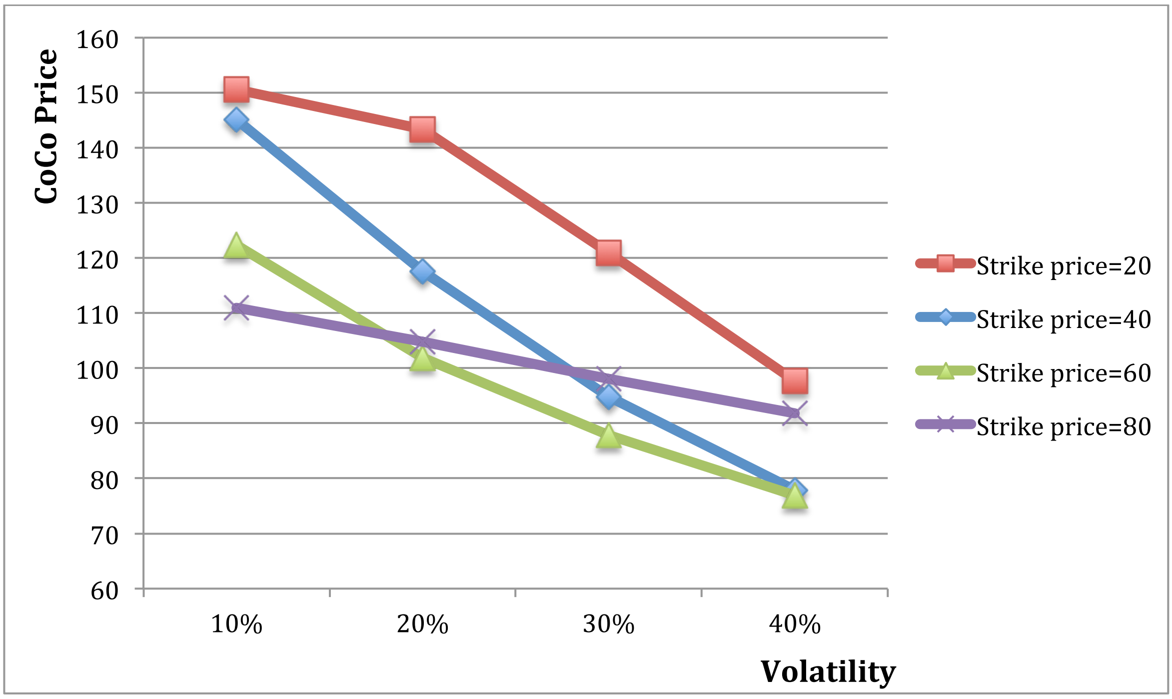


**Figure 8.** CoCo price as a function of volatility $\sigma$ for different levels of strike prices $S^*$ with parameters given by Table 2.

In Figure 9 we examine the CoCo price as a function of the coupon rate within four different scenarios of volatility. The coupon rate is thereby not held constant. First we see that the there is a linear positive correlation between the price and coupon rate. With higher coupon rates, the investor gets more return, which naturally implies a higher price of the CoCo. Also, there is different correlation between the price and coupon rate at different volatility. With higher volatility, the positive correlation decreases.

