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"A VALUATION FRAMEWORK FOR CONTINGENT CONVERTIBLE BONDS"

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INDEX

ABSTRACT

This thesis presents a recently born asset class, Contingent Convertibles (CoCos), mixing features of both debt and equity that emerged in the last few years and that is growing fast in the financial markets. CoCo bonds, converting into equity under a certain Common Equity Tier 1 ratio, are the regulatory response to the 2008 financial crisis.

The financial crisis of 2007-2008 unveiled the fragility of today's global financial system. The high number of bankruptcies and of bailouts of private banks with taxpayers' money, opened the way to new regulatory directives aimed at strengthening the banking system, especially with regard to their capital base. The desire to protect taxpayers and to make managers more responsible, lead to the beginning of the "bail–in" era, in which banks are saved by their equity and debt holders. It is in this contest of regulatory reform, to strengthen the capital stability and reduce banks failures, the birth of contingent capital takes place. CoCos, instruments also known as Additional Tier 1 bonds, are financial hybrid securities issued by banks, which offer the advantages of debt in good times and equity in times of financial distress. These securities are imposed to European banks through the EU Capital Requirements Directive of 2013 (CRD IV), which is inspired by Basel III framework for strengthening the financial system. The purpose of this thesis is to analyze the hybrid instruments of Additional Tier 1, identifying their key risks from a fixed income investor perspective, and to try assessing a framework to come out with a credible "fair" spread that the investor will require for accepting bearing all the uncertainty surrounding this particular and new asset class.

Chapter 1 will briefly introduce the reader to the Basel III framework, discussing the main interventions of the regulator with a specific focus on the new definition of the capital base and on the minimum capital requirements for internationally active banks. In the regulator's intent of improving the capital quality, Additional Tier 1 CoCos, which are the centerpiece of this thesis, play the most innovative role.

In Chapter 2, a definition of CoCo bonds will be given, and all the key features that make them a hybrid instrument between debt and capital will be discussed. In particular, after presenting their deeply subordinated nature, the risks of coupon deferral, of extension and of conversion will be analyzed, pointing out the reasons for the huge uncertainty that surrounds these financial hybrid securities and their differences with previous "old style" Tier 1 debt. The key point we will discuss

is the loss absorption mechanism and the conversion trigger, which are fundamental for the design of CoCos and for which many proposals were elaborated by the academic world.

Chapter 3 will briefly present some valuation models for CoCo bonds existing in literature and will describe the valuation methodology elaborated in this thesis. Most existing models are related to Tier 2 CoCos, which have different characteristics with respect to Additional Tier 1 CoCos, which are the object of this thesis. These models focus only on the conversion feature of the securities, which are priced as derivatives instrument. While we think these proposals correctly price the conversion risk upon a certain maturity, these models neglect other risks such as the coupon cancellation and the extension risk, which are important new features of AT1 CoCos. In this thesis we will instead extend the so-called "Rock-bottom spread" framework based on a discounted cashflow approach and on credit fundamentals, developed by J.P. Morgan in 2001 and adjusted for old-style Tier 1 by Henriques, Goulden, & Granger (2006). We will adapt this framework introducing the different features of new Additional Tier 1 CoCos.

In chapter 4, we will then test the new framework, which takes into account all the possible cash flow scenarios through the empirical rating migration matrix representing all the possible financial conditions of the issuing institution, on some hybrid securities recently issued by six European Banks.

Chapter 5 will finally discuss the obtained "rock-bottom" spreads, which are the smallest spread accepted by an investor with a fully diversified portfolio, based on his performance target and on his view of the credit fundamentals of the institutions. This spread is thus almost market independent and we compare it to the one offered by the market to see whether the securities are cheap or expensive according to our views.

The conclusions will restate the assumptions of the model, and highlight its limitations, knowing that the aim of this work is not to obtain a "unique" and "correct" spread, but rather to present the new and growing asset class of Contingent Convertibles and all the risks they hide for a fixed income investor. The minimum spread the investor will accept is derived through a discounted cash flow based and almost market independent valuation framework.

1 FINANCIAL CRISIS, BASEL III AND COCOS

Contingent Convertibles are financial hybrid instruments that emerged in the Basel III framework, in the aftermath of the last global financial crisis, as a tool to strengthen financial institutions' capital and make it more effective in absorbing unexpected huge losses. This first chapter aims thus at describing the regulatory framework in which CoCo bonds were indicated as a possible mean of preventing other financial crisis.

1.1 FINANCIAL CRISIS AND FINANCIAL STABILITY

The financial crisis of 2007-2008 unveiled the weakness and the vulnerability of the highly and internationally interconnected financial system, with special regard to the so-called global, systemically important banks (G-SIB), which are the ones carrying the highest systemic risk (Veiteberg et al. 2012). These banks, also known as systemically important financial institutions (SIFIs), were particularly affected by insufficient capital buffers, and are the main targets of the increased capital requirements contained in Basel III (King & Tarbert 2011).

One of the main reasons the financial crisis in 2008 became so severe indeed, is the excessive on- and off-balance sheet leverage in the banking sectors of many countries. The capital level that banks held was thus inadequate, and the quality of its common equity was not such to absorb losses and prevent insolvency (Chan & Kenadjian 2014). In addition, many banks had insufficient liquidity buffers and were not able to reintermediate the off balance sheet exposures they had in the shadow banking system, hence making impossible for them to face the trading and credit losses that the systemic crisis had generated. The crisis was amplified by a pro-cyclical deleveraging process and by the high interconnectedness of the financial systems, resulting in a market loss of confidence with respect to many banking institutions and in a huge contraction of liquidity and credit available for the real economy.

As a direct response to the crisis and to the shortcomings of previous Basel II regulation in addressing the capital requirements of globally active banks and in protecting the financial system, the Basel Committee on Banking Supervision published in December 2010 detailed rules of new global regulatory standards on bank capital adequacy and liquidity commonly known as Basel III. The aim of the new framework is "to strengthen global capital and liquidity rules with the goal of promoting a more resilient banking sector" and to absorb the shocks from the financial sector, "reducing the risk of spillover […] to the real economy" (Basel Committee on Banking Supervision 2011b). The drawbacks of the existing framework identified after-crisis analysis were the not effective loss-absorbing function of capital, the failing liquidity management, the inadequate governance and risk management of big financial groups (European Commission 2013). As a consequence of these regulatory flaws, a huge amount of public money from taxpayers had to be used to bail-out the so-called *too big to fail* financial institutions and to avoid further systemic disease (Chennells & Wingfield 2015). All these problems are addressed in the international reference framework of Basel III and are applied to European banks through the mean of the Capital Requirements Directive (CRD IV).

In the next paragraph Basel III and CRD IV rules will be reviewed more in detail, focusing in particular on the standard requirements regarding capital adequacy, since this aspect of the regulation is the one in which CoCos make appearance as instruments for increasing banks' capital.

1.2 BASEL III AND CRD IV-CRR

Basel III and CRD IV-CRR (Capital Requirements Regulation) are the masterpieces of the current regulation of the banking and financial system in the European Union. To be correct from a legal point of view, Basel III is not a law, "it is the latest configuration of an evolving set of internationally agreed standards developed by supervisors and central banks" (European Commission 2013). In order to acquire a legal validity, it has to go through a democratic process to be transposed into EU or any national law. Specific applications of Basel III principles can be slightly modified to fit with existing national arrangements especially by adding higher standards, even if the main requirements, which we explain in the next sub paragraph, tend to remain common to all the jurisdictions. CRD IV has several correspondent in different jurisdictions, such as the "Final US Rules", approved by the Board of Governors of the Federal Reserve System in July 2013 (Shearman&Sterling 2013). There exist some differences between the European and the other national interpretations of Basel III framework; nevertheless, since we will later analyze some CoCo issuances from European banks, the discussion on the capital requirements will be treated from the European directive perspective and with respect to the CRD IV.

The Basel III framework, which, after being published by the Basel Committee on Banking Supervision, was endorsed by the G20 leaders in November 2010, is the centerpiece of the financial reform program coordinated by the Financial Stability Board, and it is composed of both of micro and macro-prudential measures. The micro-prudential rules strengthen the resilience of the single banks to periods of financial stress and mainly consist in capital and liquidity requirements. The macro-prudential reform instead, addresses the systemic risks that can originate across the banking industry as well as the procyclical amplification of these risks over time and their shift to the real economy. The two aspects are nevertheless interrelated, since a greater individual resilience reduces the risk of contagion and thus of market wide shocks (Basel Committee on Banking Supervision 2011b).

One of the priorities of the Basel III framework is to strengthen the quality, consistency and transparency of the capital base for internationally active institutions. With respect to Basel I and Basel II frameworks, the new standards are raising the total capital ratio to hold and the percentage of high quality capital, the highest quality being common equity (King & Tarbert 2011).

Capital can be defined in different ways. Thus, to have a more accurate understanding of the dynamics of the capital requirements under the new regulation, it might be useful to first have a clear definition of the capital base. For prudential requirements in banking, the definition of capital is more conservative than the accounting one (asset-liabilities), since only capital that is freely available at all the times to absorb losses can be qualified as regulatory capital. Moreover, according to Basel III, capital will be separated in going and gone concern.

Tier 1 Capital, the riskiest one, by absorbing losses on a "going-concern" basis ensures the continuity of the institution activity, since it provides immediate capital cushion for the banking business, preventing the bank's insolvency. Additional Tier 1 Cocos are part of this first class. Tier 2 capital is made of subordinated debt and is qualified as "gone-concern" capital, since it protects depositors and senior creditors but only when the institution fails, by losing its claims on the principal payment.

The following definition of capital components, will be associated with the capital adequacy requirements, which consists of the amount of capital an institution is required to hold compared with the amount of assets, to cover unexpected losses. In the CRD IV-CRR, capital requirements are computed as a percentage over risk weighted assets. CRR defines how to weigh a certain asset, according to their risk. The riskier the assets, the higher the capital an institution have to hold. In this computation, both on and off-balance sheet must be accounted. A detailed disclosure of the capital components will follow here below (European Commission 2013).

1.2.1 **Components of capital**

1. Tier 1 Capital (going-concern capital)
    a. Common Equity Tier 1
    b. Additional Tier 1
2. Tier 2 Capital (gone-concern capital)

A more detailed composition of the different capital parts is given here below:

1. Tier 1 Capital

- Common Equity Tier 1
  - Common shares
  - Stock surplus
  - Retained earnings
  - Other comprehensive income
  - Minority interests

Common Equity Tier 1 (CET1) is the part of capital composed by the purest forms of equity, broadly speaking by the banks' common stocks as well as any other stock surplus, also referred to as additional paid-in capital. The instruments belonging to Common Equity Tier 1 are required to have some common characteristics. These instruments represent the most subordinated claim in a bank's liquidation procedure; moreover, they have a perpetual principal and cannot be redeemed or cancelled by the issuer. Their dividend distribution is at full discretion of the bank and have to be recognized as equity under accounting standards. Common shares, which are the main component of this type of capital, are a fraction of ownership of the institution, so do not entitle to any claim of fixed stream of income but guarantee the participation to all gains and losses of the issuing bank. The minimum CET1 ratio that is required by the CRD IV is 4.5%.

$$CET1\ ratio = \frac{Common\ Equity\ Tier\ 1}{Risk\ Weighted\ Assets} \geq 4.5\%$$

- Additional Tier 1
  - Instruments that meet criteria for inclusion in AT 1 capital
  - Stock surplus resulting from these instruments
  - Instruments issued by consolidated subsidiaries meeting AT1 criteria

The criteria required for including the instruments in Additional Tier 1 are some equity-like features, which make them effective loss absorbing items, guaranteeing the continuity of the regular business activity of the bank. Among these equity-like features, for example, the deep subordination to depositors and other subordinated debt of the bank. In addition, these instruments must be perpetual, with no maturity, no step-ups or other incentives for the issuer to redeem. Additional Tier 1 securities can be callable only after a minimum of five years after the issuance and the issuer must not create expectations that the bond will be called. The bonds can be redeemed only if replaced by instruments of the same or better quality, and in any case, the minimum capital requirements must always be respected. Moreover, the bank has full discretion on dividends or coupons payments cancellation or deferral, and this fact do not constitute an event of default. Instruments classified as liabilities for accounting purposes must have a principal loss absorption trough either conversion to common shares or through a write-down mechanism, which activates when a pre specified trigger point is breached. The different CoCos we will analyze in this thesis, all belong to this loss absorbing kind of AT1 instruments.

The CRD/CRR IV requires the banks to have, in 2019, when the regulation will be fully loaded, a Tier 1 ratio of at least 6%. The regulation also says that, this ratio must be composed of up to 1.5% of AT1 ratio, since the CET1 ratio cannot in any case be below 4.5%:

$$Tier\ 1\ ratio = \frac{Tier\ 1\ Capital}{Risk\ Weigthed\ Assets} \geq 6\%$$

2. <u>Tier 2 Capital</u>

Tier 2 capital is composed by subordinated debt, junior to depositors and general creditors, but which intervenes in absorbing losses only in the case of insolvency. Tier 2 instruments must anyway maintain some prudential features, like the fact of being unsecured, having a minimum five years maturity with no incentives for the issuer to redeem and being callable only if approved by the supervisor and if replaced by the same amount of similar capital instruments. The Tier 2 Capital ratio that a bank has to hold as part of the total capital ratio is up to 2%, knowing that out of the 8% minimum Total Capital ratio required, the Tier 1 Capital ratio over risk-weighted assets must be at least 6%.

$$Total\ Capital\ Ratio = \frac{Total\ Capital}{Risk\ Weighted\ Assets} \geq 8\%$$

With the changes in the definition of regulatory capital, many of the instruments that under Basel II were considered Tier 1 and Tier 2, do not own anymore the criteria for inclusion in Basel III capital. With respect to these securities issued before December 2011 (CRR, 2013, Art. 484), the new regulation allows the so-called “grandfathering”, meaning that their regulatory capital value will decrease by 10% annually until 2021. Banks must gradually replace these “old style” securities with new regulation compliant instruments, such as CoCos in the case of AT1 capital. The instruments losing the regulatory capital status will later account as funding unsecured instruments (Basel Committee on Banking Supervision 2011b; Leung et al. 2012).

1.2.2 **Additional Capital Buffers**

1. Capital Conservation Buffer
2. Countercyclical Capital Buffer
3. Global Systemic Institution Buffer (G-SII buffer)
4. Other Systematically Important Institutions Buffer
5. Systemic Risk Buffer

In addition to raising minimum requirements, Basel III and CRD IV/CRR introduced some additional capital buffers, creating a security cushion and forcing institutions to build up capital reserves in good times for preventing bad times troubles.

1. Capital Conservation Buffer

Among the additional buffers, banks are required to hold a 2.5% capital conservation buffer, composed of the Common Equity Tier 1 exceeding the minimum regulatory ratio. In this way, the Basel committee indirectly brings the effective requirement of CET1 to 7% (4.5% CET1 + 2.5% Conservation Buffer). Nevertheless, banks are allowed to temporarily have lower ratios though they are pushed to quickly rebuild the buffer via restrictions on discretionary distributions. These limitations in distribution refer to dividends, deferrable coupons, shares buybacks and staff bonuses. The extent of the distribution constraints depend on the distance of the bank's CET1 ratio to the regulatory minimum capital requirement. Essentially, a bank having the CET1 very close to the minimum requirement will be forced to retain all its earnings in the subsequent financial year, while a bank with a high CET1 ratio satisfying the 2.5% of conservation buffer, will have zero constraints on distributions. For example, a bank with CET1 of 8% but with no Additional Tier 1 nor Tier 2 instruments will meet the minimum capital requirements but, having zero conservation buffer, will be imposed of restrictions on its discretionary distributions. Minimum capital conservation standards are reported in Table 1.

Common Equity Tier 1 Ratio	Minimum Capital conservation Ratios (expressed as a percentage of earnings)
4.5% - 5.125%	100%
>5.125% - 5.75%	80%
>5.75% - 6.375%	60%
>6.375% - 7.0%	40%
>7.0%	0%

Table 1. Minimum Capital Conservation Ratio (Basel Committee on Banking Supervision 2011b)

2. Countercyclical Capital Buffer

Losses that occur in a downturn preceded by a period of strong credit growth can be extremely large and destabilize the entire financial system. This because the easily availability of loans at low rates, pushes up private investments and prices, often leading to asset bubbles. When the bubble then eventually burst, prices go down, loans start defaulting and bank limit their lending activity. The contraction of credit further reduces prices and defaulting loans increase. The financial distress reverberate thus on the real economy and turns back to the financial sector in a self-perpetrating vicious circle.

In order to prevent this diabolic loop, the CRD IV-CRR introduces a new countercyclical capital buffer, which forces banks to accumulate additional capital in times of economic prosperity. This policy aims at reducing credit availability during times of credit growth to provide banks with more capital to face times of distress, reducing the extent of credit crunch during a downturn (King & Tarbert 2011). This buffer requirement addresses the risks deriving from the macro-financial environment in which the bank operates. When the national authorities judge credit growth excessive and associated with a system-wide risk, they can impose banks to hold this countercyclical buffer ranging from zero to 2.5%. The amount of this buffer depends on the financial stability conditions of the jurisdiction and on the weighted average of buffers deployed in all the other jurisdictions in which the internationally active institutions have credit exposures. When the authorities consider the risk is over, the buffer requirement can simply be removed. As before, banks not complying with the requirements can face distribution limits, according to the CET1 ratios. Table 2 indicates the minimum capital conservation standards for a bank subject to a 2.5% countercyclical requirement.

Common Equity Tier 1 Ratio (including other fully loss absorbing capital)	**Minimum Capital conservation Ratios (expressed as a percentage of earnings)**
4.5% - 5.75%	100%
>5.75% - 7.0%	80%
>7.0% - 8.25%	60%
>8.25% - 9.5%	40%
>9.5%	0%

Table 2. Minimum Capital conservation Ratios with countercyclical capital buffers (Basel Committee on Banking Supervision 2011b)

3. Global Systemic Institution Buffer (G-SII buffer)

The CRD IV includes a mandatory systemic buffer for banks that are considered globally systemically important. The amount of the required buffer will be between 1% and 3.5% CET1 on RWAs and will be applied starting in January 2016. This surcharge is motivated by the high risk that these banks present for systemic stability, which would otherwise be restored with taxpayers' money. The Financial Stability Board has listed 28 G-SIFI banks including 14 EU institutions.

4. Other Systematically Important Institutions Buffer

In addition to G SII buffer, CRD IV set a supervisory option on other systemically important institutions that are domestically important or EU important. The criteria for identification include a notification procedure and there is an upper limit to the buffer size, equal to 2% on RWAs.

5. Systemic Risk Buffer

According to CRD IV, other systemic risk buffer can be introduced by each Member State in order to prevent non-cyclical systemic or macro-prudential risk for the real economy in the specific State. Starting in 2015 the Member State willing to set a buffer rate between 3 and 5% will have to notify the EU banking authorities. The EU Commission will have to agree on the measure.

1.2.3 Pillar II Capital

In addition to the capital requirements coming from the Pillar I, art. 97 and 104 of Directive 2013/36/EU 5 (CRD) establishes that Member States must ensure that competent authorities are empowered, among others, to require banks to hold additional own funds requirement (Pillar II capital). The amount of additional own funds is assessed by the authorities through the supervisory review and evaluation process (SREP). This process is a risk management and governance control over single institutions, which can end up in the requirement of an additional buffer ranging from zero to 2% (European Union 2013; Bank of England 2014; European Banking Authority 2015).

The capital adequacy requirements, the regulatory additional capital buffers discussed in this chapter and their size are represented in the following Figure 1.

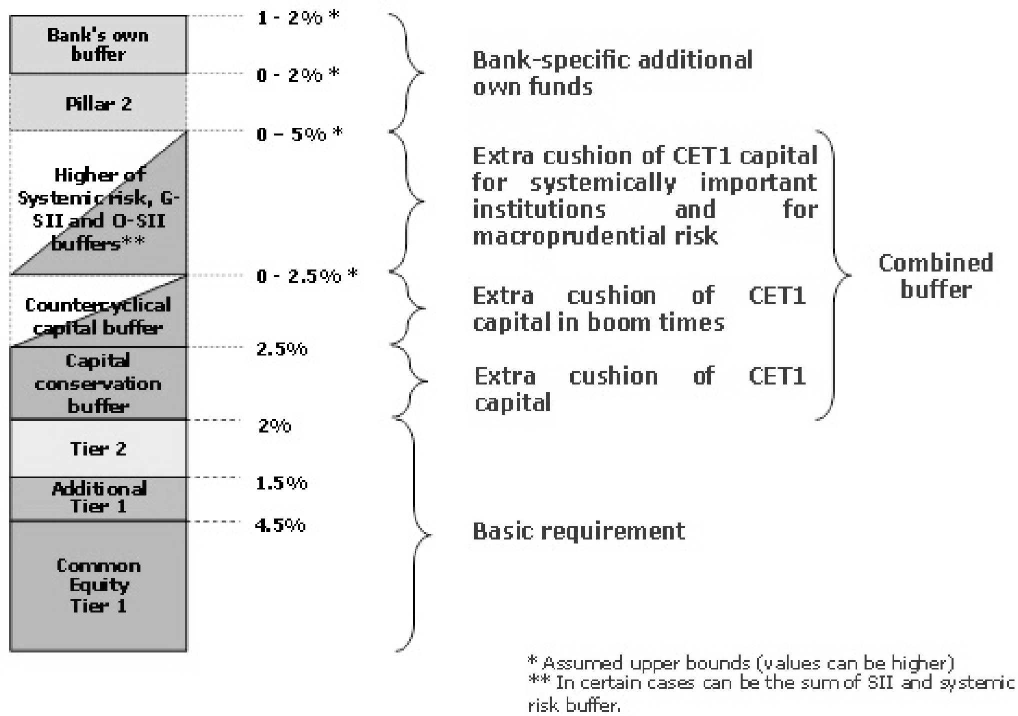


Figure 1. Capital base and additional buffers under the CRD IV. From (European Commission 2013)

Another important aspect to consider about capital requirements is the way in which they will be phased-in to reach the fully loaded regulation in 2019. The gradual implementations of requirements allows banks to take the measures to be compliant with the law as stated in Table 3.

	Capital adequacy phase-in arrangements						
	2013	2014	2015	2016	2017	2018	2019
Common Equity Tier 1	3.5%	4.0%	4.5%	4.5%	4.5%	4.5%	4.5%
Capital Conservation Buffer	-	-	-	0.625%	1.25%	1.875%	2.5%
Minimum CET1 + Buffer	3.5%	4.0%	4.5%	5.125%	5.75%	6.375%	7.0%
Minimum Tier 1 Capital	4.5%	5.5%	6.0%	6.0%	6.0%	6.0%	6.0%
Minimum Total Capital	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
Minimum Total capital + Conservation Buffer	8.0%	8.0%	8.0%	8.625%	9.25%	9.875%	10.5%

Table 3. From Basel Committee on Banking Supervision, (2011)**.**

Additional Tier 1 and Tier 2 Capital are not explicitly showed in the table above, but are included in the minimum Tier 1 Capital and in the minimum Total Capital ratio whose phase-in arrangements from 2013 to 2019 can be seen in the graphical representation below.

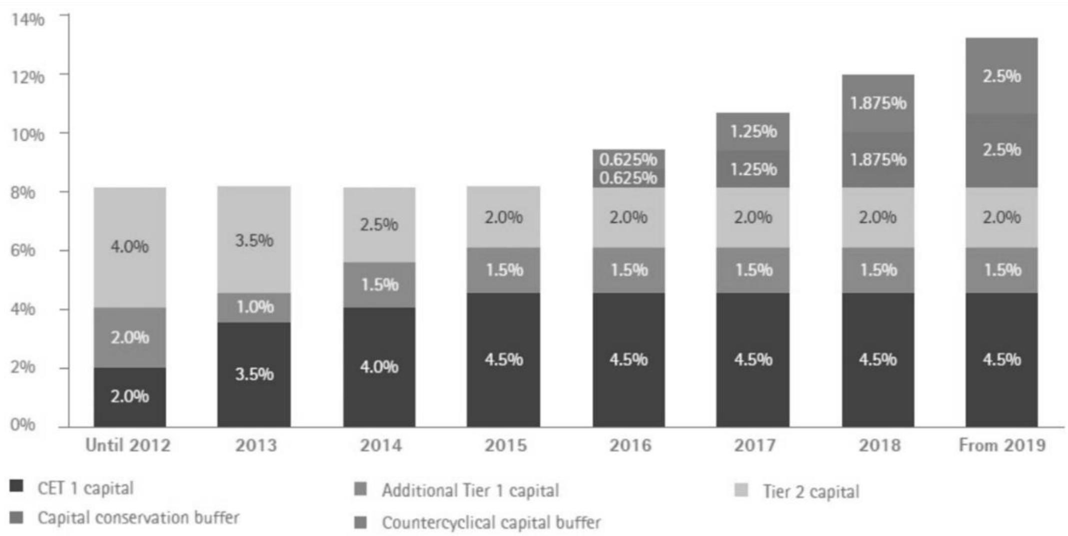


Figure 2. Phase-in arrangements Basel III capital requirement. Source (Auer & Von Pfoestl 2012)

Understanding the regulatory capital and buffer requirements is very important for an investor analyzing the hidden risks embedded in Contingent capital securities. As we will see in chapter 2 indeed, many features of CoCos having an impact on the expected value of the securities, are directly linked to the breach of some of the just presented capital requirements.

1.3 THE EXPANSION OF COCO MARKET

In order to accomplish their regulatory "mission" of enhancing financial stability of banking institutions, Cocos must be appreciated and bought by the investors. It seems thus interesting to analyze the market of CoCos, to see what factors could help its development and growth.

1.3.1 The issuers perspective

The first driver for CoCo expansion comes from the supply side, since the phasing-in of the Basel III and of CRD IV in Europe, is pushing a strong recapitalization of the banking sector. The growing requirement of Equity Tier 1 and the possibility to fill the regulatory buffers with up to 1.5% Additional Tier 1 provides incentives to European banks to issue a huge amount of these CoCos and the market growth is expected to continue in the following years (Henderson Global Investors 2014). The rationale for bank's preference of AT1 with respect to equity is in the cost of funding. Thanks to the tax deductibility of coupon payments, CoCos, which are considered as debt on an accounting basis, represent a more cost-effective capital instrument than common equity.

This seems to offset the high coupon that banks are forced to pay to the investors to compensate for the riskiness of this type of securities.

1.3.2 The investors perspective

On the investors' side, great appetite for CoCos was showed in the two last financial years. This can be explained by the low rate environment characterizing the markets as a consequence of central bankers expansionary policies aimed at boosting economic recovery. Almost ten year of very low federal fund rates and the recent Quantitative Easing from the European Central Bank, generated a low returns market with very little options for investors seeking higher yield. CoCos are providing high yields in a low yield environment. In 2014, for instance their yield normally ranged from 4.5% to 10% depending on issuer and on the security structure, which is quite high compared with an average yield of around only 4-4.5% for the European high yield sector (Muenstermann 2014). This is why the appearance of this new asset class was welcomed by the market. The initial fears, regarding the opacity of AT1 with respect to their accounting and taxing rules, due to their ambiguous hybrid nature, are being overcome as the regulation is getting better known and as the credit quality of the banks is improving, thanks to the huge recapitalization effort.

Given these discussed factors, namely the active supply from banks and the global low yield environment, the buyer base and thus the market for Additional Tier 1 bonds is expected to grow fast in the next five years (J.P.Morgan 2015).

1.3.3 Rating CoCos

Another factor that help boosting bonds market growth is the credit rating attribution from the agencies. Initially, rating agencies have been reluctant about rating CoCos for the high uncertainties surrounding the asset class. For instance, the heterogeneity of their regulatory treatment across jurisdictions makes it more difficult to create consistent rating methodologies. In addition, the presence of discretionary triggers and of the Point-Of-Non-Viability (PONV), which is declared by the government and imposes automatic conversion of the bond, further complicates the rating attribution. Nevertheless, the growth of this market and pressures from the issuing institutions pushed major rating agencies to provide these securities with a rating. Having a rating is important for CoCos market growth, since the main buyers of these securities are institutional investors, such as pension funds, hedge funds or insurance and asset management companies. Some of these funds have strict rules about the kind of assets they can invest in, and giving a rating to AT1 bonds widens the potential buyer's base. The ratings are generally given by downgrading the senior rating of four notches, with the possibility of further notching down in presence of high coupon cancellation or conversion risk (Avdjiev & Kartasheva 2013; Lambert 2014).

The factors explained above, allow to predict a persistent market growth, according to J.P. Morgan (2015), whose research found that the amount of issued CoCos in 2014 was of USD 97,7 billion, more than double with respect to the USD 38 billion issued in 2013. The issued AT1 securities as of April 2015 are estimated around USD 72 billion, assuming a total market size at the same date of USD 229 billion. Among the different regions, European banks are estimated to account for USD 81 billion and the European market is expected to grow further, being the expected issuances valued around EUR 106 billion in the next 2-3 years.

In the light of what we said regarding regulatory setting and of the growing market of Additional Tier 1, chapter 2 will provide a useful deeper look into the different non-standard features of CoCo bonds, to provide with more awareness about the risks one has to consider when willing to invest in this particular asset class.

2 CONTINGENT CONVERTIBLE CAPITAL INSTRUMENTS

2.1 DEFINITION

Contingent Convertibles, Contingent Capital, CoCos, Enhanced Capital Notes are all different names for the same kind of hybrid securities issued by banks to absorb losses when their capital ratio falls below a certain level (De Spiegeleer & Schoutens 2009; Avdjiev & Kartasheva 2013). They are defined hybrid instruments, since they present characteristics both of debt and of equity (Öfinger 2012). Indeed, they behave as plain vanilla bonds, paying a regular coupon rate during normal stability times, but they convert into equity when the issuing institution experiences a state of financial distress (McDonald 2013; Koziol & Lawrenz 2012).

Hybrid bonds offer thus both the advantages related to their debt-like features and to their equity-like features. As debt, CoCos benefit from the tax shield on coupon payments and thus reduce the weighted cost of funding even if, as Rozansky (2010) states, the fiscal advantage may vary from country to country, according to the local jurisdiction. In addition, with respect to equity, pre-conversion CoCos reduce agency costs because they force the firm to pay coupons, reducing the excess cash disposable by management. Moreover, being safer than capital, hybrid bonds avoid negative signaling effect of issuing equity (Pennacchi et al. 2011). The loss absorption mechanism, allows the issuing bank to promptly recapitalize through an automatic debt-for-equity swap, without an ex-post action which would be more costly (since the shares would be issued at a significant lower price), and prevents the need for a public bail out (Albul et al. 2010; Flannery 2009). The conversion or write down of the CoCo's face value should take place when the bank is still a "going-concern", i.e. when the bank in severe financial distress is still a viable business, avoiding bankruptcy without the need of a public bail-out (Goodhart 2010; De Spiegeleer & Schoutens 2014a).

Moreover, since existing shareholders generally do not welcome a conversion, Cocos also enhance in another way the financial stability of banking firms. According to D'Souza et al. (2009), as stated in Calomiris & Herring (2011), a large size of Cocos with a credible trigger and a high dilutive conversion ratio, strengthens the incentive to pre-emptively recapitalize. If these conditions are met, an institution getting closer to the dilutive conversion will prefer to issue new equity and restore its capital ratio, since this would end up in smaller losses for existing shareholders. For these reasons, Cocos do provide incentives to shareholders to keep banks well capitalized, which is exactly the regulator goal (Goodhart 2010; Von Furstenberg 2011a)

To sum up, contingent capital is intended to effectively reduce the financial risk in the banking sector, not only through the automatic recapitalization of banks, but also providing implicit incentives to responsibility to managers, bondholders and shareholders (McDonald 2013).

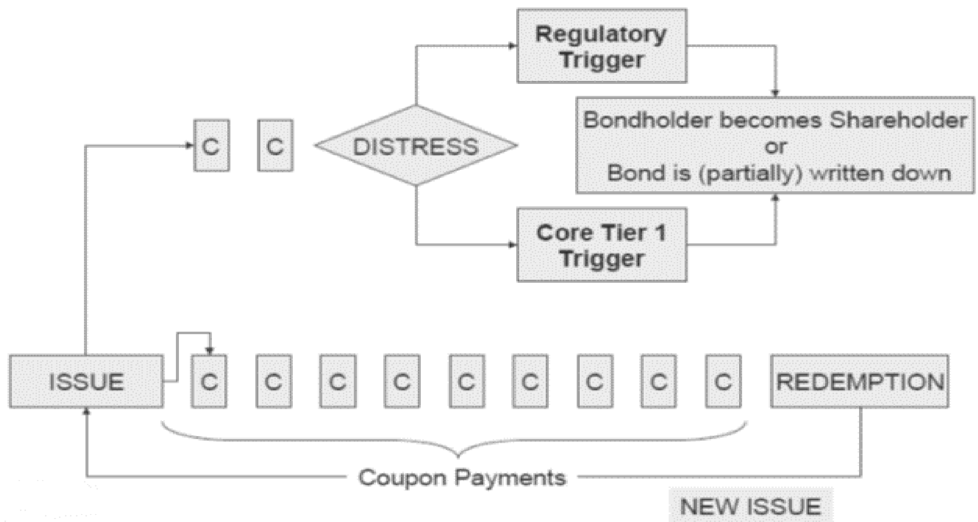


Figure 3. Life of a CoCo (De Spiegeleer & Schoutens 2014b).

2.2 ELEMENTS OF CONTINGENT CONVERTIBLE BONDS

In this paragraph, we will present the main elements characterizing contingent capital, in particular with respect to the specific new features of Additional Tier 1 instruments as imposed by Basel III and by CRD IV of 2013. We will especially focus on the biggest innovation in AT1 capital, the conversion mechanism. We will review the main proposals expressed in literature, discussing pros and cons of the different options for an optimal CoCo bond design. The features we are going to illustrate, which also hide the key risks for investors are the subordination, the coupon cancellation, the call/extension risk and the conversion feature.

2.2.1 **Subordination**

The term subordination refers to the order of priorities of claim on assets of the bank among the different classes of the asset liabilities.

Subordination means that in the event of default, the holder of the subordinated debt, must wait until the holders of senior or less subordinated bond are repaid, before having the chance of recovering some value from their bond. Subordination thus plays an important role on bond's recovery rate, and it is empirically found that, on average, higher seniority is associated with higher payoffs in case of bankruptcy. The seniority ranking of the different classes of liabilities is shown in Figure 4, which represent a simplified balance sheet of a bank.

CoCos are classified as junior subordinated debt, and their deep subordination is mandatory according to the criteria 2 and 3 for inclusion in Additional Tier 1, as stated in Basel III regulation.

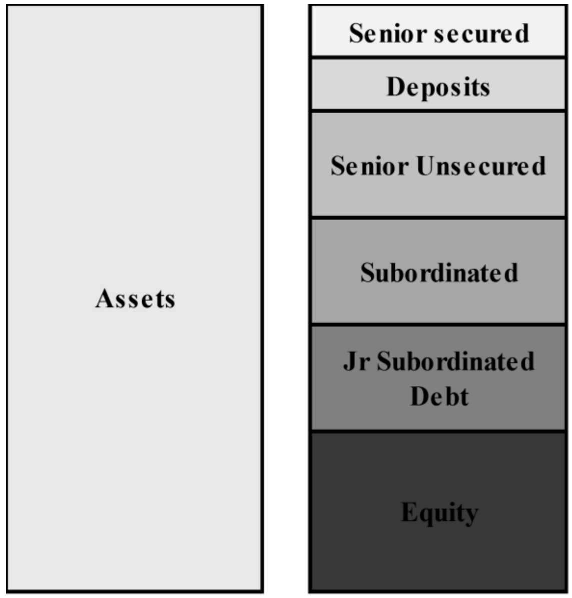


Figure 4. Simplified balance sheet of a bank. Own illustration

2. "Subordinated to depositors, general creditors and subordinated debt of the bank
3. Is neither secured nor covered by a guarantee of the issuer or related entity or other arrangement that legally or economically enhances the seniority of the claim vis-à-vis bank creditors" (Basel Committee on Banking Supervision 2011a).

The regulators' intention to make of Additional Tier 1 the most subordinated liability after common equity is clear in these two points. In fact, in the case of bankruptcy, CoCo holders will become shareholders thus the first absorbing the losses. Although CoCos are moved by the same rationale as the bail-in resolution tool, whose application in Europe was introduced through the EU Bank Recovery and Resolution Directive of 2014, the two things do not have to be confused. While the bail-in is a regulatory procedure for managing banking failures that allows the authorities to impose the mandatory write-down on all the bank's liabilities, (except on deposits and covered debt), CoCos are a financial instrument that is converted or is written down on a contractual agreement and on a pre-determined trigger event. CoCos are involved in the case of a bail-in resolution and can be converted also on a discretionary base by the regulator declaring the bank is at its point of non-viability (PONV) like the bail-in debt. Nevertheless, they are expected to be written down or convert before the bail-in procedure starts (Patrick n.d.; Chennells & Wingfield

2015). Given the deep subordination they have, the expected recovery rate in case of default may be expected to be very close to zero.

2.2.2 Coupon cancellation

The rules related to coupon distributions are exposed at the points 7 and 8 of the criteria for inclusion Additional Tier 1, as exposed in the Basel III regulatory framework. The aim of these criteria is to make CoCos coupon similar to stock dividends with no obligation for the issuer to respect the regular payment of the promised coupons.

7. "Dividend/coupon discretion:
    a. the bank must have full discretion at all times to cancel distributions/payments
    b. cancellation of discretionary payments must not be an event of default
    c. banks must have full access to cancelled payments to meet obligations as they fall due
    d. cancellation of distributions/payments must not impose restrictions on the bank except in relation to distributions to common stockholders.
8. Dividends/coupons must be paid out of distributable items"

According to these regulatory dispositions, the cancellation of the Additional Tier 1 Coupon can be either voluntary or mandatory (under certain conditions).

2.2.2.1 *Discretionary cancellation*

Point 7 of the inclusion criteria is related to the discretion of coupon cancellation, clearly stating that the cancellation of a coupon can be performed at any time from the issuing bank and that such choice from the issuer does not represent an event of default. This deferability of coupons was already existing in old-style Tier 1 debt under Basel III. Nevertheless, this equity-like feature of AT1 debt is further enhanced by removing any kind of limitation on other distribution in the case of AT1 coupon cancellation. While these limitations are removed but still allowed in Basel III (point 7 d) of the AT1 Criteria), the European Authorities formally prohibit them, as stated at art. 52 point (1) (1)(v) and at art. 53 (a)(b)(c) of the REGULATION (EU) No 575/2013, (2013).

The CRR establishes that the coupon cancellation must impose no restriction on the issuer, with particular reference to two situations:

1. there must be no obligation to pay coupons on the CoCo if the issuer pays distributions on *pari passu* or junior capital such as ordinary shares ("dividend pusher") and

2. there must be no prohibition to pay dividends or of other distributions on equal or junior ranked capital just because a distribution on the CoCo is cancelled ("dividend stopper") (Welsh & Fried 2011; Leung et al. 2012).

The removal of the stopper and pusher, might be interpreted as a violation of debt subordination principle, since CoCos holder could, in principle, suffer losses even before the shareholders. Nevertheless, several issuers clearly state the intent of respecting the seniority of CoCos with respect to equity, thus committing to pay the AT1 coupons, or in any case not to cancel them in the place of stock dividends.

2.2.2.2 ***Mandatory Cancellation***

Point 8 of the AT1 criteria, stating that coupons must be paid out on distributable items, refers to the regulatory conditions under which a bank may be imposed not to pay coupons. Distributable items means the amount of profit from the last financial year plus any profit brought forward from previous years and reserves available for that purpose, less any losses brought forward, profits which are non-distributable according to the legal provisions and sums placed to a non-distributable reserve. Further restrictions for coupon payments through these distributable items, come because of the additional capital buffers required by Basel III, as discussed in Chapter 1. As stated in the Article 141 of the CRD IV 36/2013, a breach of the combined buffer requirement would impose the calculation of the maximum distributable amount (MDA), which according to the severity of the buffer breach is a decreasing percentage of the banks' earnings.

The amount of combined required buffer varies from bank to bank, since except the capital conservation buffer, which is equal to 2.5%, all the other additional buffers' size varies from bank to bank. The sum of these other buffers ranges from a minimum of zero to a maximum of 7.5% without considering any additional country imposed buffer. Calculating the distance to the MDA trigger or the MDA when the trigger is breached can be useful to make assumption on the probability to have the coupon cancelled.

The computation of the MDA starts by determining the level of the bank Common Equity Tier 1, and via the deduction of the Pillar I and Pillar II requirements, obtaining the CET1 disposable, we can determine through the table 4, the MDA of earnings in percentage. Multiplying this the distributable percentage with the profits, we obtain the absolute value of the liquidity that the bank is allowed to use for distributions (Kaijser 2013).

Available CET1 buffer above PII	MDA%
75-100%	60%
50-75%	40%
25-50%	20%
0-25%	0%

Table 4. Maximum Distributable Amount. Source: Kaijser, (2013).

2.2.3 **Extension/callabilty**

This risk is linked to the perpetual maturity of CoCo bonds, and to the possibility the issuer has to call back the bond at certain pre-specified dates. This uncertainty is associated to the passage from fixed to floating coupon after the first call date, in the case the life of the bond is extended.

These features are addressed in the points 4, 5 and 6 of the Basel III Additional Tier 1 criteria reported below.

4. "Is perpetual, i.e. there is no maturity date and there are no step-ups or other incentives to redeem
5. May be callable at the initiative of the issuer only after a minimum of five years:
    a. To exercise a call option a bank must receive prior supervisory approval; and
    b. A bank must not do anything which creates an expectation that the call will be exercised; and
    c. Banks must not exercise a call unless:
        i. They replace the called instrument with capital of the same or better quality and the replacement of this capital is done at conditions which are sustainable for the income capacity of the bank; or
        ii. The bank demonstrates that its capital position is well above the minimum capital requirements after the call option is exercised."

(Basel Committee on Banking Supervision 2011a).

We can clearly see the regulator intention of making these instruments very equity like in the perpetual maturity, and the enhancement of this characteristic of AT1 capital with respect to Basel II in the removal of the coupon step-up, which is a clear incentive to redeem that old-style Tier 1 had. The prohibition for the issuer to generate expectations that the call will be exercised will remove the reputation costs as determinants of the call or not choice. This decision instead is expected to be based on a purely economic rationale since now on called CoCos must be replaced by an amount of the same or better quality of debt. Funding costs and benefits of calling the debt and issue new or instead to keep the existing debt instruments paying the floating rate coupon, will be the main focus point for financial institutions at every call date (McCarthy 2014).

2.2.4 Loss Absorption Mechanism

The loss absorption mechanism is the process through which the issuing bank's equity is boosted on the appearance of a trigger event. This automatic recapitalization can occur in two ways, either converting the bond into equity shares or operating a haircut (write down) on the bond's face value (Avdjiev & Kartasheva 2013). Basel III requirements are exposed at point 11 of the criteria for inclusion in Additional Tier 1 capital.

11. "Instruments classified as liabilities for accounting purposes must have principal loss absorption through either (i) conversion to common shares at an objective pre-specified trigger point or (ii) a write-down mechanism, which allocates losses to the instrument at a pre-specified trigger point. The write-down will have the following effects:
    a. Reduce the claim of the instrument in liquidation;
    b. Reduce the amount re-paid when a call is exercised; and
    c. Partially or fully reduce coupon/dividend payments on the instrument"

This feature ensures CoCos perform their fundamental role of providing a readily and easily available source of new capital for the bank in times of crisis (Avdjiev & Kartasheva 2013). Related to this, two key features are (1) the loss absorption mechanism and (2) the trigger event that activates the loss absorption mechanism. Their design must be robust enough to face potential price manipulation and speculative attacks (Albul et al. 2010). Several proposals are present in literature for Cocos design, focusing on the design of these two key features. All the proposals, which we are going to review, make implicit or explicit assumptions on the behavior of the different actors, meaning regulators, managers, accountants, investors and markets. All the options present both advantages and disadvantages, reason why academics are still uncertain about a recognized optimal design model (McDonald 2013).