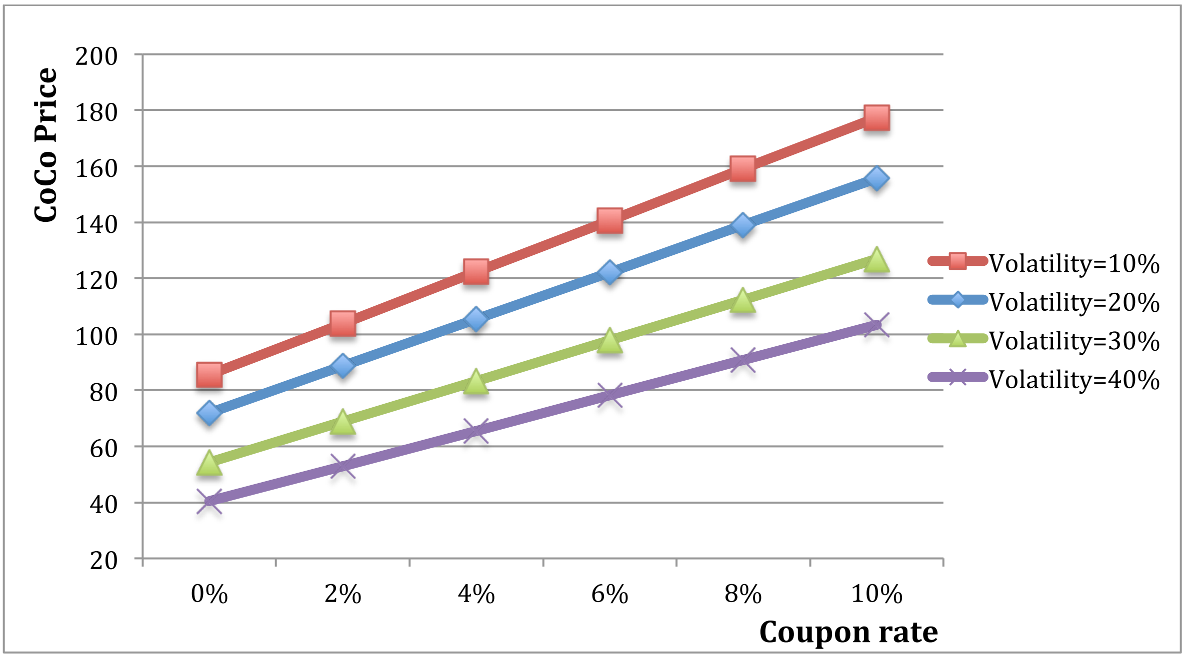


**Figure 9.** CoCo price as a function of Coupon rate $c$ for different levels of volatility $\sigma$ with parameters given by Table 2.

To get at another perspective of how the relationship in Figure 9 could look, we here in in 3D (Figure 10), display how the price is affected by the coupon rate within four different scenarios of volatility.