2.2.4.1 ***Conversion into shares***

The conversion ratio defines the amount in shares the CoCo holder will receive in exchange to the face value of his bond. According to Flannery (2009), the conversion price distributes the CoCo's value between shareholders and bondholders and since this could generate pressures on the stock prices, it is important to set a strong and right conversion ratio (Öfinger 2012).

The conversion ratio (C_r), is the result of the face value of the bond N divided by the conversion price (C_P).

$$C_r = \frac{N}{C_p}$$

If the bond is converted in shares, the loss for the investor depends on the conversion rate and on the value of the shares at time of the conversion.

$$L_{CoCo} = N - C_r \times S^* = N\left(1 - \frac{S^*}{C_p}\right) = N\ (1 - RCoCo)$$

The equation above introduces the concept of recovery rate for a CoCo. The closer the conversion price to the nominal value of the share at the trigger date, the smaller the loss. In addition, the smaller the conversion price the better off the investor, since he will receive a largest number of shares. On the contrary, a small conversion price will damage the existing shareholders because of the ownership dilution (De Spiegeleer & Schoutens 2014a).

De Spiegeleer & Schoutens (2013) identify three methods to deal with the conversion price:

1. <u>Floating conversion price: $C_P = S^*$</u>

In this type of conversion, that Von Furstenberg (2011) defines as dilutive, the conversion price is set at the observed market share price at the trigger moment. Normally, this corresponds to a low price, since the trigger takes place in some event of financial distress for the issuing bank. The number of shares (X) received after the conversion is computed through the following ratio:

$$X = \frac{N}{S^*}$$

The face value of the bond can converted at par, premium or discount. At the date, the Additional Tier 1 bonds issued are converted at par. Under this conversion price mechanism, the bondholder would not suffer any losses, since he will receive the exact face value in shares.

In fact, with low prices and the equivalent amount of the face value converted, bondholders have a very safe claim, while most part of the brunt of the trigger breach is born by old shareholders, suffering from a substantial dilution. The lower the conversion price, the grater the dilution and expropriation of existing shareholders and the more likely the disrespect of the subordination hierarchy (Von Furstenberg 2011a). Meanwhile, this dilution risk has the advantage of increasing the incentives for shareholders to avoid a breach of the trigger (Avdjiev & Kartasheva 2013).

According to De Spiegeleer & Schoutens (2014), so far no CoCo issuance has this conversion method. A Coco with this feature would not be accepted from a regulatory point of view since it would not provide true loss absorption and the dilution would be unbounded.

2. Fixed Conversion Price: $C_P = \alpha S_0$

With this option, the conversion happens at a pre-specified price, which normally corresponds to a fraction $\boldsymbol{\alpha}$ of the bank's share price $\boldsymbol{S_0}$ at the CoCo's issue date. Establishing a fixed conversion number of shares protects existing shareholders from excessive dilution in the case of trigger breach. The number of newly issued shares (X) can be found with the ratio:

$$X = \frac{N}{\alpha S_0}$$

This method, which Von Furstenberg (2011) calls anti-dilutive, while providing pre-existing shareholders with more guarantees on the dilution phenomenon, sets bondholders in a more uncertain position, since they cannot know the amount of the loss they will incur at the conversion. This loss is indeed very likely to happen and be huge since the share price of the bank in a moment of financial distress is almost certainly lower than the conversion price set at the bond issue (Öfinger 2012). The fixed conversion price, while limiting the risk of share price manipulation, also reduces the incentive for shareholders to avoid the risk of the trigger breach (Avdjiev & Kartasheva 2013). This mechanism was used in the first CoCo issuance by Lloyds Bank in November 2009, which was a lower Tier 2 instrument, and had a price equal to the volume-weighted average price of its ordinary shares for the five consecutive trading days from November11 to 17, 2009 (Maes & Schoutens 2012; Von Furstenberg 2011a).

3. Floored Conversion Price: $C_P = max(S^*, S_F)$

This method, is a combination of the previous two, since the price is set equal to the price S^*, which is the market price at the moment of the conversion, but only if this price is not lower than a pre-specified price floor S_F.

This option prevents excessive dilution of the shares, reduces the violation of the subordination of the pre-existing debt since CoCos can suffer a substantial haircut when the market price S^* is smaller than the floor price S_F. The bondholders do not have to take on all the uncertainty of stock price deriving from a pre-specified conversion price, even if in the in most cases the conversion price is expected to be higher one, corresponding to an effective write-down

(Wilkens & Bethke 2014). This method was first used by Credit Suisse in February 2011, with a floor price equal to 20 CHF or 20 USD, and is the most common used in AT1 CoCo issuances (De Spiegeleer & Schoutens 2014a).

2.2.4.2 ***Principal write down***

Another possibility for banks to absorb losses and increase the level of common equity is to operate a write down on the face value of the bond. This loss absorption mechanism can be used by banks that have no listed shares such as Rabobank, but it is also adopted by banks with shares that are publicly traded on the stock markets as, for example, UBS or Barclays.

According to De Spiegeleer & Schoutens (2014a), this write down can occur in three ways:

1. <u>Full Write Down</u>

In this case, if the triggering capital ratio breached, the nominal value of the bond is completely written off and lost for the investor, and becomes equity of the issuing bank.

2. <u>Partial Write Down</u>

The first CoCo bond of this kind was issued by Rabobank in 2010, had a haircut of 75% and reimbursed 25% of the face value at the trigger. The written-off amount can also be at discretion of the issuer.

3. <u>Staggered Write Down</u>

This mechanism consists in a principal loss that occurs up to the point where the breach on the capital trigger is solved. This type of write down is flexible and depend on the size of the bank's distress, since the amount of principal written off corresponds to how much is needed to reach back the trigger point.

2.2.5 **Trigger event**

The second key feature in the design of CoCos is the definition of the trigger event, i.e. the situation that automatically activates the loss absorption mechanism and that hence represent the potential loss for the investors.

According to De Spiegeleer & Schoutens (2011), an effective CoCo trigger event should be:

- Clear: Carry the same message whatever the jurisdiction of the issuer.
- Objective: The conversion mechanism must be set at the issuance date and presented in the prospectus
- Transparent: The event should represent the real conditions of capital.

- Fixed: The trigger cannot be changed during the bond's lifetime.
- Public: The trigger event must be knowable by everyone.

Triggers can be single or multiple, in which case the breach of any of them activates the conversion mechanism. Generally, the trigger event is contractually defined in the prospectus, but the resolution authority is free to impose conversion, if it consider the institution to be in a critical situation.

Previous literature on CoCo bonds distinguishes different ways to establish the trigger point, some related to bank's specific events and others linked to more systemic financial distress. Despite the several trigger structures explored in literature, so far in real issuance the triggering has been linked to accounting ratios (De Spiegeleer & Schoutens 2009).

2.2.5.1 ***Bank specific trigger***

Bank specific triggers as suggested by Flannery (2009), subordinate the bond conversion or write-down only to negative economic conditions of the issuing financial institution.

Among the advantages of this kind of triggers, the incentive for prudential behavior of management and shareholders and the focus in the single institution's capital needs. To accomplish the contingent capital task, the trigger must activate conversion while the bank is still a "going concern", i.e. before entering a situation of severe distress (Pennacchi et al. 2011). On the disadvantages side, the fact that the trigger may be insufficiently responsive to systemic risk (Pazarbasioglu et al. 2012).

Among the bank-specific triggers several options can be distinguished, some linked to accounting ratios and some linked to market based indicators.

2.2.5.1.1 Capital ratio-based trigger

Under this mechanism, the conversion of the bond into equity is linked to the health of the bank's balance sheet. The loss absorption happens in the case that the CET 1 ratio, falls below a certain value, which can be pre-specified in the bond prospectus or in any case, according to the CRD IV cannot be lower than 5.125%.

On the pros, capital ratio triggers prevent speculation on the stocks that could happen with a share price based trigger, when approaching to the conversion price. In this sense, it prevents an undue recapitalization of the bank due to market manipulation. An accounting trigger like the CET1 ratio, guarantees transparency and objectiveness to investors willing to assess the bank's capital distance from the trigger. On the other hand, this kind of triggers are widely criticized for their dependence on accounting techniques which are "likely to overstate the market value of a distressed firms' equity" (Von Furstenberg, 2011b). Another negative point of accounting-based trigger is that the financial statements are published only quarterly, so there is some kind of time lag between the actual state of the capital and the one stated on financial reports (Pazarbasioglu et al. 2012).

This timing problem and the reliability of the flexing rules was evident during the 2007 financial crisis when some institutions, which were financially in trouble, were still qualified as stable and well capitalized. According to Kuritzkes & Scott (2009) indeed, the five largest US financial institutions that failed or were forced into government-assisted mergers in 2008 -Bear Stearns, Washington Mutual, Lehman Brothers, Wachovia and Merrill Lynch- had better capital-ratios than the standard requirements.

Despite these negative aspects, the capital ratio is the most used mechanism in real issuances of CoCos, and for what concerns the Additional Tier 1 CoCos, which is the type of CoCos that is analyzed in this thesis, the capital ratio trigger is the conversion method legally required under Basel III framework. As we have already seen indeed, these kind of instruments originate specifically in order to allow banks to meet the capital requirements imposed by Basel III.

- <u>The timing of conversion</u>

An important aspect to consider about capital ratio triggers, is the level (of CET1/RWA) at which the loss absorption mechanism takes place. The level set is important for the regulator, for the issuing institutions and for investors.

Since the conversion or write-down must be activated while the distressed institution is still viable, the regulator set a minimum level for the trigger. The CRD IV determined this minimum level, required for CoCos to qualify as AT1 capital in a CET 1 ratio of 5,125%. As a consequence, the developing trend among financial institutions is to set the trigger exactly at that level even if they are free to impose higher trigger (Avdjiev & Kartasheva 2013)

Banks generally prefer low trigger CoCos since it postpones the recapitalization and its negative signaling effect for the market. A low trigger also allows banks to collect cheaper Tier 1 capital, since lower probability of conversion implies lower required spreads from the investors with respect to high trigger levels. The trigger level influences the type of investor interested in the bond. Conservative, long-term investors will prefer low trigger CoCos since the risk of conversion is limited, while speculative, high yield investors will go for high trigger CoCos. As Avdjiev & Kartasheva (2013) found, as of 2013 low trigger bonds offer only a 2.5% excess return with respect to non-coco subordinated bonds, while for high trigger this spread is of 3.6%.

On the opposite with respect to banks, the regulator prefers high trigger, which would start the recapitalization before the distress situation is really critical and while the bank is still in "going concern". This would stabilize the bank situation with the main contribution of the private sector instead of the taxpayers, ensuring AT1 capital effectively accomplish the role it has in the regulator's intention. High triggers hence seem to be more prudential but still they present some negative aspects for the issuing institutions. In addition to be more expensive for banks they could also lead to a premature conversion that would imply negative effects for initial shareholders, since the dilution effect would act even if it is still unnecessary.

The choice of the trigger level for banks depends thus on the trade-off between regulatory requirements and more favorable cost of financing.

2.2.5.1.2 Market-based trigger

Many researchers, among which Flannery (2009) and Goodhart (2010) for instance, are skeptical about accounting-based triggers, because of the lack of transparency and of timing consistency of accounting ratios. To overcome these problems, the option proposed in literature, which is preferred by the academic world is that convertibility must be associated to market values, such as share or CDS price (De Spiegeleer & Schoutens 2011; Von Furstenberg 2011a).

Among the advantages of a market-based trigger, we find that the trigger breach does not depend on managers' honesty or on regulators' thoughtfulness. Moreover, market values are forward looking, while accounting measures are based on past elements and they are slow in displaying changes in the issuer financial condition (Pazarbasioglu et al. 2012). Market prices reflect the financial state almost instantaneously because share prices and CDS spreads are continuously requested and incorporating off-book information are more accurate representation of the true equity value especially in the event of financial crisis, when managers have convenience to overstate banks consistency and solvability (Öfinger 2012). In addition market triggers are preferred by investors because they are easier to price.

On the other hand, also market-based triggers present some negative aspects, which are the main reasons why despite being preferred by the academic world, they have not become a regulatory standard. The main point against market triggers is that they are vulnerable to market manipulation. Trigger may be activated if, for example, a certain market player sells a huge amount of shares when the price is already trading close to the trigger barrier. A large decline in stock prices happened for instance in May 6, 2010 in the United States, during the so-called Flash Crash event. That day due a large fundamental trader that via a "Sell algorithm" and to high frequency trading, more than 20,000 trades across more than 300 securities were executed at a price that was over 60% away from their values just moments before (U.S. CFTC. U.S SEC 2010). In the cases like this one, or even in less extreme situations, an unjustified short-selling of banks shares could activate the conversion trigger without the existence of a real financial distress. A fall in shares price will increase the risk of conversion for bondholders and the dilution risk for existing shareholders, turning into more sales and activating a downward price spiral. This phenomenon, analyzed by Hillion & Vermaelen (2004), is defined as Death Spiral, since the self-reinforcing downward movement can end in a conversion not justified by the underlying financials. In addition to manipulation, other market distortions like prices volatility, investors' panics or other market pricing errors might trigger undue bond conversion.

Undue conversion risk can be mitigated by setting the trigger at an average share price. For example, by imposing the conversion at the triggering of an average of 5 to 10 consecutive days' share prices, short sellers would have to maintain their positions for a longer period of time (Flannery 2009; De Spiegeleer & Schoutens 2011). Still the lack of confidence in market efficiency and reliability explains the tendency of regulators to prefer account-based triggers.

2.2.5.1.3 Regulatory trigger

With this kind of trigger mechanism, the conversion or write down of the bond is activated by a decision of the government. This trigger, also called discretionary or point of non-viability (PONV), reflects the supervisor's negative judgment about the issuing bank's solvency prospects. The inclusion of this trigger clauses in AT1 CoCos is due to regulatory capital eligibility requirements (Avdjiev & Kartasheva 2013).

On the pros, this modality allows the regulator to overcome the problem of timing gap or unreliability of book-value trigger and also of the risk of market manipulation linked to market-based triggers. However, on the cons, the discretion given to the supervisor makes the trigger activation less clear and predictable both for issuers and for investors, deeply reducing the marketability of the bond. The funding costs for the issuer might increase since the investors may charge a premium for the uncertainty (De Spiegeleer & Schoutens 2011; Avdjiev & Kartasheva 2013). Moreover, being a non-automatic mechanism, the supervisor judgment and discretion might increase the negative signaling problem of recapitalization (Pazarbasioglu et al. 2012)

2.2.5.2 *Systemic trigger*

Systemic triggers, as opposite to bank specific triggers, do not aim at preventing the financial distress of a single institution but rather address "system-wide risks that can build up across the banking sector as well as the pro-cyclical amplification of these risks over time" (Basel Committee on Banking Supervision 2011b). The goal of these triggers is to strengthen the resilience, and increase the capitalization of the entire financial industry in the case of a systemic crisis. The systemic trigger can be linked either to some market crisis indicators, as for instance loss rates or indexes, or to regulatory declaration of systemic crisis. While providing the financial system with huge amount of capital in times of crisis, systemic triggers remove the incentive for banks to efficiently manage risk in case of low capital ratio, since the triggering event does not depend on their specific situation.

Systemic trigger imposed by the supervisor may generate the so-called first troubled bank problem, which consists in the fact that the first institution that is experiencing financial distress cannot access its contingent capital resources until the regulator or the market index forces all banks to recapitalize. That moment may be too late for the first bank and consequently the regulators have an incentive to declare systemic crises too early. On the contrary, uncertainty and shareholders aversion for conversion pushes regulators to a recapitalization delay. It is historically ascertained that regulators tend to delay too much recapitalization in order to reduce negative signaling to the market and to avoid generating a general lack of confidence.

A market based systemic trigger as an index could seem more reliable, since it is always disclosed, opened to the public and very difficult to manipulate through short-selling. On the other hand, the index must represent the entire financial industry and since every crisis is different, it is impossible to find a "correct" index that exactly anticipate the beginning of the crisis. The use of inappropriate trigger would expose the financial system to a huge risk since it would trigger CoCos' conversion either too early or too late.

To sum up, the two main problems related to the systemic trigger are the risk of wrong timing in systemic crisis declaration from the regulator and the fact that once the conversion is activated, the recapitalization happens for all the institutions with no distinction, thus penalizing the stable, well capitalized banks. To overcome this problem, researchers as Flannery (2009), McDonald (2013) or the Squam Lake Working Group (2009) suggested a dual trigger option, a combination of a systemic trigger and of a bank-specific one.

2.2.6 **Two part trigger**

Another suggestion from literature about the optimal CoCo design is the possibility of using two triggers on the same instrument, preventing risks linked both to the single institutions and to the entire financial system. According to Pazarbasioglu et al. (2012), the dual trigger mode allows implementing a broad-based recapitalization of the banking system still guaranteeing differentiation among banks. These solutions that take into account both micro and macro risk measures are proposed as an improvement of the options presented above (Veiteberg et al. 2012).

Supporting this view, McDonald (2013) presents a study for contingent capital with dual market trigger. His claim converts bond into equity based on market prices, and specifically, when bank's own stock price falls sufficiently and only if, at the same time, also a given broad financial stock index falls below an established trigger value. In this way, conversion occurs when the bank is performing poorly in a distressed financial industry environment but allows a bad bank to fail when the rest of the industry is in a good situation.

Similar to McDonald (2013) proposal is the one by the Squam Lake Working Group (2009), a pool of 15 non-affiliated leading financial academics that also suggested the conversion shall happen if two conditions are met. The first requirement is the declaration of systemic crisis by the regulator and the second is the violation of covenants contained in the security contract, which they identified in the bank's capital adequacy, measured by its CET1 ratio (French et al. 2010). Support to this proposal, comes from a Rajan (2009), who slightly modifies the Squam Lake Group proposal, suggesting that the systemic trigger should be activated by some objective indicators, such as aggregate bank losses, rather than by regulator's will. Here again the bank-specific trigger activates on an accounting basis, when the bank's capital ratio falls below a certain value (Calomiris & Herring 2011).

Having analyzed the different trigger proposals from literature, and said that the CRD IV imposes a trigger based on the capital ratio, the next section will introduce some pricing models existing in literature and will set down the valuation methodology used in this thesis.

3 THE VALUATION FRAMEWORK

3.1 PRICING ISSUES

Finding the correct value for Contingent Convertible instruments is a complicated task. Different proposals and methods were elaborated both in the academic and in the professional world around contingent convertibles since their very first appearance on the capital markets. Nevertheless, the continuous evolution and large variety of non-standard features of these hybrid bonds, make it difficult to find a comprehensive and definitive approach (Deufel et al. 2011).

In this section, we are going to briefly discuss the principal pricing issues and we will introduce the so-called Rock-bottom spread model from J.P. Morgan, which is the starting point for our extended framework. The extension will aim to adapt the 2006 version on financial hybrids to the new regulatory context and to the new and specific features required to CoCos to be included in Additional Tier 1 capital under the CRD IV.

The first CoCo bond was issued in 2009 by Lloyds, and was quite different from the AT1 CoCos that boosted the contingent capital market in the very last years. The Lloyds 2009 CoCo is classified as Tier 2 capital, has a fixed coupon, a capital ratio trigger of 5% and a maturity of 10 years. This instrument is very different from the securities described in the previous chapters and the valuation method varies significantly for the two instruments. Most pricing existing model are focused on this first type of CoCo, having a fixed non-cancellable coupon and a defined maturity, and thus tend to focus only on the conversion risk. The main issues related to conversion are in quantifying the value of the shares the investor will receive upon conversion. This is a function of the market share value at the trigger time and of the conversion price set in the prospect.

Other uncertainties complicating the valuation of Additional Tier 1 are related to the coupon payment streams, which are at full discretion of the issuer and to the undefined maturity of the security. The high heterogeneity of this asset class makes the modelling of a standard consistent framework something puzzling and far from being achieved (Henderson Global Investors 2014).

In addition to that, since these instruments originated as a response to the Basel III regulation, they are very sensitive to changes in the bank's capital requirements. In fact, the constant evolution of financial system regulation, could make the already issued instruments no more compliant with legal requirements, thus modifying their risk profile and expected return when already in possession of investors. This phasing out is exactly what happened with old style Tier 1 hybrid bonds which were considered as Tier 1 capital before the new rules of Basel III. These old-style

Tier 1 bonds, which failed to protect banks during the crisis, were perpetual callable bonds with a step-up mechanism after the first call date. This feature strongly stimulated issuers to call the bonds and many operators considered them as fixed maturity bonds. The removal of the step-up feature, eliminating the incentive to call, enhances the perpetuity characteristic of AT1 capital changing the relevant time horizon in the securities' valuation (De Spiegeleer & Schoutens 2014a).

More uncertainty around AT1 instruments, according to the Global Credit Research (2015) by J.P. Morgan, could be added by the trend towards higher triggers for AT1 Cocos in the European banking sector. If this trend is respected, although having a good impact on the sector, it will have a more uncertain impact on outstanding AT1 contingent debt (since it would be no more compliant) and could lead to unexpected outcomes not priced in the market (J.P.Morgan 2015).

For the reasons above, pricing models may need to be frequently modified to adapt to the regulation changes. Nevertheless, since the prospected strong growth of this asset class and since this complexity and evolving nature of this under-researched market can give rise to attractive investment opportunities, having a tool allowing to find a "fair price" for Cocos is a relevant matter for high yield securities investors (Henderson Global Investors, 2014).

While, at the date, the loss absorption triggers in real issuances are linked to the CET1 ratio, most existing models on pricing Cocos are based on substituting the accounting trigger with a triggering stock price. All these models imply high correlation between stock price and capital ratio, which is historically inconsistent, and do not consider the banks' ability to control the ratio through their risk management. Some proposals with accounting triggers and conversion to shares are presented below, with a focus on assumptions on capital ratio and stock prices co-movements (Veiteberg et al. 2012). Among the existing models we are going to briefly present the credit derivatives approach, developed by De Spiegeleer & Schoutens (2011), which models the recovery rate at conversion, based on the ratio between the market share price at the moment of conversion and the conversion price, set in the prospectus, at which the investor effectively pays the shares.

The credit derivatives approach is based on a fixed income investor's perspective, seeking the extra yield on top of the risk free rate required to face the risk of support losses. This starts from a reduced form approach, which establishes the relationship between the spread, the recovery rate and the probability of default (λ) of the bond according to the following equation:

$$cs = (1 - R) \times \lambda$$

Moving from this relation, the model considers the trigger event as some kind of special case of default event. Obviously, we have that $\lambda_{Trigger} > \lambda$, since we assume that the trigger event will take place before the institution defaults and thus has a higher probability to materialize. The required spread hence becomes:

$$csCoCo = (1 - R_{CoCo}) \times \lambda_{Trigger}$$

The recovery rate of the contingent convertible depends on the conversion price into shares, as already seen in section 1.2, so the only missing part, according to De Spiegeleer & Schoutens (2011), is the probability of the trigger event. Since estimating $\lambda_{Trigger}$ reveals to be a complicated task, this approach assumes that stock prices move in an equivalent way as capital ratio and thus replaces the accounting trigger with a market-based value. By doing this, the trigger probability can be modeled in a Black–Scholes setting. We presented this model, since based on its results on the recovery rate for the same securities we study, we will set our assumption about their possible recovery rate.

3.2 THE ROCK-BOTTOM SPREAD FRAMEWORK

The so-called rock bottom spread model is a valuation framework developed by Peter Rappoport (2001) from J.P. Morgan Securities, to value the significant additional exposures that many bonds present in addition to plain government bonds, namely credit and liquidity risk.

In 2006, Henriques, Goulden, and Granger, from J.P. Morgan Credit Research, adapted this model to financial hybrids, and specifically to bank's Tier 1 bonds, the regulatory ancestor of Additional Tier 1 Cocos, which this master thesis aims to fairly value. Henriques et al. (2006) valuation framework allows taking into account the non-standard features of Tier 1 bonds, namely the subordination, the coupon deferral and the extension risk.

In this thesis, we will adjust the framework to value the new features of AT1 Cocos deriving from the changes in the regulatory environment. The new framework developed will take origin from the basic Rock-bottom spread mechanics (Rappoport, 2001a), will include the changes made by Henriques et al. (2006) and will be modified and extended in order to be test on some recent European banks CoCo issuances.

3.2.1 Overview of the framework

As the original valuation framework for corporate hybrids, the model is based on the calculation of the present value of a set of cash flows in order to find out a fair price, and thus fair spread, for the financial hybrids. However, the specific and not standard features of these instruments makes the calculation far more complicated that it would be with plain vanilla bonds.

CoCos structure indeed, generates a huge amount of uncertainty around the effective instrument's cash flows, and the probability of the missed payment of coupons and the probability of the activation of loss absorption mechanism have to be included in the derivation of the fair value of these securities.

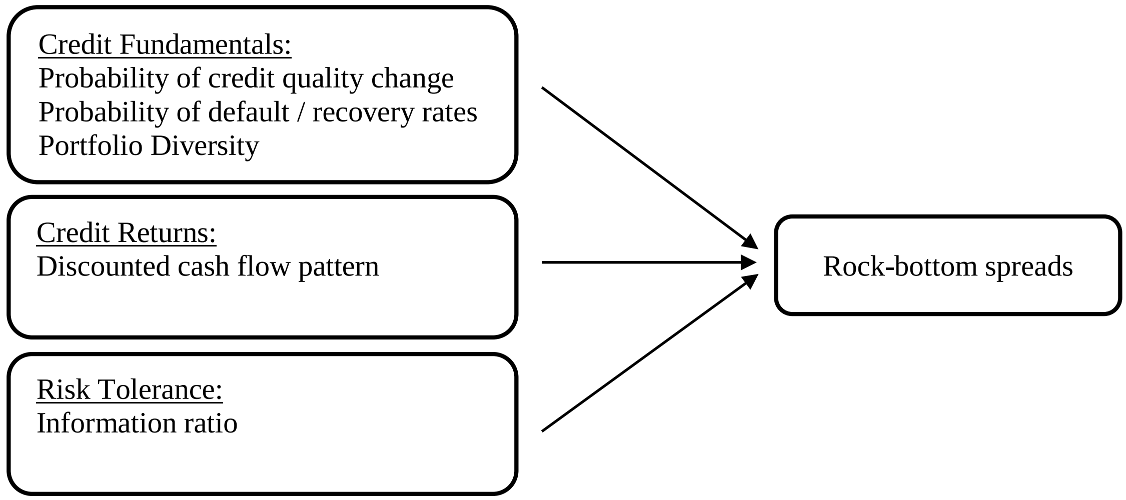


Figure 5. Rock-bottom spread model pillars. Adapted from (Rappoport 2001b).

The main output of this valuation model is, indeed, the rock-bottom spread, which represents the lowest amount that an investor need to be paid to bear the credit exposure. Any lower spread from the security would not compensate enough for the additional risk. This spread reflects three pillars on which the model is based:

1. Credit Fundamentals: the credit quality and views on credit trends over the bond's life the probability as represented by ratings;
2. Credit Returns: the expected cash-flow, the maturity and seniority ranking of the bond;
3. Risk Tolerance: the rate of return the investor requires for taking risk, expressed by the information ratio.

These elements will correspond to a certain required spread, which is independent from any market influence. This allows then, to compare the spread found out according to the model and to the credit valuation of the issuing institution, with the spread that the market is offering for the same bond, so to make more informed purchase decisions based upon the model's results.

There are two main and most important assumptions that are made in the construction of the framework. First, the probability of the cash flows being received by investors is assumed to be linked to the financial state of the issuing institution. Secondly, the model assumes that the financial state of the issuer is represented by its ratings. Linking each CoCo risk feature to a corresponding rating of the issuer means associating each risk event and the connected expected cahsflows to the underlying financial state of the issuer. Given these assumptions on the link between ratings and future cash flows, we have to build a probability distribution for the issuer rating state and thus for its possible financial situation. The medium adopted to determine the empirical evidence of the probability of being in each rating state is the rating transition matrix. This matrix represents the historical chance for each institution with a given initial rating to change or maintain its rating state over a certain period, one year in our case. This method provides us with a forward looking probability distribution of the rating transition of the firm and to estimate the likelihood of receiving a certain cashflow from the instrument issued by the firm (Henriques et al. 2006).

The three factors composing the model and determining the rock-bottom spread will be discussed, with special attention to the way they were modified with respect to the original framework to better fit the valuation of Additional Tier 1 CoCos.

3.2.2 **Credit fundamentals**

Credit fundamentals concern the potential losses that the investor is facing when investing in a certain security. These potential losses depend on the actual and future credit quality of the issuing institution, which reflects in its probability of downgrading and default.

3.2.2.1 ***Credit migration matrix***

As said, one of the crucial assumptions in the basic valuation framework and in our adjusted version, is that the financial condition of the bonds' issuing firms can be represented through their ratings. Standard and Poor's defines issuer credit ratings as their "forward-looking opinion of a company's overall creditworthiness to pay its financial obligations" (S&P 2014). According to that, changes in the credit quality of the issuers are predicted following what is empirical evidence about senior ratings migration, as reported in credit transition matrices. According to Schuermann (2007), this method is common practice in several risk management applications, among which portfolio risk assessment, pricing of bonds and credit derivatives.

Many examples of the use of transition matrices as a cardinal input of valuation models can be found in previous literature, as for instance in the Markov chain based risky bond pricing method by Jarrow, Lando & Turnbull (1997) or in the credit derivatives pricing model from Kijima and Komoribayashi (1998). This approach is also used in credit portfolio models as showed by Gupton, Finger, & Bhatia (1997) in their *CreditMetrics*^{TM} framework, which calculates bond prices and assesses credit risk assuming asset returns to be normal distributed and to be linked to the issuing firm's rating states. Given these assumptions and the likelihoods derived from the transition matrix, it is possible to compute every asset return threshold corresponding to a specific credit rating

(Bangia et al. 2002; Crouhy et al. 2000). This relation is represented in Figure 6, where the horizontal axis represents a BBB firm's assets value.

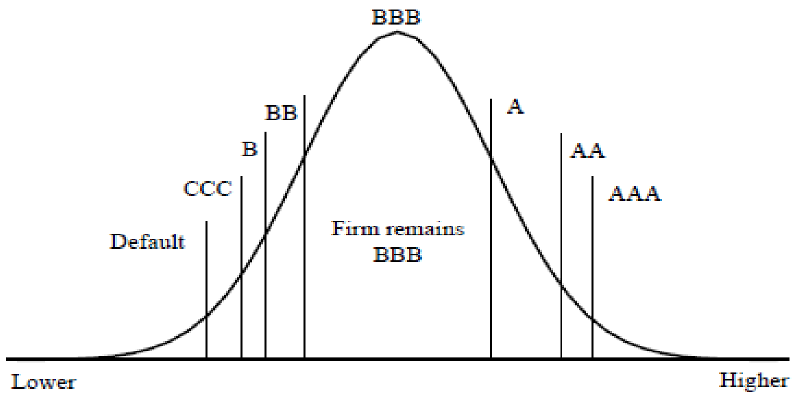


Figure 6. Model of a value firm and migration (Gupton, Finger, & Bhatia,

The examples reported in Figure 7, show the probability for respectively, an A, AAA, and BBB rated institutions to be in the same or another rating class by the end of the year. A first general rule is that the sum of the likelihoods must be equal to 100 % since these represent all the possible "states of the world" for the changes in issuers' credit quality. Taking the first example, it can be seen that, according to historical data, an A rated institution has 91.05% probabilities to still be an A rated company at the end of the year and 5.52% likelihood to be downgraded of one notch, thus becoming a BBB rated firm, always on a one year time interval.

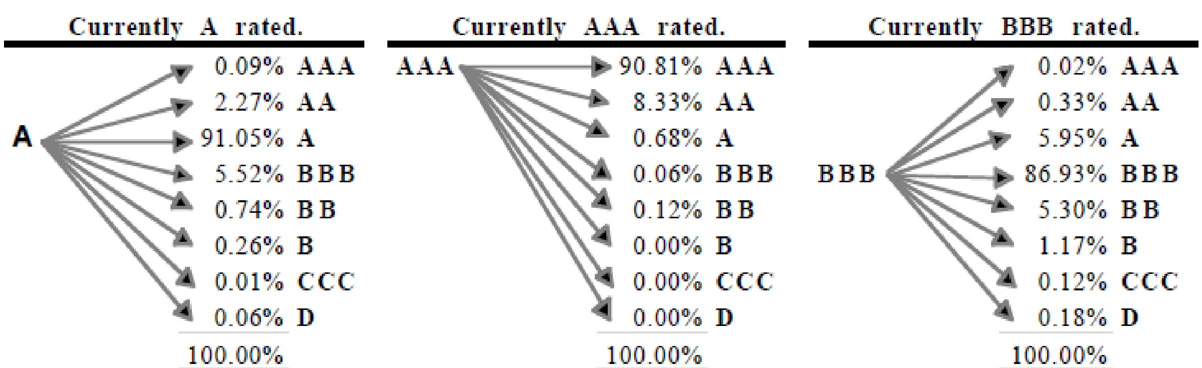


Figure 7. Examples of credit quality migration on a one-year horizon (Gupton et al., 1997).

Instead of representing the quality migration probabilities separately for each rating, it is common practice to use transition matrices, which indeed result in square table of probabilities.

The market of the migration matrices in the U.S. is dominated by Moody's Investors Services and by Standard & Poor's, which yearly publish studies about the default probability ad the rating migration. Because of their broader coverage, Moody's and S&P data have been used in several published studies (Jafry & Schuermann 2004). For the same reason we will use a transition matrix adjusted from the yearly matrices published by Standard & Poor's Rating Services in their Annual Global Corporate Default Study and Rating Transitions. From now on, the S&P ratings nomenclature is going to be used.

There are several different kind of matrices and several aspects to consider when choosing the most suitable matrix for purpose. Hereafter we will discuss some of these aspects and give a rationale for choices made in this thesis.

First, the dataset originating the matrix must be analyzed. The matrices by S&P are generated using the Standard & Poor's CreditPro database, which contains, as of year 2013, the issuer credit ratings history for 16857 companies that were first rated in the period from December 31st, 1980 to December 31st, 2013. They include both US and non-US industrials, banks and other financial institutions and real estate companies. The matrices can be created on a country, region or on an industry basis. This separation is quite important, since the probability distribution or rating transitions may vary in a significant way depending on the group of institutions under observation (S&P 2014).

In order to capture credit quality, the ratings composing the matrix must be related to the issuer, as credit events normally concern firms as a whole. Since ratings are generally related to specific debt, S&P perform some steps to create a corporate matrix. First, bond ratings are converted into issuer rating by taking the long-term senior unsecured rating, since they do not carry any additional risk to the issuer credit risk. Second, issuers are grouped into economic entities, this allowing making a correct rating attribution taking into account parent-subsidiary links, mergers and acquisitions and similar corporate structures (Bangia et al. 2002).

Matrices can count 8 or 18 different rating states, depending if the rating modifiers +/- are included or not. S&P yearly calculates both types of matrices, and both of them present positive and negative aspects. The 8 categories matrix, for instance, provides larger sample sizes for each rating category which reduces the risk of incurring in statistical errors, that, as outlined by Bangia et al. (2002), could happen when using the 18 states transition matrix because of the small number of issuer in the lower rating categories. Nevertheless, since 2002, the dataset has significantly increased, reducing this problem and leaving with the positive aspect of using an 18 rating state matrix, which consists in having a greater accuracy and granularity of determining the issuers financial condition. The 18 states matrix in addition to the rating modifiers +/-, includes the Default state (D) and the "not rated" state (NR). Default is treated in transition matrices as an absorbing state, which means that once a firm goes into default it is removed from the sample. What emerges from bankruptcy and could be represented as a migration from D to another rating state is instead typically considered as a new firm. Another rating category that is present in the 18 states transition matrix is the “not rated” state (NR), which is formed by firms that were normally rated at the beginning of the year and whose rating is withdrawn at the end of the same year. There are several reasons for a firm to end up in the not rated status and dealing with them is a quite complicated task. What is evident is that no credit quality can be associated with the NR state and hence the probability of ending in that class must be somehow distributed to the other rating categories. There is far less evidence instead why a specific firm ends up in the “not rated” category. According to Gupton et al. (1997) and to S&P (2014), ratings are withdrawn when an entity entire debt is paid off or when rated debt issuance programs are terminated and relevant debt is extinguished. Otherwise, rating can be withdrawn as a consequence of firms mergers or acquisitions. A “bad” transition to NR occurs instead, when there is a lack of cooperation and transparency especially when a firm is experiencing financial troubles and refuses to provide all the information required to come out with a certified rating, or when due to deterioration of the credit quality the entity itself decides to bypass an agency rating (S&P 2014). Due to this high uncertainty on rating withdrawals, there are different proposals regarding how eliminate the NR category from the matrix.

In the literature there are at least three methods. The first method is conservative and assumes the NR as a negative information with respect to the credit quality of the issuer. The probability of transition to NR class is distributed among the downgraded and defaulted states proportionally to their values. The second method is liberal and treat the NR status as positive, allocating thus the probability of transition to NR to all other ratings, except for the default status, proportionally to their values. The third method, that has emerged as an industry standard is to treat transition to NR status as a neutral information thus allocating the probability of transition proportionally to all the others categories (Bangia et al. 2002).

Another variable that changes in transition matrices is the time horizon, since matrices can be estimated for any desired time horizon. The shortest horizon is potentially a quarterly transition matrix, since financial statements and ratings are updated on a quarterly basis. However, it has to be said that generally one-year transition matrices are used since shorter matrices have not been published by agencies yet. In the figure 8, an example of the 8-states migration matrix is reported.

T+1

T		AAA	AA	A	BBB	BB	B	CCC	D
	AAA	**93.00**	6.18	0.66	0.07	0.08	0.01	0.00	0.000
	AA	0.61	**91.03**	7.53	0.64	0.09	0.08	0.01	0.005
	A	0.08	1.99	**91.69**	5.55	0.49	0.18	0.01	0.008
	BBB	0.03	0.26	4.05	**89.70**	5.05	0.76	0.07	0.083
	BB	0.04	0.11	0.56	5.26	**83.80**	8.95	0.73	0.548
	B	0.00	0.07	0.23	0.50	4.67	**84.36**	5.71	4.448
	CCC	0.06	0.01	0.34	0.56	1.10	7.99	**47.02**	42.896
	D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**100**

Figure 8. Example of one year migration matrix, based on S&P histories, 1981-2004 (Schuermann 2007)

From Figure 8 we can figure out a characteristic common to all migration matrices, namely the high probability load on the diagonal, which means that firms are most likely to keep their current rating through one year, and have the second highest probability to move in the direct neighborhood to the diagonal. A decreasing trend in probabilities can be observed getting away from the diagonal, a phenomenon that has been addressed as monotonicity (Bangia et al. 2002).

For what concerns our framework, some adjustments have to be made on the transition matrix, in order to get the more suitable forecast of credit quality migration for the banking firms.

The matrix we are going to use, as said, will be taken from the annual Standard & Poor’s reports about default and credit quality because of the availability of the data. In particular, we will take the “Financial Institutions” matrix, which is computed only based on the financial sector. This point is important since probabilities significantly vary from an industry to another.

Related to the number of rating categories we chose the 18-state migration matrix because it allows a greater granularity in bond pricing. This will allow us to have more rating categories to calibrate the different triggers of the bond affecting expected cashflows –namely the extension, the coupon deferral and the conversion or write-down- to a certain financial condition of the issuing bank. Having the rating modifiers allows differentiating the trigger rating for bonds having a different conversion trigger rate (generally 5.125% or 7% CET1 ratio) or a different combined required buffer. Using the 18-states matrix, we have to deal with the NR state, as discussed above. We will in this case adopt, contrarily with the industry standard, a negative interpretation of withdrawn ratings since given the uncertainty about the reason of the withdrawal and of the concerns about the effect of the bail-in regulation on rating migration we prefer to assume a prudential and conservative position to avoid the risk of over-evaluating CoCos. The migration horizon we are going to use is one year, since the bond price will be obtained by backward calculation, discounting cashflows year by year. Actually, the coupon payment of the analyzed bond are paid on a quarterly or semiannual basis, so the most correct way would be to use quarterly migration matrices. Nevertheless, for a matter of simplicity we approximate coupon as annual payments, so to use the one-year transition matrix, which is the shortest time horizon for published matrices.

Most previous studies use a one-year matrix that is the average of the matrices from 1981 to the study date. However, we propose a different approach since the changes in banking regulation that occurred after the 2008 financial crisis strongly affected the perception about the credit quality of financial institutions. New rules made necessary a negative review of credit ratings assigned by the agencies and introduced a more strict regulation of the banking sector and of the rating industry (Chennells & Wingfield 2015). The most important legislative change imposed by the European Union is the switch from the 'bail-out' system to the 'bail-in' one, a subject we have already discussed in the introductory paragraph. This procedure, that has become officially operating in January 2016, changes the credit view on financial institutions even for their senior rating, since before this regulatory change, a government support uplift was added to the bank standalone credit rating. In a default event the government would have rescued the insolvent bank and repaid its creditors (State Street Global Advisors 2015). Nowadays the situation has changed, the credit risk connected to a bank is more independent from the State it belongs to and entirely lies on its debt holders. All this translates in negative implications for the ratings that do not benefited anymore of the uplift for potential government support (Standard & Poor's 2012).

Since the crisis and the consequent regulation affected the rating attribution methodology, we suggest taking as observation period the years going from 2010 to 2013. We compute then the average one-year migration matrix for this period. Although this will give us a smaller observation period, we consider that taking only the post crisis era, provides us to more precise forecast about rating migrations.

The last adjustment made to the transition matrix used in this thesis is the correction of the default row in order to make default probability increase monotonically as suggested by Henriques et al. (2006). For some historical anomalies that the BB and B+ rated companies have higher probability of default than their respectively one grade higher rated firms, namely the BB+ and BB-. In order to keep the sum of transition probabilities equal to one, the part added to the default probability is removed from the just above rating state for the considered column.

The matrix used as starting point for this framework is shown in Figure 9. The matrix is transposed with respect to the Standard & Poor's original one, and is to read from top-down.