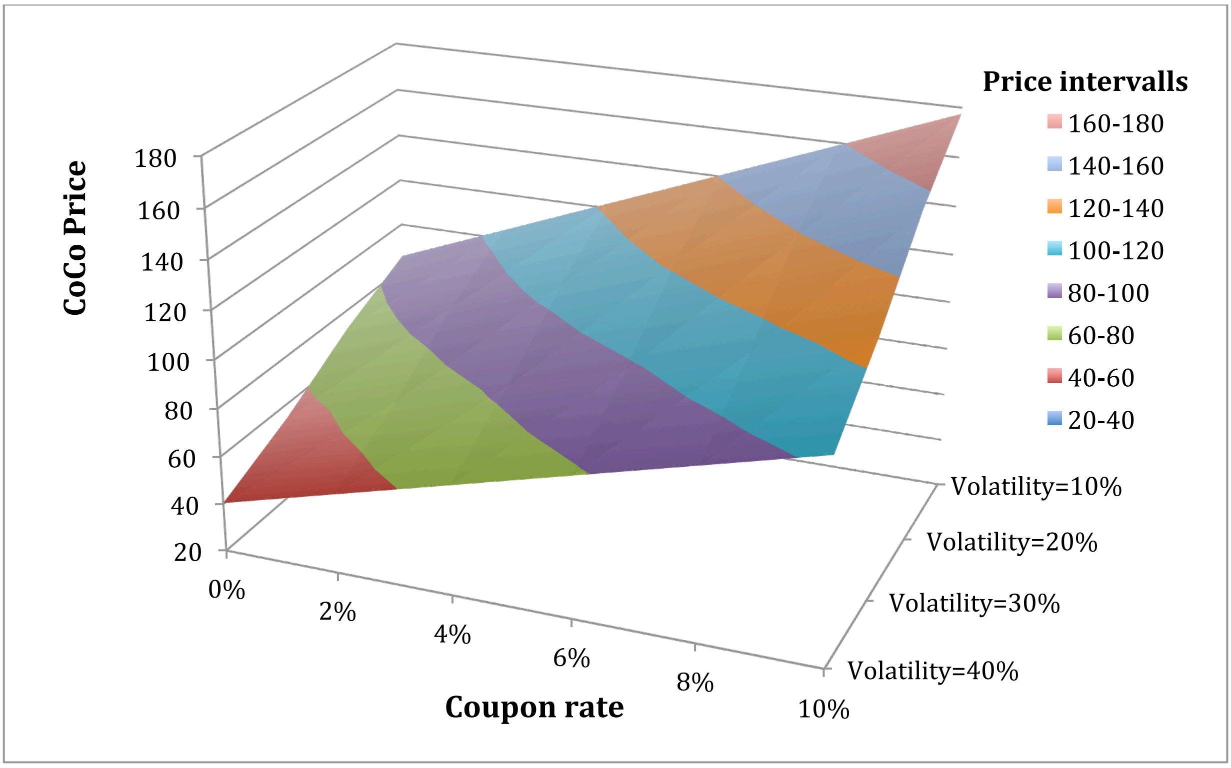


**Figure 10.** 3D perspective of the CoCo price as a function of Coupon rate $c$ for different levels of volatility $\sigma$.

## 4.2 Pricing of Nordea CoCo

In the previous Subsection, we only used fictive data to model how the Credit spread and price changed in different scenarios. Here we have calculated some variables from real stock data of Nordea. In this and the following subsection, we use historical volatility instead of implied volatility since its more accessible. Still the values for the strike price, maturity, conversion price and coupon rate are assumptions we have made. We have chosen to set the strike price at approximately 50 % of the share price at the issue date. We assume that this is a realistic level for the CoCo to trigger. We set the coupon rate at 7 % because the coupon rate for a CoCo should be some percent units higher than a normal bond. Also, the banks that have issued CoCos have a coupon rate between 6-9 %. Table 3 below shows all the variables used to compute the price of a Nordea CoCo.

| Variable | Value | Definition |
|---|---|---|
| $S^*$ | 40 | Strike price/trigger level |
| $S_0$ | 82,6 | Share price as of 22/5-13 (Nordnet) |
| $\sigma$ | 27,86% | Yearly average volatility since may 2003 as of 22/5-13 (Yahoo Finance) |
| $T$ | 10 | Assumed to be issued 22/5-13 with a maturity of 10 years |
| $C_p$ | 82,6 | Conversion price equal to $S_0$ |
| $r$ | 1,5% | Swedish short term government bond as of 21/5-13 |
| $q$ | 3,45% | Dividend yield as of year 2013 (Yahoo Finance) |
| $c$ | 7% | Coupon rate |

**Table 3.** Variables for application on Nordea

When implying these variables using the Credit Derivative approach, we got the data results displayed in table 4.

| Variable | Result |
|---|---|
| $p^*(t)$ | 64,04% |
| $\lambda_{CoCo}$ | 0,102 |
| $R$ | 48,42% |
| $S_{CoCo}(T)$ | 527,53 bp |
| $Y$ | 6,78% |

**Table 4.** Results of application on Nordea.

With these values computed we are now able to get the price by calculating the present value of all the upcoming cash flows. The results are displayed in Table 5. The price of our Nordea CoCo would then be at 82,54 SEK.

| $t_i$ | $CF$ | $CF * e^{(-Y*t_i)}$ |
|---|---|---|
| 1 | 5,782 | 5,403229701 |
| 2 | 5,782 | 5,049272087 |
| 3 | 5,782 | 4,718501714 |
| 4 | 5,782 | 4,409399621 |
| 5 | 5,782 | 4,12054635 |
| 6 | 5,782 | 3,850615432 |
| 7 | 5,782 | 3,59836729 |
| 8 | 5,782 | 3,362643552 |
| 9 | 5,782 | 3,142361728 |
| 10 | 88,382 | 44,88665657 |
| **Sum** | 140,42 | **82,54159404** |

**Table 5.** CoCo price of Nordea.

## 4.3 Pricing of Handelsbanken CoCo

To get some more empirical results, we are going to calculate the price for a CoCo issued by Handelsbanken. As in the previous calculation of the Nordea CoCo, we have also here calculated some variables from real stock data of Handelsbanken. Still, the values of the strike price, maturity, conversion price and coupon rate are assumptions we have made.
Table 6 below shows all the variables used to compute the price of a Handelsbanken CoCo.