Corporate Transition Matrix--One Year Ended Dec. 31, (2010-2013) (%)

Financial Institutions

to\From	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC/C
#	83	72	127	291	522	566	461	430	535	419	205	220	250	214	223	176	70
AAA	0,7350	0,0278	0,0000	0,0000	0,0000	0,0000	0,0022	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
AA+	0,2386	0,8750	0,0079	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
AA	0,0132	0,0972	0,5905	0,0103	0,0000	0,0000	0,0000	0,0023	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
AA-	0,0000	0,0000	0,3381	0,7698	0,0364	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
A+	0,0000	0,0000	0,0528	0,1811	0,7280	0,0495	0,0022	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
A	0,0000	0,0000	0,0000	0,0216	0,2043	0,7544	0,0629	0,0000	0,0000	0,0048	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
A-	0,0000	0,0000	0,0000	0,0043	0,0131	0,1366	0,7267	0,0628	0,0037	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
BBB+	0,0000	0,0000	0,0106	0,0043	0,0078	0,0440	0,1214	0,7233	0,0935	0,0071	0,0049	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
BBB	0,0132	0,0000	0,0000	0,0086	0,0079	0,0066	0,0536	0,1319	0,7215	0,0883	0,0293	0,0045	0,0040	0,0000	0,0000	0,0000	0,0000
BBB-	0,0000	0,0000	0,0000	0,0000	0,0026	0,0088	0,0141	0,0399	0,1148	0,7255	0,1122	0,0136	0,0040	0,0000	0,0000	0,0000	0,0000
BB+	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0113	0,0184	0,0363	0,1130	0,5561	0,1318	0,0200	0,0000	0,0000	0,0000	0,0000
BB	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0056	0,0184	0,0242	0,0376	0,1287	0,6273	0,1120	0,0280	0,0000	0,0000	0,0000
BB-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0061	0,0189	0,0885	0,1425	0,6480	0,1168	0,0090	0,0057	0,0000
B+	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0321	0,0178	0,0985	0,6495	0,1121	0,0057	0,0143
B	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0031	0,0000	0,0000	0,0161	0,0178	0,0833	0,1398	0,6323	0,1875	0,0286
B-	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0080	0,0089	0,0076	0,0576	0,1687	0,5796	0,1428
CCC/C	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0080	0,0267	0,0000	0,0000	0,0520	0,1754	0,4571
D	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0047	0,0161	0,0089	0,0227	0,0082	0,0260	0,0462	0,3571

Figure 9. 18-states Financial Institutions credit migration matrix. Adjusted from S&P

3.2.2.2 *The diversity score*

The effect of potential losses on investor's choices is not only influenced by the credit quality and the probability of default, but also by another factor, which is not linked only to the issuing institution, but also to the investor's general strategy. This element is the so-called diversity score, a theoretical measure originally created by Moody's to estimate the diversification of a portfolio and to assign credit quality ratings to Collateralized Loan Obligations (CLO). This measure, slightly modified in J.P. Morgan's 2001 Rock-bottom spread model is taken into account in the framework's, since the diversification of an investor's portfolio influences the exposure to credit risk that this investors will be prepared to bear. In fact, a high diversity score will translate in smaller rock-bottom spread required while a smaller diversity score, making the investor more risk averse, will result in a higher required spread. The purpose of this metric is to evaluate the extent to which it is likely that default events of the issuers present in the portfolio occur as correlated circumstances instead of as independent events (Di Bartolomeo 1998). The computation methodology takes into account the issuers and the industry concentration in the analyzed portfolio and incorporates assumptions on default correlations, converting that portfolio of correlated exposures in a smaller number of independent exposures (Moody's Investor Services 2007). Moody's assumes that there is high correlation between issuers in the same industry, thus having a very small number of equivalent independent exposures, but that there is zero correlation across industries so that the diversity scores of the bonds in each industry are summed up into the portfolio diversity score (Rappoport 2001b). According to the original J.P. Morgan Rock-bottom spread model, the diversity score we will use in our extended version is 70. This number is the diversity score offered by the entire US High Yield corporate sector, and means that even if there are over

1000 issuer that are rated as speculative-grade, they provide the same diversity as 70 issuers with independent asset values. A diversity score of 70 represents hence, a fully diversified investor holding a portfolio equivalent to the entire High Yield US corporate market and corresponds to the lowest required spread. The way in which the diversity score is inserted in the calculations, reducing the excess return volatility, will be showed in the paragraph 3.2.4

3.2.3 **Credit Returns**

The second point to consider in the framework is the cashflows pattern generated by the analyzed bond. What we search is the credit return i.e. the excess return that the corporate bond (AT1 CoCo), is expected to provide over an identical government bond. The cashflow pattern of a corporate bond is different from the one of a sovereign bond, since the first one has a certain probability to default. The corporate bond should hence provide an additional return, in the form of a spread over government return to compensate the investor for the uncertainty about the actual cashflows he is going to receive. As figure 10 shows, the two bonds have the same principal and the same maturity of one year. They both receive a coupon after one year but since the corporate bond faces the possibility of a default, it will pay a spread over the government 5% coupon.

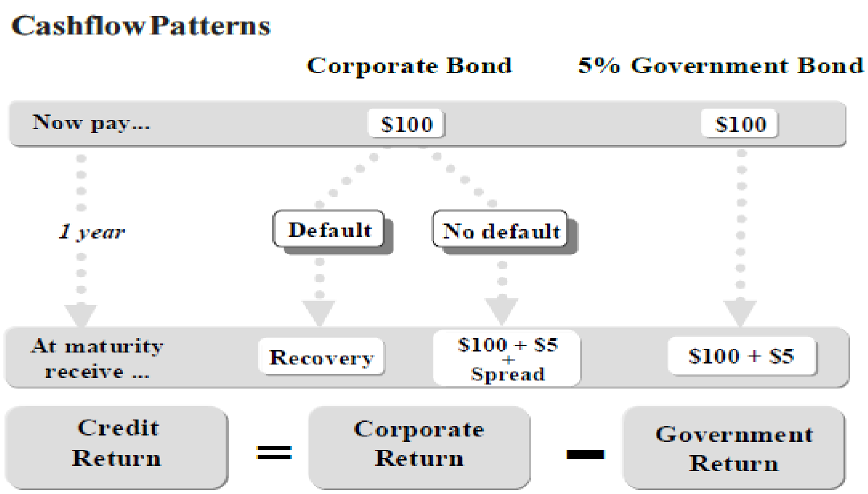


Figure 10. Cashflow scenario for a one-year corporate bond (Rappoport, 2001c)

Figure 10 illustrates the easiest case of a one-year bond with two only possible scenarios, either the repayment of the bond or the default. When considering more than one year, the probabilities of rating changes have to be considered in computing the average credit return. The idea behind the use of transition matrices, consistently with the CreditMetrics approach, is to make future cashflow pattern dependent on issuer's rating state, thus a threshold of expected cashflows for the bondholder can be created using an adjusted migration matrix as previously described.

Figure 11, on based on Rappoport (2001a), represents the possible credit scenarios for a 3-years BBB rated bond and the related cashflows. Every state of the transition matrix has a certain cashflow associated with it and according to the initial senior rating, the probabilities of migration for the next year are established. Discounting the cashflows backward to the actual date, we find the price resulting from different credit scenarios and hence establish the credit return of the bond.

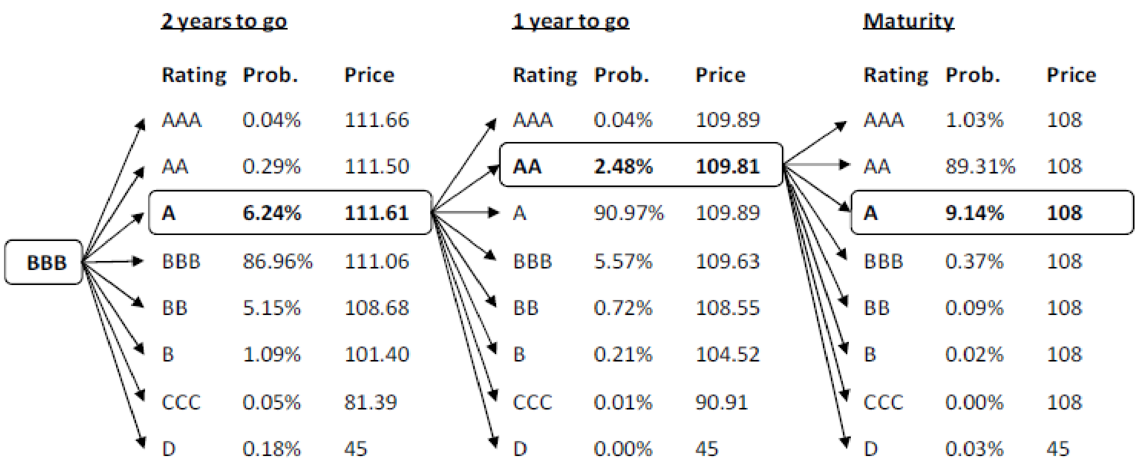


Figure 11. Example of a 3 years scenario for corporate bond (Schaffner 2010).

To quantify this rock-bottom spread we have to define one more element, which is related to the risk premium required by the investor as a compensation for bearing the default risk. This risk tolerance measure will be introduced in the following paragraph (Rappoport 2001a).

3.2.4 **Risk Tolerance**

The investors risk aversion of the can be measured through the information ratio, a ratio that was first exposed by Jack Treynor and Fisher Black in 1973 (Schaffner 2010). This metric is useful to isolate the excess return per unit of risk taken (Kidd 2011).

The information ratio is basically a volatility-adjusted excess return since it describes the relationship between the excess return over the benchmark and the volatility of this excess return. The information ratio is expressed by the following equation:

$$IR_i = \frac{E[R_i - R_b]}{\sqrt{Var[R_i - R_b]}}$$

where R_i is the return of the coco bond and R_b is the return of the benchmark. The denominator term $\sqrt{Var[R_i - R_b]}$ stands for the standard deviation of the tracking error, which is the difference between the return of the bond and that of the benchmark.

The importance of the information ratio in the adjusted rock-bottom spread framework, according to Rappoport (2001), derives from the fact that it is interpreted as the asset's performance target that an investor requires in order to accept the risk of holding a given security, a contingent convertible in this specific case. The target ratio is chosen by considering alternative investment opportunities, since it would be nonsense to pursue a strategy that produces a lower information ratio than other possible alternatives, so having less return for unit of risk. In the case of bonds the excess return considered is the credit return (Rappoport 2001b).

In the model, the target information ratio will influence the maximum price an investor will buy the Coco bond, and thus the credit spread that he requires for investing in that. Pricing the bond in this way, ensures the fact that the obtained eccess return will be related to the one obtainable by investing in other opportunities of outperforming government bonds.

According to Henriques et al. (2006), the target information ratio we will assume is equal to 0.5, which is something that has become a standard in the industry. Several studies have analyzed the distribution of the information ratios obtained by active fund managers in different historical periods finding a sort of scale of ratios. As mentioned by Kidd (2011) and according to Grinold & Kahn (1996) and Goodwin (1998), empirical evidence on before-fee information ratios offers the results reported on Figure 12. Although the results may change somewhat by time period, by asset class or by fee level, the following figure represents an overall reliable distribution of ratios.

Percentile	Information Ratio	Manager Skill
90	1.0	Exceptional
75	0.5	Good
50	0.0	Above Average
25	-0.5	
10	-1.0	

Figure 12. Ranking of Information Ratios (Cameron, 2009).

An adjustment that must be done, when passing from a single asset to a portfolio or index is to reduce the volatility, dividing it by the diversity score $\sqrt{d}$. This provides us with the reduced volatility, which expresses the fact that the hydiosincratic risk of a single asset is reduced when this security is introduced in a diversified portfolio. The adjusted equation is the following one:

$$IR_a = \frac{E[R_i - R_b]}{\frac{\sqrt{Var[R_i - R_b]}}{\sqrt{d}}}$$

The information ratio, obtained by introducing the diversity score at the denominator, provides us with the target excess return over unit of risk, and thus the minimum spread that a fully diversified investor will ask to introduce a certain Coco bond in his portfolio. As we will se in the next paragraph, this equation is the starting point for the rock-bottom spread calculations since it includes the credit returns as well as the measures of risk aversion that characterize our investor. In our framework we will use the Sharpe ratio, which is a particular case of information ratio, where the benchmark is represented by the risk free asset.

3.2.5 Computing Rock-Bottom spreads

In this section, we will show the algebraic calculations to compute the rock bottom spread, the lowest spread the investor requires to bear the credit risk of holding a corporate bond.

Following J.P. Morgan's framework we first have to compute the rock bottom price. We will then compute the spread, through a conventional price-to-yield calculation.

To simplify the methodology understanding, we will show procedures and computations with a standard bond, contemplating only two possible credit scenarios "default/no-default", and with an 8-state corporate transition matrix. The complex features of AT1 CoCos will be later introduced, once the model mechanics are clearly stated. Related to the target performance, the information ratio will be set, for the reasons earlier explained, equal to 0.5. In the example, we consider the financial 8-state matrix in Figure 13, with time horizon of one-year calculated as the average of the period going from 1981 to 2014, adjusted from S&P (2015).

Average One-year Global Corporate Transition Matrix (1981-2014)
All Financials

to\From	AAA	AA	A	BBB	BB	B	CCC
AAA	0,8955	0,0054	0,0002	0,0000	0,0000	0,0000	0,0000
AA	0,0977	0,8996	0,0267	0,0029	0,0014	0,0005	0,0000
A	0,0039	0,0892	0,9254	0,0533	0,0024	0,0015	0,0000
BBB	0,0008	0,0043	0,0428	0,8947	0,0778	0,0054	0,0000
BB	0,0008	0,0003	0,0027	0,0383	0,8401	0,0871	0,0196
B	0,0004	0,0003	0,0008	0,0055	0,0578	0,8329	0,1862
CCC	0,0008	0,0004	0,0001	0,0017	0,0105	0,0386	0,5915
D	0,0000	0,0004	0,0013	0,0035	0,0101	0,0341	0,2027

Figure 13.8-states transition matrix. Adjusted from (S&P 2015).

For what concerns the bond instead, we start by considering a one-year senior unsecured bond, which has only the default/no-default possible scenarios. The inputs used for the example (except from the matrix) are taken from Rappoport's (2001) original valuation framework and are reported in the table below:

Example inputs	
Default/Downgrade probability	As in figure 14
Face value	100
Recovery rate	45%
Coupon	8%
Information ratio	0.5
Diversity score	70
Discount rate	6%

Table 5. Example valuation inputs. From Rappoport (2001a)

In this case, hence, the credit scenarios for a one-year period are:

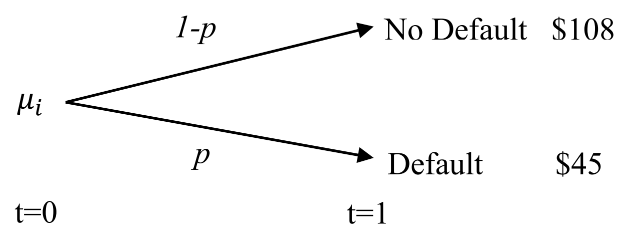


Figure 14. One-year bond credit scenarios

The value of the bond depends on how likely each scenario is expected to realize. We then compute the average price, i.e. the expected future value between the two possible scenarios using the following formula for all the 7 possible ratings (we do not consider the "D" state):

$$E[CF_i] = \mu_i = (1-p)(FV + C) + p(R)$$

where p is the probability of default, FV the bond face value, C the coupon and R the recovered amount in case of default. The probabilities for each scenario, used in this example, are taken from the matrix in Figure 13.

$$\mu_{AAA} = \sum_{i=1}^{s} p_i \mu_i = \begin{pmatrix} 1 * 108 + \\ 0 * 45 \end{pmatrix} = 108$$

$$\mu_{AA} = \sum_{i=1}^{s} p_i \mu_i = \begin{pmatrix} 0.9996 * 108 + \\ 0.004 * 45 \end{pmatrix} = 107.97$$

.

$$\mu_{CCC} = \sum_{i=1}^{s} p_i \mu_i = \begin{pmatrix} 0.7973 * 108 + \\ 0.2027 * 45 \end{pmatrix} = 95.23$$

As expected, the prices are decreasing going from the higher to the lowest rating category of the issuer. To obtain the rock bottom price another important factor we need is the volatility of the bond prices, which we obtain (for the "default/no-default" case), via the following formula:

$$sd_i = \sqrt{[(1-p)(FV+C)_i^2 + pR_i^2] - \overline{CF}^2}$$

which in a multiple scenario case, becomes:

$$sd_i = \sqrt{\sum_{i=1}^{s} p_i \mu_i^2 - \overline{\mu}^2}$$

Back to our example, we compute thus the volatility of prices for the different ratings.

$$sd_{AAA} = \sqrt{\sum_{i=1}^{s} p_i \mu_i^2 - \overline{\mu}^2} = \sqrt{\begin{pmatrix} 1 * 108^2 + \\ 0 * 45^2 \end{pmatrix} - 108^2} = 0$$

$$sd_{AA} = \sqrt{\sum_{i=1}^{s} p_i \mu_i^2 - \overline{\mu}^2} = \sqrt{\begin{pmatrix} 0.9996 * 108^2 + \\ 0.0004 * 45^2 \end{pmatrix} - 107.97^2} = 1.26$$

.

$$sd_{CCC} = \sqrt{\sum_{i=1}^{s} p_i \mu_i^2 - \overline{\mu}^2} = \sqrt{\begin{pmatrix} 0.7973 * 108^2 + \\ 0.2027 * 45^2 \end{pmatrix} - 95.23^2} = 25.33$$

To obtain the rock-bottom price we first have to set the relation it has with the target information ratio. Since the performance depends on returns, it also depends on prices for the reason that the reservation price is the one that allows the investor reaching his target performance. The benchmark we take for computing the information ratio in this example is a risk-free investment in government bond, which following Rappoport (2001) example is equal to 6%. We want hence to write an equation for rock bottom price in function of expected future cashflows, their volatility and of the information ratio.

We start from the Information Ratio formula (without considering diversification for the moment) as expressed in the previous paragraph:

$$IR_i = \frac{E[R_i - R_f]}{\sqrt{Var[R_i - R_f]}}$$

We have that $E[R_i - R_f]$ is the excess return of the bond over the government bond, which we call also the credit return in scenario and $\sqrt{Var[R_i - R_f]}$ is the volatility of the excess return over the government bond in scenario. Anyway, since we are interested in considering every possible scenario the information ratio we are interested in is:

$$IR_a = \frac{average\ credit\ return}{credit\ return\ volatility} = \frac{E[R_a - R_f]}{\sqrt{Var[R_a - R_f]}}$$

First, we deal with the average credit return across scenarios. This corresponds to the (expected) difference between the average bond return and the government return, which we assume to be constant across scenarios. This is expressed as follows:

$$\begin{pmatrix} Average \\ credit \\ return \end{pmatrix} = \frac{\begin{pmatrix} average\ price \\ across\ scenarios \end{pmatrix} - \begin{pmatrix} current \\ price \end{pmatrix}}{current\ price} - \begin{pmatrix} gvt \\ ret \end{pmatrix}$$

$$= \frac{\begin{pmatrix} average\ price \\ across\ scenarios \end{pmatrix}}{current\ price} - \left(1 + \frac{gvt}{ret}\right)$$

Which can be also written as:

$$E\left[R_a - R_f\right] = \frac{\mu_s - x}{x} - R_f = \frac{\mu_s}{x} - (1 + R_f)$$

Where μ_s corresponds to the average price at the *(s)* rating state, *x* is the current price of the bond and R_f is the risk-free return of a government bond.

At the denominator of our information ratio formula, we have the credit return volatility, which is just the price volatility across the different scenarios divided by the current price.

$$\begin{pmatrix} credit \\ return \\ volatility \end{pmatrix} = \frac{\begin{pmatrix} price\ volatility \\ across\ scenarios \end{pmatrix}}{current\ price}$$

Government returns, which we assume to be constant and risk free, have volatility equal to zero, so they disappear from the denominator.

$$\sqrt{Var\left[R_a - R_f\right] =}\ sd\left[R_a - R_f\right] = \frac{sd_s}{x} - sd\left(1 + R_f\right) = \frac{sd_s}{x}$$

We now put together these two parts of the information ratio and write:

$$IR_a = \frac{\frac{\mu_s}{x} - (1 + R_f)}{\frac{sd_s}{x}}$$

Through some easy algebraic calculations, we express the current price as function of future prices and their volatility, of government returns and on the information ratio. Setting the information ratio equal to the investor target performance and incorporating the diversity score, we are finally able to obtain the rock bottom price for a bond held in a diversified portfolio.

$$\begin{pmatrix} Rock \\ Bottom \\ Price \end{pmatrix} = \frac{\begin{pmatrix} average\ price \\ across\ scenarios \end{pmatrix} - \begin{pmatrix} Target \\ information \\ ratio \end{pmatrix} * \begin{pmatrix} \frac{price\ volatility \\ across\ scenarios}{\sqrt{diversity\ score}} \end{pmatrix}}{(1 + govt\ return)}$$

Rewriting with the symbols:

$$Rbp = \frac{\mu_s - IR_a * \frac{sd_s}{\sqrt{d}}}{(1 + R_f)}$$

Having found average scenarios value at t+1 (μ_s) and the bond volatilities sd_s , we can now plug these data into the rock bottom prices equation to find the maximum amount the investor would pay for the one-year bond according to the rating category of the issuer.

$$Rbp_{AAA} = \frac{\mu_{AAA} - IR_a * \frac{sd_{AAA}}{\sqrt{d}}}{(1 + R_f)} = \frac{108 - 0.5 * \frac{0.00}{\sqrt{70}}}{1.06} = 101.89$$

$$Rbp_{AA} = \frac{\mu_{AA} - IR_a * \frac{sd_{AA}}{\sqrt{d}}}{(1 + R_f)} = \frac{107.97 - 0.5 * \frac{1.26}{\sqrt{70}}}{1.06} = 101.79$$

.

$$Rbp_{CCC} = \frac{\mu_{CCC} - IR_a * \frac{sd_{CCC}}{\sqrt{d}}}{(1 + R_f)} = \frac{95.23 - 0.5 * \frac{25.33}{\sqrt{70}}}{1.06} = 88.41$$

At his point we can easily compute the yield of the bond given its rock bottom price via a standard excel price-to-yield calculation. The formula used is the following one:

$$\begin{pmatrix} Rock \\ Bottom \\ Yield \end{pmatrix} = \frac{\left(\frac{redemption}{100} + \frac{rate}{frequency}\right) - \left(\frac{par}{100} + \left(\frac{A}{E} * \frac{rate}{frequency}\right)\right)}{\frac{par}{100} + \left(\frac{A}{E} * \frac{rate}{frequency}\right)} * \frac{frequency * E}{DSR}$$

where A is the number of accrued days, i.e. from the beginning of the coupon period to the settlement date, E is the number of days in the coupon period and DSR is the number of days from the settlement date to the redemption date. Subtracting from the yield calculated this way, the yield of the risk free investment, we finally obtain the rock bottom spread.

$$Rbs_{AAA} = yield_{Rbp} - yield_{rf} = 6.00\% - 6.00\% = 0\ bps$$

$$Rbs_{AA} = yield_{Rbp} - yield_{rf} = 6.10\% - 6.00\% = 10bps$$

$$Rbs_{CCC} = yield_{Rbp} - yield_{rf} = 22.16\% - 6.00\% = 1616bps$$

As expected, the premium required by the investors is increasing when moving to a lower rating category of the issuer. The mechanism showed can be repeated for longer maturities, performing backward calculation and using the rock-bottom prices found for one-year as expected value of the cashflows for the previous year (adding the coupon to these prices). The most important difference is that not only two credit scenarios are possible, but all the rating states have to be taken into account as a possible future scenario, with the probability given by the rating migration matrix. The average expected value after one year of the two-years bond is calculated as below:

$$\mu_{AAAt=1} = \sum_{i=1}^{s} p_i \mu_i = \begin{pmatrix} 0.8955 * (101.89 + 8) \\ 0.0977 * (101.79 + 8) \\ 0.0039 * (101.68 + 8) \\ 0.0008 * (101.47 + 8) \\ 0.0008 * (100.93 + 8) \\ 0.0004 * (99.22 + 8) \\ 0.0008 * (88.41 + 8) \\ 0.000 * (45) \end{pmatrix} = 109.86$$

$$\mu_{AAt=1} = \sum_{i=1}^{s} p_i \mu_i = \begin{pmatrix} 0.0054 * (101.89 + 8) \\ 0.8996 * (101.79 + 8) \\ 0.0892 * (101.68 + 8) \\ 0.0043 * (101.47 + 8) \\ 0.0003 * (100.93 + 8) \\ 0.0003 * (99.22 + 8) \\ 0.0004 * (88.41 + 8) \\ 0.0004 * (45) \end{pmatrix} = 109.75$$

.

$$\mu_{CCCt=1} = \sum_{i=1}^{s} p_i \mu_i = \begin{pmatrix} 0.0000 * (101.89 + 8) \\ 0.0000 * (101.79 + 8) \\ 0.0000 * (101.68 + 8) \\ 0.0000 * (101.47 + 8) \\ 0.0196 * (100.93 + 8) \\ 0.1862 * (99.22 + 8) \\ 0.5915 * (88.41 + 8) \\ 0.2027 * (45) \end{pmatrix} = 89.87$$

As before, we now compute the volatility of expected values across credit scenarios two year to maturity at the end of year one.

$$sd_{AAAt=1} = \sqrt{\sum_{i=1}^{s} p_i \mu_i^2 - \overline{\mu}^2} = \sqrt{\begin{pmatrix} 0.8955 * (101.89 + 8)^2 \\ 0.0977 * (101.79 + 8)^2 \\ 0.0039 * (101.68 + 8)^2 \\ 0.0008 * (101.47 + 8)^2 \\ 0.0008 * (100.93 + 8)^2 \\ 0.0004 * (99.22 + 8)^2 \\ 0.0008 * (88.41 + 8)^2 \\ 0.2027 * (45)^2 \end{pmatrix} - 109.86^2} = 0.39$$

$$sd_{AAt=1} = \sqrt{\sum_{i=1}^{s} p_i \mu_i^2 - \overline{\mu}^2} = \sqrt{\begin{pmatrix} 0.0054 * (101.89 + 8)^2 \\ 0.8996 * (101.79 + 8)^2 \\ 0.0892 * (101.68 + 8)^2 \\ 0.0043 * (101.47 + 8)^2 \\ 0.0003 * (100.93 + 8)^2 \\ 0.0003 * (99.22 + 8)^2 \\ 0.0004 * (88.41 + 8)^2 \\ 0.0004 * (45)^2 \end{pmatrix} - 109.75^2} = 1.19$$

.

.

$$sd_{CCCt=1} = \sqrt{\sum_{i=1}^{s} p_i \mu_i^2 - \overline{\mu}^2} = \sqrt{\begin{pmatrix} 0.0000 * (101.89 + 8)^2 \\ 0.0000 * (101.79 + 8)^2 \\ 0.0000 * (101.68 + 8)^2 \\ 0.0043 * (101.47 + 8)^2 \\ 0.0003 * (100.93 + 8)^2 \\ 0.1862 * (99.22 + 8)^2 \\ 0.5915 * (88.41 + 8)^2 \\ 0.2027 * (45)^2 \end{pmatrix} - 89.87} = 19.07$$

Again, plugging these results into the rock bottom price equation and converting it into the yield we can obtain as before the rock bottom spread.

$$Rbs_{AAAt=0} = yield_{Rbp} - yield_{rf} = 6.02\% - 6.00\% = 2\ bps$$

$$Rbs_{AAt=0} = yield_{Rbp} - yield_{rf} = 6.10\% - 6.00\% = 10bps$$

$$Rbs_{CCCt=0} = yield_{Rbp} - yield_{rf} = 18.47\% - 6.00\% = 1216bps$$

The method shown for a two years bond can be reiterated by backward calculation for an infinite number of times and can thus be adapted to all possible maturities. Rappoport (2001) and Schaffner (2010) in their respectively creation and adjustment of the rock bottom spread framework, determined the shape of the spread term structure by calculating for longer maturities the rock bottom spreads of a bond similar to the one of the example here introduced.

Having provided an insight on the original rock-bottom spread framework for plain vanilla bonds, the next section will introduce some adjustments to this methodology in order to value the specific risks of AT1 CoCo bonds.

3.3 THE ADJUSTED MODEL

All Additional Tier 1 CoCos have some key characteristic that influence the expected cash flow for the investor and that hence have to be included in the model. The extension and the coupon cancellation features already existed for hybrid bonds since their first issuances and have already been discussed in valuing corporate hybrids or "old style" bank Tier 1 debt. The conversion feature instead, a new characteristic that emerged with Basel III regulation for Additional Tier 1 debt, has not been taken into account in previous elaborations of this framework and is the trickiest aspect to value because of the high uncertainty about stock price evolution after the conversion. As for plain vanilla, the expected cash flows depend on the financial state of the issuer, as represented by the migration matrix, so, keeping the same tree discounting structure, the cash flows have to be adapted for all the possible scenarios originated by these features. As said, the matrix used in the extended model will be an 18 states matrix to be able to better differentiate the different scenarios. The rating state used to represent the financial condition, which thus triggers the different events, is the issuer senior rating, which represents credit fundamentals. Ratings take into account factors like capital solidity, asset quality, profitability and business risk, but given the high correlation of all these factors we think reasonable to use them as a proxy for capital ratios. Another difference from the example proposed above, is the discounting rate, which will be based on real forward curves instead of assuming the simplified flat government yield curve. In this section each feature will be reviewed in detail and based also on Henriques, Goulden, & Granger (2006), some assumption will be made on the rating state of the issuer triggering each of these risky events and on the cash flow corresponding to that situation.

3.3.1 **Subordination**

The word subordination refers to the hierarchy of debt instruments for what concerns the repayment of their holders in the event of default. As we have seen, in the capital structure of banks, Additional Tier 1 CoCos rank directly ahead of equity (ordinary and preferred shares) for reimbursement priority of the bank capital structure. These bonds are also called junior subordinated bonds because they come after, in terms of seniority, not only to senior secured and unsecured bonds, but also to the other forms of subordinated debt, i.e. to upper and lower tier 2 instruments. For this reason, according to Henderson Global Investors (2014) the recovery rate could be very low in case of distress. The standard recovery rate assumed in the CDS market for senior debt is 40%, while according to Schaffner (2010), Moody's calculates an issuer-weighted average corporate debt recovery rate (1985-2009) of 31.3% for subordinated debt a and 24.7% for junior subordinated bonds. Anyway, the novelty of financial regulation regarding the bail-in mechanism that is in effect since January 2016 and the features of Additional Tier 1 instruments, suggest assuming lower recovery rates. More precisely, since CoCos is converted into equity or is written down in case of financial distress it may seem not overly pessimistic to assume for the Cocos holders a recovery rate of 0% in the event of default. This zero recovery rate view is consistent with Henriques et al. (2006) assumption for "old style" Tier 1 debt which still was not as risky as Additional Tier 1 Cocos.

3.3.2 **Coupon cancellation**

Another assumption is made to associate a certain rating state of the issuer to the event of coupon cancellation, i.e. on the decision from the issuer not to pay the regular coupon associated to the hybrid security. Including the possibility of a coupon cancellation in the framework is important because this event changes the future streams of cashflows for the bondholder, influencing the present value of the bond and thus the spread required.

The deferral mechanism can be activated in two ways. The first way in which the coupon can be deferred or cancelled, is the mandatory deferral, i.e. the obligation for the bank not to pay the coupon in the case of breaching buffer capital requirements. This is achieved by establishing a

Maximum Distributable Amount, which is the maximum amount that can be distributed in dividends and AT1 coupons payments. The second chance to have a coupon deferral is for voluntary initiative of the issuer, to prevent the triggering of the mandatory deferral. These two possibilities will occur in different financial situations of the issuing institutions and thus have to be associated with two different rating states.

3.3.2.1 *Mandatory Coupon Cancellation*

As seen in section 2, among the novelties of Additional Tier 1 after Basel III introduction, there is a more strict regulation of coupon payments. In this new regulatory framework, banks are prevented from paying coupons over the MDA when they are violating the Combined Buffer Requirements, in order to avoid further undermining their regulatory solvency.

For modelling reasons we have thus to establish a rating in which the bank is violating the combined buffer requirement and it is forbidden to make any distribution to its AT1 bondholders.

Looking at previous literature, Henriques et al. (2006) established for old Tier 1 instruments that the minimum regulatory solvency (which at that date was Tier 1 Capital equal to 4%) used to correspond to BB+ rating, i.e. the first rating class below the investment grade ratings. This assumption was made based on the example of Banca Popolare Italiana case, which in February ’06 was downgraded to Baa2 (S&P BBB) by Moody’s with a capital ratio of 5.5%. J.P. Morgan’s analysts decided hence to set the coupon deferral trigger at the senior rating of BB+, since regulation imposed the deferral at the breach of the minimum capital solvency.

Nowadays with the increasing capital requirements, a capital ratio of 5.55% would translate in a much lower senior rating (close to triggering the conversion), thus the association between BBB rating and 5.55% capital ratio is no more realistic. An example of this fact, is given by one of the issuers we will analyze, BBVA, which with a Tier 1 ratio of 12.30% as of September 2015 has its long-term senior debt rated BBB. In the same way, the BB+ association to 4% capital holds no more, since minimum capital requirements have been raised significantly and a 4% capital would now be associated with a much more critical rating. In other words, we think that a BB+ rating for base case of around 10% Combined Buffer Requirement today reflects a better solvency situation of the bank. Adopting J.P. Morgan model’s assumption, we suggest that this rating can still be associated to the higher level at which the breach of capital requirements induces to the non-payment of the AT1 coupon.

Another analysis to do, as performed in Lambert (2014), is to compute the amount of combined buffer requirement for each bank by summing up the buffers that the regulation will require on a different basis to every single institution according to its size and its systemic importance. According to this, we think the rating trigger for coupon cancellation should vary between BBB- and BB rating grades, the minimum CET1 requirements ranging from 11% to 8%.

3.3.2.2 *Voluntary Coupon Cancellation*

A bank can also elect not to pay coupons as a voluntary choice, even if the minimum requirement is not breached, in the case for example that the bank is experiencing a loss or it has not enough resources to distribute. This modality of coupon cancellation is far more complex to represent within this framework according to the modalities described, because it does not depend on the rating profile but can suddenly arise as a choice of the bank's board of directors as a response to an unexpected event. Obviously, the probability of this phenomenon to happen is expected to increase in lower rated institutions but still it is difficult to associate it to a certain credit rating grade (Henriques et al. 2006).

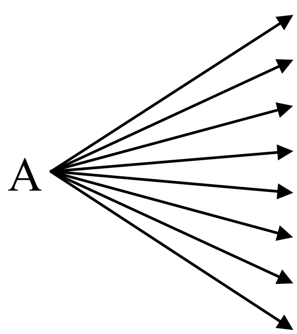
According to Lambert, Villalobos, & Theodore (2014) from *ScopeRatings* among others, the voluntary coupon cancellation is actually expected to be a very rare event since it would have a negative effect on debtholders and as a consequence a boomerang effect on the creditworthiness of the coupon cancelling institution. In fact, a voluntary choice of not paying coupons could have high hidden costs for the issuer especially in terms of reputation and on future access to credit market.

This view on voluntary coupon cancellation is supported by two empirical examples that Henriques et al. (2006) report in their framework for old Tier 1 capital instruments. These examples are related to the already cited BPI (in 2005) and to HVB (in 2004) that even though reporting material losses at the end of the financial year, decided and clearly communicated to the market that would not have deferred the payment of their Tier 1 coupons. A more recent example of this view on voluntary deferral can be found in the words of John Cryan, co-chief executive of Deutsche Bank who, in October 2015, was assuring markets that his bank would have plan to pay all dividends on its additional tier 1 securities and that coupon payments are senior to stock dividend payments (Hale & Mccrum 2015).

According to that, we will assume that a voluntary coupon deferral will happen only in extreme cases at a very low rating and in any case lower than the one activating the mandatory deferral. This is consistent also with Cuadrado's (2013) statement that mandatory deferral is potentially much riskier than the voluntary one.

To sum up, the assumption of coupon deferral will be that this event is triggered by a financial condition represented by a rating going from BB+ to BB-, which are at the boundary of the investment and non-investment grade in the 18-state credit migration matrix, according to the individual Combined Buffer Requirements of each single bank.

Figure 15, adapted from Henriques et al. (2006), shows how the coupon cancellation may affect the expected cashflows, still using the same 8-state transition matrix:



P of state	Rating state	Bond state	Cashflow
0,0002	AAA	Par + Cpn	108
0,0267	AA	Par + Cpn	108
0,9254	A	Par + Cpn	108
0,0428	BBB	Par + Cpn	108
0,0027	BB	Par	100
0,0008	B	Par	100
0,0001	CCC	Par	100
0,0013	D	Default	0

Figure 15 Expected cashflows adjusted for coupon deferral. Modified from J.P. Morgan

3.3.3 **Extension/Callability risk**

Old-style Tier 1 hybrid bonds used to have a maturity date and had a set-up spread on the coupon stream after the first call date, so were mainly expected to be called at the first occasion. Nevertheless, the bank was not forced to call these bonds, this generating uncertainty about effective maturity and on the stream of expected cashflows.

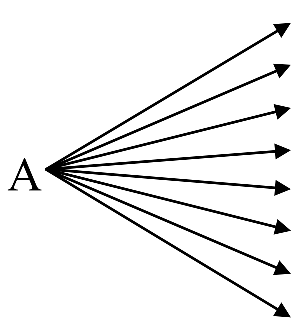
Additional Tier 1 CoCos are perpetual securities and the step-up clause is no more allowed, so no incentives are provided to the bank to redeem these securities. Still the bank has the possibility to choose whether to redeem the bond or not at any call date. This generates uncertainty in investors' expectations in their forecasts about a possible coupon deferral over a longer horizon of time and about the value of the variable coupon set after the first call date.

Getting into cash flows, the bond calling would reflect in the expected payment of the par value plus the coupon. The extension of the bond would instead reflect in the expected perpetuity value of the bond added of the coupon value if the rating of the bank suggests the coupon will be paid, according to what we assumed about the coupon cancellation trigger.

The assumption to make for the valuation framework is related to the rating state that will make preferable for the bank to redeem to CoCoo. As seen in chapter 2, new CRD IV allows banks the redemption of existing Coco bonds only if immediately replaced with the exact corresponding amount of these same instruments so remaining compliant with the minimum requirement amount for Additional Tier 1 capital. The rationale for the choice between calling and extending is to be found in the financing costs that the bank is facing in the two alternative cases. Provided that, according to Dutordoir, Lewis, Seward, & Veld (2014), European investors tend to see contingent convertibles as an extension of bond market, and thus generally expect these instruments to be called, we see the issuer choice to be influenced mainly by other factors. The elements to consider are indeed the credit market general conditions, the IRS rate and the credit quality it has at the issuance date. If the conditions of the credit markets are expected to worsen, with less demand of Cocos for example, or if interest rates such as IRS, LIBOR are expected to raise, the costs of refinancing will be higher. This fact could make it preferable for banks not to call the security even if the variable coupon they will have to pay after the call date is probably higher than the fixed one paid in the time period preceding in the first call date.

The other aspect we will consider regarding this choice is the credit quality if the issuer at the call date. The premium that an institution has to pay on its debt issuances highly depend on the creditworthiness the market is assigning them. Together with CDS, senior credit ratings given by rating agencies are a primary attribute that investors are using as a descriptor of the creditworthiness of a bond issuer, especially when these indicators announce a decrease in credit quality (Hull et al. 2004). Also, the relation between ratings downgrades and bond prices reduction is shown to be positively correlated by previous research studies (Katz 2014). According to this, we set a triggering rating grade at which the banks credit quality makes it too expensive to refinance debt on credit market with respect to maintaining the already existing debt instruments. The most logical assumption is that the bank will decide to call the Cocos and refinance, if its credit rating at the first call date is equal or above the credit rating at issuance.

A lower credit rating would mean a higher yield required by investors. The effect of the callability option on the bond cashflows is illustrated below:



P of state	Rating state	Bond state	Cashflow
0,0002	AAA	Call	Par + Cpn
0,0267	AA	Call	Par + Cpn
0,9254	A	Call	Par + Cpn
0,0428	BBB	No Call	Perp + Cpn
0,0027	BB	No Call	BB Perp + Cpn
0,0008	B	No Call	B Perp + Cpn
0,0001	CCC	No Call	CCC Perp + Cpn
0,0013	D	Default	Recovery Rate

Figure 16. Expected cashflows adjusted for call option. Modified from J.P. Morgan

3.3.4 **Conversion/write-off risk**

Among the assumptions to adjust the model for Additional Tier 1 bonds, the association of the loss absorption mechanism (conversion or write-off) trigger to a certain rating and even more the establishment of an expected loss at conversion are the trickiest ones. This is due to the high uncertainty and unpredictability of the evolution of share price after the breaching of the regulatory minimum capital ratio and to the not always defined amount of principal write down. Additional tier 1 securities can have either a low conversion trigger (CET1 ratio of 5.125%) or a high conversion trigger (CET1 ratio of 7%). This will reflect in different hypothesis on the senior rating to associate to the conversion event. For these reasons, we would set the conversion rating for the low trigger bonds equal to B, which is the first in the highly speculative rating grades, and which we consider being adequate for a bank in a situation of high financial distress, corresponding to a capital ratio breaching the minimum requirement. For high trigger bonds, we will set the triggering rating, on notch above, thus equal to B+.

3.3.4.1 ***Conversion mechanism***

For what concerns the expected value of the bond after the conversion, we have to establish a recovery rate for the investor having his bond turned into a share. This is the most uncertain point, since assuming a realistic share price corresponding to capital ratio triggering the conversion is still an unsolved task. In order to do this we are going to lean on the results found by De Spiegeleer & Schoutens (2014), who developed a pricing tool based on their credit derivatives approach for Tier 2 CoCos. In essence, what they do is to replace the CET1 ratio with a barrier stock price as the mechanism of loss absorption activation. The recovery rate of a CoCo, according to the authors, is given by the ratio between the stock price at the trigger event S_T^*, and the conversion price C_p as shown in the following equation (De Spiegeleer & Schoutens 2011):

$$R_{CoCo} = \frac{S_T^*}{C_p}$$

Generally, the market price in the event of the conversion will be lower than the conversion price because of the huge selloff form investors that we can easily imagine to happen when the imminent capital ratio breach becomes public information. For this reason, the recovery for CoCo holders will be lower than the face value paid for the bond. In any case, to calculate the recovery rate R_{CoCo}, the conversion price C_p and the market share price S_T^* are required.

Normally, most CoCo prospectuses contain a floored conversion price. The price taken is the highest among the market price at conversion, a floor price and the nominal price of the common share at the conversion moment. In this case, the payoff for the coco holder in case of conversion becomes:

$$R_{CoCo} = \frac{S_T^*}{\max(S_T^*;\ S_{\bar{T}})}$$

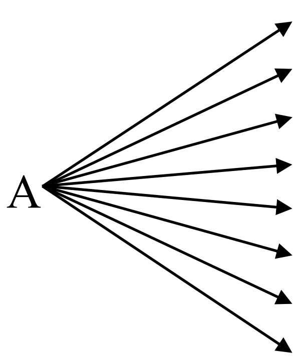
Assuming a well calibrated floor conversion price preventing from excessive share dilution and considering the price death spiral we talked about in chapter 2, we expect the conversion price C_p to be equal to the floor price.

The unknown trigger level, S_T^* at which the CoCo converts is given through the return dynamics of the credit derivatives model. The implied trigger level will be taken as correct from the De Spiegeleer & Schoutens (2011) results on the same bonds we are analyzing, namely the BBVA, the Santander and the HSBC. Another approximation we have to do is to consider the recovery rate that De Spiegeleer & Schoutens (2011) found related to the call date, to be constant for the entire life of the CoCo, so that the triggering price and the conversion price keep a costant ratio over years.

3.3.4.2 *Write-off mechanism*

For what concerns CoCos with a partial write-down, it is impossible to define the amount of the face value written off at the triggering event. In order to make a conservative assumption we set the recovery rate of CoCos with write off equal to zero. This is consistent with De Spiegeleer & Schoutens (2011) assumption.

Here below an example of loss absorption trigger is shown for the conversion case:



P of state	Rating state	Bond state	Cashflow
0,0002	AAA	Call	Par + Cpn
0,0267	AA	Call	Par + Cpn
0,9254	A	Call	Par + Cpn
0,0428	BBB	No Call	Perp + Cpn
0,0027	BB	No Call	BB Perp + Cpn
0,0008	B	Conversion	RR from conversion
0,0001	CCC	Conversion	RR from conversion
0,0013	D	Default	Recovery Rate

Figure 17. Expected cashflows adjusted for coupon deferral. Modified from Öfinger (2012)

The same structure of cashflows can be replicated for a CoCo with write-down, just substituting the different recovery rate amount for this conversion mechanism.