| Variable | Value | Definition |
|---|---|---|
| $S^*$ | 150 | Strike price/trigger level |
| $S_0$ | 300 | Share price as of 21/5-13 (Nordnet) |
| $\sigma$ | 22,49% | Yearly average volatility since may 2002 as of 21/5-13 (Yahoo Finance) |
| $T$ | 10 | Assumed to be issued 21/5-13 with a maturity of 10 years |
| $C_p$ | 300 | Conversion price equal to $S_0$ |
| $r$ | 1,5% | Swedish short term government bond as of 21/5-13 |
| $q$ | 3,4% | Average dividend yield since 2002 (Yahoo Finance) |
| $c$ | 7% | Coupon rate |

**Table 6.** Variables for application on Handelsbanken.

Again, when implying these variables using the Credit Derivative approach, we got the data results displayed in table 7.

| Variable | Result |
|---|---|
| $p^*(t)$ | 54,79% |
| $\lambda_{CoCo}$ | 0,079 |
| $R$ | 50% |
| $S_{CoCo}(T)$ | 396,97 bp |
| $Y$ | 5,50% |

**Table 7.** Results of application on Handelsbanken.

With these values we are now able to compute price by calculating the present value of all the upcoming cash flows. The results are displayed in Table 8. The price of our Handelsbanken CoCo would then be at 330,98 SEK.

| $t_i$ | $CF$ | $CF * e^{(-Y*t_i)}$ |
|---|---|---|
| 1 | 21 | 19,88221719 |
| 2 | 21 | 18,82393145 |
| 3 | 21 | 17,82197587 |
| 4 | 21 | 16,87335215 |
| 5 | 21 | 15,97522153 |
| 6 | 21 | 15,12489638 |
| 7 | 21 | 14,31983214 |
| 8 | 21 | 13,55761965 |
| 9 | 21 | 12,83597802 |
| 10 | 321 | 185,76343 |
| **Sum** | 510 | 330,9784543 |

**Table 8.** CoCo price of Handelsbanken.

# 5. Discussion

In this section will we discuss the accuracy of the Credit Derivative approach as a model for pricing CoCo bonds. We will also discuss the result from Subsection 4.2 and 4.3 where we calculated what price CoCos issued by Nordea and Handelsbanken would land at.

Like in many other financial models, assumptions have been made when using the Credit Derivative approach. First, in the estimation of the CDS, we ignore the accrued premium term and the loss in case of a default is paid at the end of the default quarter. Also, to not make the model too complex to implement we assumed that the intensity is constant. All those assumptions does reduce the accuracy of the model, but were necessary for simplifying the computations.

Further, the Black Scholes formula that we used in the Credit Derivative model has many assumptions. For example, the Black Scholes assumes that volatility is fixed, the returns over time intervals are independent and normally distributed. Since the real worlds price of different assets often are fat tailed, instead of normal distributed, this assumption is a weakness in the model. Further, the fixed volatility is a weakness, as the probability of large share price movements will not get reflected in the model. The probability of conversion will thereby get underestimated. Also there are two different types of volatility that could be used, the historical and the implied volatility. The two, generally differ from each other so depending on which volatility we use, the result will be different.

From our sensitivity analysis we clearly see that the volatility has great impact on the CoCo price. Hence, calculating a correct volatility will be an important task for getting an accurate CoCo price.

As the conversion ratio decides what amount of shares the investor of a CoCo receives, it also determines the loss of the CoCo when the trigger event occurs. Thus, the investor has to consider the price against the risk. If the conversion price is equal to the share price at the moment of the trigger, the investor will not face a loss and will therefore have to pay a higher price for the CoCo. On the other hand, like we have assumed in our sensitivity analysis, if the conversion price is equal to the share price at the issue date the investor can expect a loss. Hence, the risk is higher so the price will be lower. Our results do thereby reflect a CoCo that would be preferable for the current shareholders as the dilution get smaller because the CoCo holder bears the bigger part of the loss.

In the case of Handelsbanken, the CoCo price would be higher than the share price on the issue date. A CoCo price above the share price is expected as the coupon rate is higher than the yield. On the other hand, in the case of Nordea, the CoCo price is tiny lower than the share price on the issue date. This could be explained that in this case, the coupon rate is just slightly higher than the yield, and therefore there is not a bigger difference between the CoCo price and the share price.

## 6. Conclusion

The framework of a CoCo depends on many different input variables that in the end affect the CoCo price. A good working pricing model is very important in order to get an accurate and fair price for both the issuer and the investor.

Finally, due to the recent financial crisis and the new regulatory frameworks we can expect more CoCos in the future.

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