Having assumed a corresponding rating state for each of the characterizing features of CoCo bonds, we now have a complete overview of the cashflow associated with every rating category and, discounting backward from maturity to date, we obtain the current “rock-bottom” price. We perform the calculation starting 60 years ahead, which according to Henriques et al. (2006) approximates the perpetuity of the bond. We adapt the different coupon rates after the first call date, by adding the floating spread set by the issuer to the five years mid-swap, which we update at each reset date, normally every five years. The five years mid-swap we use is the forward EUSA5, and we discount all the cashflows using the equation seen in the basic framework, with a risk free rate equal to the IRS for European banks with the tenor equal to the maturity of the bond, i.e. the EUSA 60 years. As before, the prices found for each rating at each year are the average across scenarios for that rating grade and are used as inputs for the previous year calculations. The spread to call we obtain, is the difference between the bond’s yield to call and the deutsche Bund with the closest maturity to the first call date.

In Figure 18, we show the backward calculations for a theoretical CoCo issued by an A rated institution. As we can see, all the possible states are introduced in the discounting framework, following the assumptions discussed above in the previous paragraphs.

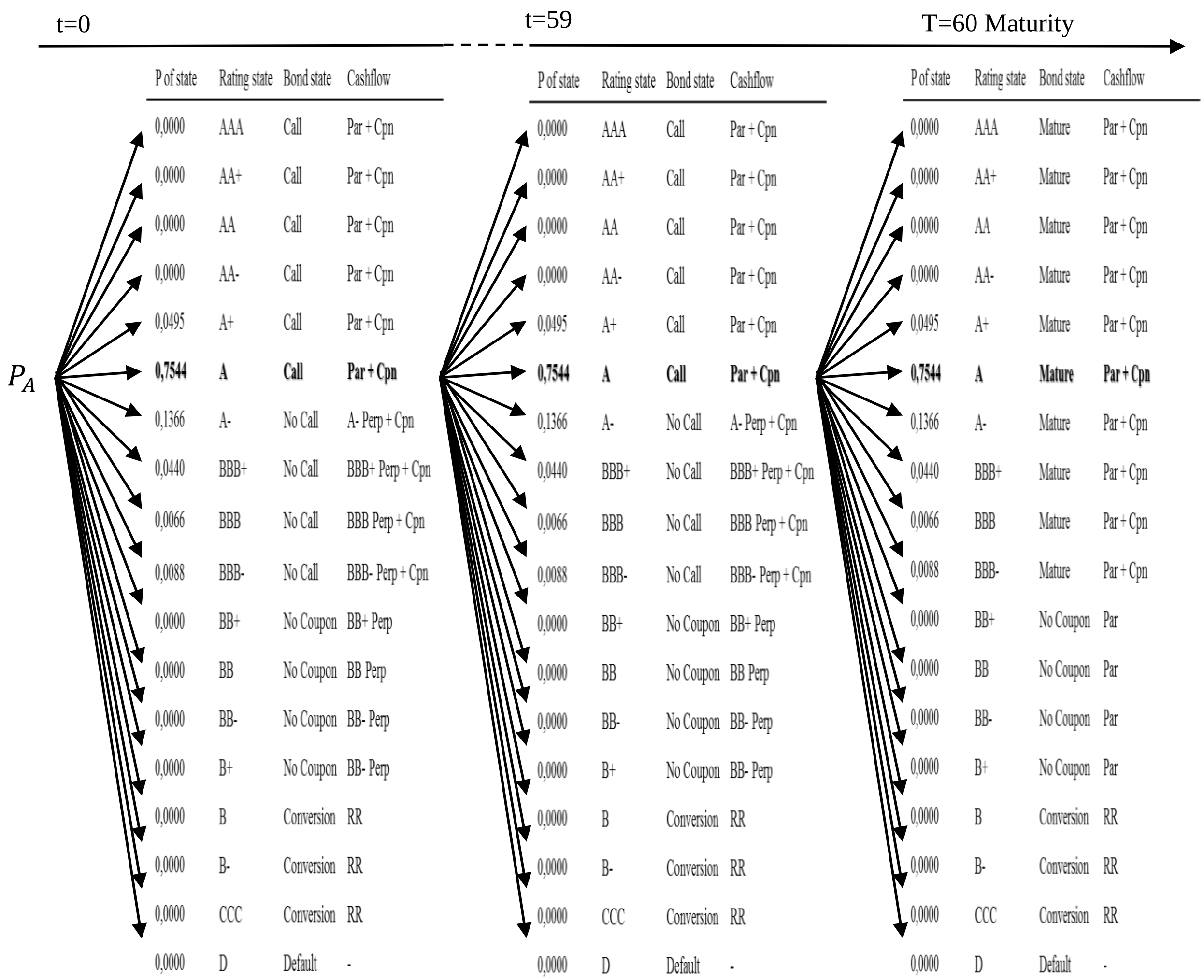


Figure 18. Backward valuation of an A rated institution's CoCo. Own illustration adapted from Schaffner (2010).

Having stated all the assumptions and explained the mechanics of the framework, in next chapter these calculations will be applied to six CoCos issued by European Banks between 2014 and 2015, with the purpose of determining a "fair" credit spread according to the model's assumptions.

4 VALUING COCOS

In this chapter, we introduce the financial institutions on whose AT1CoCos the framework will be tested. For this purpose, we selected six European banks that issued CoCos compliant with the CRD IV between 2014 and 2015, and which have their first call date between 2019 and 2022. These Cocos have different contractual terms and the firms have different credit and capital quality, which influences the assumptions on ratings and on scenarios in the binomial tree framework. The institutions we will consider are the Spanish Banco Santander and BBVA, the British HSBC, the Belgian KBC Bank, the Dutch Rabobank and the Italian UniCredit. All the spreads are computed as of January 25, 2016. All the relevant information contained in the prospectus for the description of each CoCo is in Appendix 1.

4.1 BBVA

This CoCo is a low-trigger one since the loss-absorption mechanism takes place at the minimum regulatory CET1 requirement of 5.125%. The loss absorption feature is conversion into equity at a floored conversion price of € 4.5, which can be modified according to condition 5.4 of the Prospectus, in the case of a consolidation, reclassification/redesignation or subdivision affecting the number of common shares.

In table 6, we list the inputs for the valuation framework.

Model inputs	Values
Default/Conversion/downgrade Probability	Adjusted 18-states average annual migration matrix for financial institutions (2010-2013) S&P
Recovery Rate from Default	0
Recovery Rate from Write-off	44% (source: De Spiegeleer, Schoutens)
Call Trigger	BBB (equal to S&P long-term Senior Rating)
Coupon Cancellation Trigger	BB+
Conversion Trigger	B
Coupon to Call	7,00%
Coupon after Call	EUSA 5 + 6,155%
Information Ratio	0,5
Diversity Score	70
Discount Rate	EUSA 60
Risk free benchmark	German Bund 1%, 2018

Table 6. Framework inputs for BBVA 7% CoCo

The minimum CET1 required to BBVA not to be restricted on distributions is 9,75%, since to the minimum ECB requirement of 9.5% it will be added a 0.25% G-SIB buffer. Given our assumptions we associate to this value the coupon cancellation trigger at the rating BB. The conversion trigger of 5.125% corresponds to our base case assumption of triggering rating B. The recovery rate is taken from De Spiegeleer & Schoutens (2011) credit derivative approach results and assumed constant. Under these assumptions, the CoCo price is equal to € 92.08 corresponding to a spread at the first call equal to 1047 basis points (bps).

4.2 BANCO SANTANDER

Here again, the conversion mechanism is a Floored price, set by the issuer at € 5.01, adjusted for capital actions. Our assumptions for valuation are reported in the table.

Model inputs	Values
Default/Conversion/downgrade Probability	18-states average annual migration matrix for financial institutions (2010-2013) S&P
Recovery Rate from Default	0
Recovery Rate from Write-off	33% (source: De Spiegeleer, Schoutens)
Call Trigger	BBB+ (equal to S&P long-term Senior Rating)
Coupon Cancellation Trigger	BB+
Conversion Trigger	B
Coupon to Call	6,25%
Coupon after Call	EUSA 5 + 6,54%
Information Ratio	0,5
Diversity Score	70
Discount Rate	EUSA 60
Risk-free benchmark	German Bund 2%, 2022

Table 7. Framework inputs for Santander 6.25% CoCo

The floor price is set by prospectus at € 5.01. We expect the share price to be lower than the floor when the minimum CET1 ratio is breached, and according to De Spiegeleer & Schoutens (2011) results, we set the recovery rate equal to 33%. The minimum required CET1 for combined buffer requirement is 9.75%, so we set the triggering rate for coupon cancellation at the rate BB+. The conversion trigger is 5.125%, which corresponds in our framework to a triggering rate of B. We value Santander's CoCo worth € 94.97, corresponding to a required spread of 752 bps.

4.3 HSBC

For this CoCo, the conversion is set at the fixed price of € 3.37. Table 8 reports our assumptions for valuation.

Model inputs	Values
Default/Conversion/downgrade Probability	18-states average annual migration matrix for financial institutions (2010-2013) S&P

Recovery Rate from Default	0%
Recovery Rate from Write-off	66%
Call Trigger	A+ (equal to S&P long-term Senior Rating)
Coupon Cancellation Trigger	BBB-
Conversion Trigger	B
Coupon to Call	5,25%
Coupon after Call	EUSA 5 + 4,38%
Information Ratio	0,5
Diversity Score	70
Discount Rate	EUSA 60
Risk-free rate benchmark	German Bund, 1.5% 2023

Table 8. Framework inputs for HSBC 5.25 CoCo

Being HSBC a high internationally active bank, it is required to hold more systemic buffers to avoid restrictions on distributions. The minimum CET1 it has to hold is 11.4%, which corresponds in our framework in a higher coupon cancellation trigger, which we set at BBB-. The conversion trigger at 5.125% corresponds to the base case trigger of B. The recovery rate at conversion is 66% as estimated by De Spiegeleer & Schoutens (2011) computations. The obtained price is € 105.38, which reflects the good credit quality of the issuer, and corresponds to a minimum required spread of 420 bps.

4.4 KBC BANK

This low-trigger CoCo has a conversion mechanism with write down of its principal value, with no shares in exchange for the CoCo holder. The assumptions for valuation are reported in table 9.

Model inputs	Values
Default/Conversion/downgrade Probability	18-states average annual migration matrix for financial institutions (2010-2013) S&P
Recovery Rate from Default	0
Recovery Rate from Write-off	0
Call Trigger	A- (equal to S&P long-term Senior Rating)
Coupon Cancellation Trigger	BB+
Conversion Trigger	B
Coupon to Call	5,63%
Coupon after Call	EUSA 5 + 4,759%
Information Ratio	0,5
Diversity Score	70
Discount Rate	EUSA 60
Rate at Call	German Bund,1%, 2018

Table 9. Framework input for KBC 5.625% CoCo

The minimum CET1 ration that KBC has to hold in order to avoid restriction of distributable items is 9.25%. We maintain the base case assumption to its coupon cancellation trigger at the rating category BB+. The conversion mechanism being a discretionary partial write off, leaves us with high uncertainty about the recovery rate in case of conversion trigger breach. We opt for a very prudential assumption of 0% recovery rate, knowing that this is an extreme case, in which the banks need all the CoCo nominal value to absorb its capital losses. The write down trigger level is 5.125% CET1, which corresponds to our base case rating B. Under these assumptions, the CoCo price we find is €98.16, meaning a required spread of 671 bps.

4.5 RABOBANK

This bond is the only one among the bonds we analyze with a high trigger, since the loss absorption mechanism is activated at the CET1 ratio of 7%. The assumptions for valuation are reported below.

Model inputs	Values
Default/Conversion/downgrade Probability	18-states average annual migration matrix for financial institutions (2010-2013) S&P
Recovery Rate from Default	0%
Recovery Rate from Write-off	0%
Call Trigger	A+ (equal to S&P long-term Senior Rating)
Coupon Cancellation Trigger	BB+
Conversion Trigger	B+
Coupon to Call	5,50%
Coupon after Call	EUSA 5 + 5,25%
Information Ratio	0,5
Diversity Score	70
Discount Rate	EUSA 60
Rate at Call	German Bund 0.25%, 2020

Table 10. Framework inputs for Rabobank 5.5% CoCo

The minimum CET1 requirement to avoid restriction on coupon payments for Rabobank is 9.5%, thus we set the triggering rating for coupon cancellation at BB+. The loss absorption mechanism for Rabobank CoCos being 7%, we raise our triggering rating for write-down of one notch with respect to low-trigger CoCos. We assume this event happening when the issuer rating is B+. We still assume a 0% recovery rate from write-off, keeping this prudential view on the securities with discretionary write-down mechanism. The strong credit fundamentals of Rabobank, such as its CET1 ratio of 13.2%, which reflect in an issuer rating of A+, lead our framework to assess a very high price of €112.86, which in terms of “fair” spread corresponds to 624 bps.

4.6 UNICREDIT

The assumptions for the valuation framework are summarized here below.

Model inputs	Values
Default/Conversion/downgrade Probability	18-states average annual migration matrix for financial institutions (2010-2013) S&P
Recovery Rate from Default	0%
Recovery Rate from Write-off	0%
Call Trigger	BBB- (equal to S&P long-term Senior Rating)
Coupon Cancellation Trigger	BB+
Conversion Trigger	B
Coupon to Call	6,25%
Coupon after Call	EUSA 5 + 6,10%
Information Ratio	0,5
Diversity Score	70
Discount Rate	EUSA 60
Risk free at call	German Bund 2.250%, 2021

Table 11. Framework inputs for Unicredit 6.25% CoCo

The loss absorption trigger being CET1 ≤ 5.125%, we keep the base case assumption of corresponding trigger ratio to B. The minimum CET1 requirement for not incurring in distribution restrictions is 9.75%, so we keep the base case assumption of triggering coupon cancellation at BB+, and once again the recovery rate associated to the write down event is assumed equal to zero. The price we find for Unicrdit's CoCo is very low, and reflects the lower capitalization of the bank with respect to its European peers, and the fact that the current rating is BBB- which implies a higher probability for negative actions with respect to CoCo holders. The obtained price is equal to € 66.92, associated to a minmum required spread of 1600 bps.

In the next chapter, these results will be summarized and the spreads obtained from the framework will be compared to the spreads available on the market, both in times of stability and of turbulence. The outcomes of the framework and their interpretation with respect to market's spread will be discussed and an analysis of sensitivity of the model to the assumptions will also be performed.

5 INTERPRETING RESULTS

In this chapter, we will compare the spreads obtained from the valuation framework for the securities presented in chapter 4 with the spreads offered by the market. The aim is to assess whether the risk embedded in these bonds is fairly priced according to our view on the credit fundamentals of the issuing institutions. The difference between the framework's spreads ("Rock-bottom spreads") and the market spreads, given the market independent model here developed, are due to factors that influence market prices beyond the pure credit quality of the issuers as expressed by their credit ratings. The following table summarizes the outcome of our analysis.

Issuer	Coupon	Loss absorption mechanism	First Call	Issuer Rating	Bloomberg mkt Spread	Rock bottom Spread (bps)	Excess Spread (bps)	Relative value
BBVA	7%	Conv. €4,5	19/02/2019	BBB	931	1047	-115	DEAR
HSBC	5,25%	Conv. €3,3	16/09/2022	A	613	420	193	CHEAP
KBC	5,63%	Write-off	19/03/2019	A-	659	671	-12	DEAR
Rabobank	5,50%	Write-off	29/06/2020	A+	599	264	335	CHEAP
Santander	6,25%	Conv. €5	11/09/2021	BBB+	810	752	58	CHEAP
UniCredit	6,75%	Write-off	10/09/2021	BBB-	947	1600	-653	DEAR

Table 12. Results from the valuation framework. Own calculations

The relation between the framework spreads and the market spreads is plotted in Figure 18. At a first sight, the overview illustrates the general plausibility of the valuation framework, since considering that all the input parameters and the assumptions made in the valuation framework are purely based on credit fundamentals, the results obtained are to a considerable extent in line with the market spreads. The credibility of the results is indeed attested by the fact that market spreads and framework spreads show a correlation coefficient of 0.91.

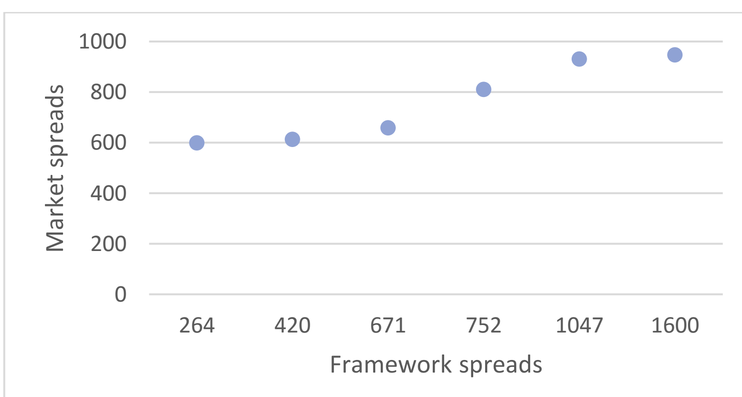


Figure 19. Framework spreads vs model spreads.

A second point that seems important to notice, is the strong relation between the framework spreads and the long-term senior ratings of the AT1 CoCos issuers. This relation is a consequence of the fact that credit ratings, representing the credit quality of the issuers, affects through the credit migration matrix, the expected cashflow pattern associated to the CoCos. The relation between ratings and spreads, even if to a smaller extent, appears to be true also for market spreads. This allows us to conclude that the ratings might have a quite important role in influencing bondholders' purchasing decisions. This phenomenon is illustrated in Figure 20.

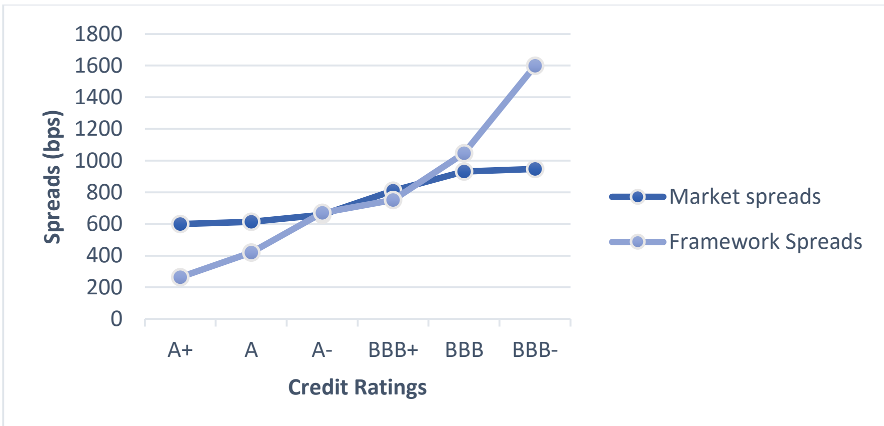


Figure 20. Framework and model spreads vs S&P long-term rating.

Another general trend that can be seen in the figure above is that the market seems to correctly price (according to our results) the CoCos issued by institutions situated in the middle of our ratings spectrum, while tend to misprice issuers with considerable high or low rating. In fact, the larger excess returns, both positive and negatives, are at the extremes issuer ratings of our analyzed pool of CoCos. More precisely, it we obtain that higher rated institutions have their CoCos traded cheap, while low rated institutions have their CoCos traded dear. For example, we have, as of January 2016, that the Coco bond from Rabobank, which is rated A+ was offering a spread of 599 bps significantly higher than our framework spread of 264 bps. On the other side, we have that Unicredit, whose senior long-term rating is BBB-, has a CoCo that offered a spread of 947 bps, while we assess that should offer to the investor a minimum spread of 1600 bps. These results are in line with the findings of Henriques et al. (2006) related to old-style Tier 1 financial hybrids. The rock-bottom spread methodology, suggest thus that the market is potentially overstating the risks linked to CoCos from high rated institutions, while is underestimating the risk connected to CoCos issued from low rated institutions. In fact, for what concerns CoCos, the higher fully-loaded CET1 ratio of Rabobank (11.8%) with respect to Unicredit (10.4%), as of June 2015, provides the investors with more confidence that Rabobank will breach the minimum CET1 regulatory requirements associated to coupon cancellation or to CoCO write-down, with far less probability than Unicredit. Having a general view of the overall framework results, we are now going to perform a sensitivity analysis of the assumptions to the initial rating, taking as example the Santander 6.25% CoCo.

5.1 SENSITIVITY TO ISSUER'S INITIAL RATING

Given the strong reliance of our model on credit ratings as a good proxy for banks fundamental value, we first analyze how the "fair spreads" we obtain are affected by a change in the senior rating of the issuer, that is by a change on its credit fundamentals. We consider here a change in rating that happens after issuance, so that it does not affect the rating triggering the redemption. As expected, the degree of sensitivity to this parameter is very large, since the current initial rating determines the probability to move in each other state. The sensitivity of CoCos to starting ratings is much higher than it is for vanilla bond, since it influences the probability of different risks to happen and not only the probability of default. Looking at Figure 21 referred to the Santander 6.25% CoCo (senior rating BBB+), we can see how the required spread increases going down the rating scale, and how also the sensitivity increases for lower ratings, where the probability of deferral, conversion and default are higher.

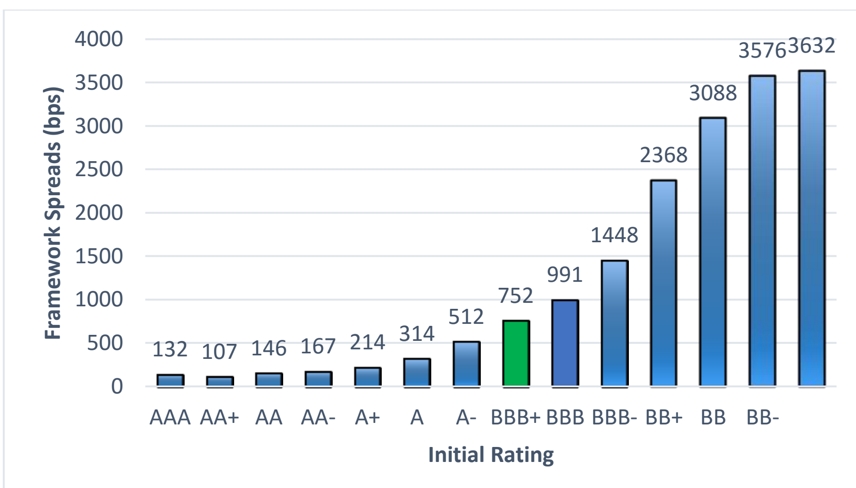


Figure 21. Framework spreads sensitivity to issuer initial rating for Santander 6.25% CoCo

5.2 SENSITIVITY TO COUPON CANCELLATION TRIGGER

The second assumption we are going to analyze is the trigger for coupon cancellation. Changing the assumption of its realization has a large impact on the "fair value" of the CoCo, especially around the issuer senior rating, since for a BBB+ rated firm the marginal cancellation probabilities vary more passing from BBB+ to BBB, than from AA to AA-. As we can see in figure 22, related to Santander 6.25% CoCo, if we set the coupon cancellation trigger at a high rate, the almost certainty of coupon cancellations lowers the bond price and widens spreads. Required spreads decrease setting the coupon cancellation trigger at lower levels, as the investor will bear smaller risk to have his coupon cancelled. In our framework, this trigger is represented by the Combined Buffer Requirement, which establishes the minimum amount of CET1 a bank must hold not to be imposed of restrictions on its distributions.

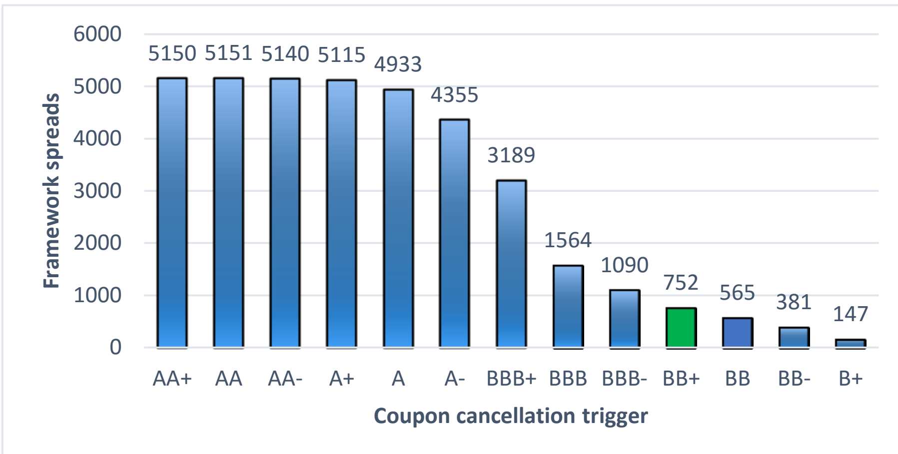


Figure 22. Framework spread sensitivity to changes in coupon cancellation trigger for Santander 6.25% CoCo. Base case assumption: BB+

5.3 SENSITIVITY TO CALL TRIGGER

The influence of changes in the call triggering rate on spreads does not show a monotonic decrease as happened for sensitivity to coupon cancellation. Moving towards high rating triggers, corresponding to the almost certainty that the CoCo will not be called, result in decreasing spreads, since the high coupon rate and the small probability of its cancellation or of conversion activation increases the value of holding the CoCo for longer time horizon. Approaching to lower rating levels the positive effect of high coupons is offset by the higher probability of coupon cancellation, making the spreads widen. At ratings lower than BBB+, we see the spreads falling again, suggesting that for higher default probability levels investors prefer to get the principal back in short time, pushes required spreads down again. The illustration of spreads behavior is plotted in figure 23, always related to the Santander 6.25% CoCo.

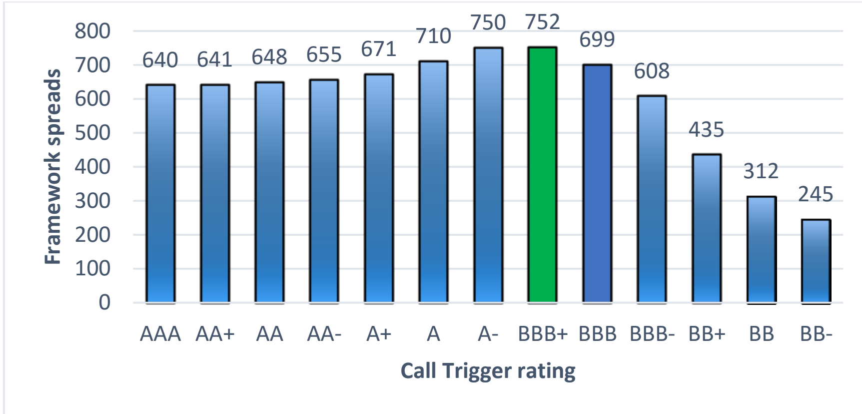


Figure 23. Framework spreads sensitivity to changes in call trigger assumptions for Santander 6.25% CoCo. Base case trigger BBB+

5.4 SENSITIVITY TO CONVERSION TRIGGER

We control here the variation of "fair spreads" with respect to the conversion trigger rating, having set the base case assumption to B, which represents a point of financial distress but in which banks are assumed to still be able to run their business. We notice, as expected, that the conversion at higher rates leads to higher required spreads, while at ratings close to our base case assumption, we see that for Santander 6.25% Cocos, having a recovery rate of 33% as computed by De Spiegeleer & Schoutens (2011), the notching down or up to the next rating category has very small impact. We explain this with the fact that the perpetual bond value at ratings close to conversion is similar to the amount in shares the investor would receive.

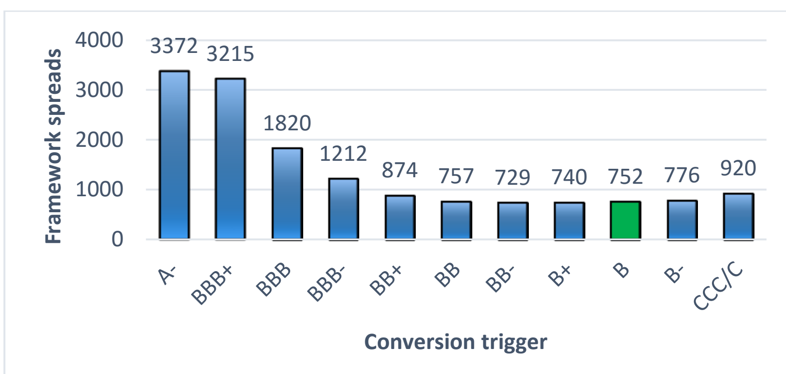


Figure 24. Framework spreads sensitivity to changes in conversion trigger for Santander 6.25% Coco. Base case assumption: B

5.5 SENSITIVITY TO CONVERSION RECOVERY RATE

The recovery rate for the investor when the bond is converted into equity is a very uncertain issue, since it no case of conversion has happened at the date, and for the difficulty to link the market share price corresponding to the triggering capital ratio. We have assumed a constant recovery rate, according to the findings from De Spiegeleer & Schoutens (2011) credit derivative approach on the same analyzed securities. Here again the impact on fair spreads depend on the issuer rating which influences the probability of conversion. The figure below reports the sensitivity for the Santander 6.25% CoCo, which shows a change of around 100 bps for a 10% change in recovery rate assumption. For our bonds with write-off mechanism, we assumed a conservative 0% recovery rate, given the full discretion of the bank around the write-off size.

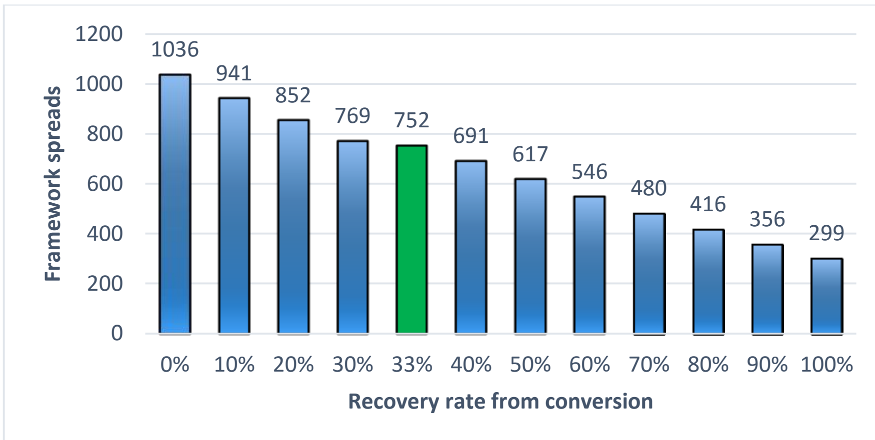


Figure 25. Framework spreads sensitivity to recovery rates from conversion

6 CONCLUSIONS

The framework we developed aims at establishing a “fair” spread, based on credit fundamentals for AT1 CoCo bonds. The difficulty of this task derives mainly from different sources of risk and form the fact that this market is only three years old and that no security has already been tested in times of severe financial distress.

The starting framework being the J.P. Morgan so-called rock-bottom spread model, we kept the discounted cash-flow structure, which allows to evaluate every single non-standard feature of Additional Tier 1 CoCos, and to easily adapt the framework for testing different securities.

As the models it borrows from, thus, our framework is based on the assumption that credit ratings are a good proxy for credit quality and financial situation of banks, and that the empirical credit migration matrix represents the probability of fundamentals evolution, with a special attention to capital ratios, in a credible way. Academic literature is ambivalent about ratings utility in pricing, nevertheless the transition matrix is a tool often used in assessing credit risk. The main issue, represented by the withdrawn rating category, is treated in this thesis in a conservative way preferring to slightly raise the probability of a downgrade than to underestimate the risk of a negative event to happen. We believe that ratings represent better capital ratios developments, to which trigger events for Cocos are linked by regulation, than share price would do.

The second main critical aspect, in which we find the association to share price unavoidable, is the computation of the recovery rate for conversion. To do this, we rely on the implied trigger price assumed as found by De Spiegeleer & Schoutens (2011) through their credit derivative model. This implied share price at the triggering event divided by the conversion price gives us the recovery rate in the case of conversion. We directly take that ratio from the authors, since it is computed on our same securities even if at the first call date, and we make the strong assumption that, since the conversion price is adapted by the bank in case of action on stock prices, it will be constant for the entire life of the Coco. Discounting the cashflows of six European banks’ CoCos, we obtain our “rock-bottom” spread, which is the “fair” smallest spread at which a fully diversified and risk averse investor is requiring to accept holding the security.

The findings we obtained are quite consistent with the ones derived from the original J.P. Morgan model for financial hybrids. In times of financial stability, we find, as J.P. Morgan did, that high rated banks’ CoCos offer higher spreads than we would require assessing the risk with our framework, while we notice that market does not discount enough the risk embedded in lower rated institutions' CoCos. This originates from the strong influence the framework structure attributes to ratings to predict the risk of a contingent capital event to happen.

The framework finds credit spreads that are in general not too far from the market ones in times of stability of the financial markets. In periods of markets stress, when market spreads are influenced by investors' sentiment and by high volatility, this volatility highly affects Cocos spreads due to their riskiness and to the strong equity feature of this new asset class. This discrepancy of model spreads from unjustified low or high market ones is explainable by the fact that the spreads obtained through the model are almost market independent and solely rely on credit fundamentals, that we assume, according to Rappoport (2001) original's model, being represented by credit ratings.

This reliance to credit fundamentals, in our opinion, may reveal to be at the meantime a strength and a weakness of the model. The strength comes from the fact that a transitory market sell-off or an unjustified peak do not influence our "fair" spread, providing with a more solid opinion of the correct security's value thus suggesting us the value at which the securities should theoretically tend. At the same time, real changes in the macroeconomic context, which could affect the fundamentals of the issuing institutions, reflect in our CoCo's values only after the rating agencies change their view on the issuer initial rating. Of course, one could make its own conjectures about the credit quality of the issuing bank, but sticking to the mechanics of the rock-bottom spread framework, the valuation could have some lag with respect to the market incorporation of information in prices.

The main issues are related to the conversion recovery rate for which we assumed as an input, the results obtained by De Spiegleer & Schoutens through their credit derivative model spreadsheet. These recovery rates, which the authors computed at the first call date, were assumed to be constant for every year. The partial write down mechanism is another ambiguous point, since the full discretion the issuer has related to the write-off size does not allow to make better assumption than a prudential zero recovery rate.

To sum up, we believe that the framework we have developed here as a useful tool, to assess the risks that are embedded in CoCos instruments. It provides an insight to understand how their fair spread varies according to the capital and the other fundamentals of the issuers, how it is affected by regulatory requirements such as the combined buffer requirements and by design features such as the coupon size, the after-call spread, the years to first call and the loss absorption mechanism.

7 APPENDIX

Cocos information from prospectus:

BBVA Security description	
Name	Non-Step-Up Non-Cumulative Contingent Convertible Perpetual Preferred Tier 1 Securities
Issuing Institution	Banco Bilbao Vizcaya Argentaria S.A.
Issuer Rating	BBB (as of June 2015)
Issue size	€1,500,000,000
ISIN	XS1033661866
Maturity	Perpetual
Issue date	Feb 19, 2014
First Call Date	Feb 19, 2019
Coupon Rate	7% until the First Call Date, payable QTL
Floating After Call Coupon	Mid-swap 5Y + 6.155%, Reset date every 5Y
Loss-absorption mechanism	Conversion at par
Conversion Trigger	CET1 Ratio ≤ 5.125% or authority declaring PONV
Conversion Price (C_P)	max (S^*(market price at conversion), € 4.5 (Floor Price), € 0.49(nominal value common share))

Table 13. BBVA 7% CoCo data

Santander Security description	
Name	Non-Step-Up Non-Cumulative Contingent Convertible Perpetual Preferred Tier 1 Securities
Issuing Institution	Banco Santander S.A.
Issuer Rating	BBB+ (as of June 2015)
Issue size	€1,500,000,000
ISIN	XS1107291541
Maturity	Perpetual
Issue date	Sept 11, 2014
First Call Date	Sept 11, 2021
Coupon Rate	6.25% until the First Call Date, payable QTL
Floating After Call Coupon	Mid-swap 5Y + 5.640%, reset date every 5Y
Loss-absorption mechanism	Conversion at par
Conversion Trigger	CET1 Ratio ≤ 5.125% or authority declaring PONV
Conversion Price (C_P):	max (S^*(market price at conversion), € 5.01 (Floor Price), € 0.49(nom. value common share))

Table 14. Santander 6.25% CoCo data

HSBC Security description	
Name	Perpetual Subordinated Contingent Convertible Securities
Issuing Institution	HSBC Holdings plc
Issuer Rating	A (as of June 2015)
Issue size	€1,500,000,000
ISIN	XS1111123987
Maturity	Perpetual
Issue date	Sept 9, 2014
First Call Date	Sept 16, 2022
Coupon Rate	5.25% until the First Call Date, payable S/A
Floating After Call Coupon	Mid-swap 5Y + 4.380%, reset date every 5Y
Loss-absorption mechanism	Conversion at par
Conversion Trigger	CET1 Ratio ≤ 5.125% or authority declaring PONV
Conversion Price (C_P):	Fixed € 3.37 (GBP 2.70)

Table 15. HSBC 5.25% CoCo data

KBC Security description	
Name	Undated Deeply Subordinated Additional Tier 1 Fixed Rate Resettable Callable Securities
Issuing Institution	KBC
Issuer Rating	A- (as of June 2015)
Issue size	€1,400,000,000
ISIN	BE0002463389
Maturity	Perpetual
Issue date	Mar 19, 2014
First Call Date	Mar 19, 2019
Coupon Rate	5.625% until the First Call Date, payable QTL
Floating After Call Coupon	Mid-swap 5 years + 4.759%, reset date every 5Y
Loss-absorption mechanism	Write-down
Conversion Trigger	CET1 Ratio ≤ 5.125% or authority declaring PONV
Write-down	Partial and temporary

Table 16. KBC 5.625% CoCo data

Rabobank Security description	
Name	Perpetual Additional Tier 1 Contingent Temporary Write Down Capital Securities
Issuing Institution	Rabobank B.A.
Issuer Rating	A+ (as of June 2015)
Issue size	€1,500,000,000
ISIN	XS1171914515
Maturity	Perpetual
Issue date	Jan 22, 2015
First Call Date	Jun 29, 2020
Coupon Rate	5.50% until the First Call Date, payable S/A
Floating After Call Coupon	Mid-swap 5 years + 5.25%, reset date every 5Y
Loss-absorption mechanism	Write-down
Conversion Trigger	CET1 Ratio Group ≤ 7% CET1 Ratio Local Bank ≤ 5.125% or authority declaring PONV
Write-down	Partial and temporary

Table 17. Rabobank 5.50% CoCo data

Unicredit Security description	
Name	Non-Cumulative Temporary Write-Down Deeply Subordinated Fixed Rate Resettable Notes
Issuing Institution	UniCredit S.p.A..
Issuer Rating	BBB- (as of June 2015)
Issue size	€1,000,000,000
ISIN	XS1107890847
Maturity	Perpetual
Issue date	Sept 10, 2014
First Call Date	Sept 10, 2021
Coupon Rate	6.25% until the First Call Date, payable S/A
Floating After Call Coupon	Mid-swap 5 years + 6.10%, reset date every 5Y
Loss-absorption mechanism	Write-down
Conversion Trigger	CET1 Ratio Group ≤ 7% CET1 Ratio Local Bank ≤ 5.125% or authority declaring PONV
Write-down	Partial and temporary

Table 18. Unicredit 6.75% CoCo data

8 LIST OF FIGURES

9 LIST OF TABLES

10 REFERENCES

Albul, B., Jaffee, D.M. & Tchistyi, A., 2010. *Contingent Convertible Bonds and Capital Structure Decisions*, Available at: https://escholarship.org/uc/item/95821712.

Auer, M. & Von Pfoestl, G., 2012. *Basel III Handbook*,

Avdjiev, S. & Kartasheva, A., 2013. CoCos: a primer 1. *BIS Quarterly Review*, (September), pp.43–56.

Bangia, A. et al., 2002. Ratings migration and the business cycle, with application to credit portfolio stress testing. *Journal of Banking and Finance*, 26, pp.445–474.

Bank of England, 2014. The Pillar 2 framework – background. , pp.2013–2015.

Di Bartolomeo, D., 1998. A Review of Moody ' s Methods Used to Assign Credit Ratings to Collaterized Loan Obligations. *Northfield Information Services*.

Basel Committee on Banking Supervision, 2011a. *Basel III: A global regulatory framework for more resilient banks and banking system*,

Basel Committee on Banking Supervision, 2011b. *Basel III: A global regulatory framework for more resilient banks and banking systems*, Available at: http://www.bis.org/publ/bcbs189.pdf.

Calomiris, C.W. & Herring, R.J., 2011. Why and how to design a contingent convertible debt requirement. *Available at SSRN 1815406*, (April). Available at: http://www.nomurafoundation.or.jp/data/20111014_R_Herring-C_Calomiris_006.pdf.

Chan, A. & Kenadjian, P., 2014. Contingent Convertible Securities: From Theory to CRD IV. *Institute for Law and Finance*, Working pa.

Chennells, L. & Wingfield, V., 2015. Bank failure and bail-in : an introduction. *Bank of England - Quarterly Bulletin*, (1), pp.228–241. Available at: http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2015/q302.pdf.

Crouhy, M., Galai, D. & Mark, R., 2000. A comparative analysis of current credit risk models. *Journal of Banking & Finance*, 24(1-2), pp.59–117.

Cuadrado, N., 2013. *Corporate Hybrids*,

Deufel, P. et al., 2011. Pricing Hybrid Bonds " Nowadays people know the price of everything. *Bachelor Thesis. Karlsruhe Institute of Technology (KIT). Institute for Finance, Banking, and Insurance*, (July).

Dutordoir, M. et al., 2014. What we do and do not know about convertible bond fi nancing ☆. *Journal of Corporate Finance*, 24(June 2011), pp.3–20. Available at: http://dx.doi.org/10.1016/j.jcorpfin.2013.10.009.

European Banking Authority, 2015. Opinion of the European Banking Authority on the interaction of Pillar 1 , Pillar 2 and combined buffer requirements and restrictions on distributions. , 2012(575), pp.1–15.

European Commission, 2013. *Capital Requirements - CRD IV / CRR – Frequently Asked Questions*,

European Union, 2013. Directive 2013/36/EU of the European Parliament and of the Council. *Official Journal of the European Union*, (October 2010), pp.338–436. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:176:0338:0436:En:PDF.

Flannery, M.J., 2009. Stabilizing Large Financial Institutions with Contingent Capital Certificates. *SSRN Electronic Journal*. Available at: http://papers.ssrn.com/abstract=1485689.

French, K. et al., 2010. The Squam Lake Report: Fixing the Financial System*. *Journal of Applied Corporate Finance*, 22(3), pp.8–21. Available at: http://papers.ssrn.com/abstract=1684891.

Von Furstenberg, G.M., 2011a. Concocting Marketable CoCos. *HONG KONG INSTITUTE FOR MONETARY RESEARCH*, (22).

Von Furstenberg, G.M., 2011b. Contingent capital to strengthen the private safety net for financial institutions: Cocos to the rescue? *Deutsche Bundesbank Eurosystem*, (01). Available at: http://www.econstor.eu/handle/10419/44598.

Goodhart, C.A.E., 2010. Are CoCos from Cloud Cuckoo-Land ? What triggers conversion ? , (June). Available at: http://www.voxeu.org/article/are-cocos-cloud-cuckoo-land [Accessed June 17, 2015].

Goodwin, T.H., 1998. The information ratio. *Financial Analysts Journal*, 54(4), pp.34–43.

Grinold, R.C. & Kahn, R.N., 1996. Active Portfolio Management. *The Journal of Finance*, 51(4), p.1559. Available at: http://www.jstor.org/stable/2329407?origin=crossref.

Gupton, G.M., Finger, C.C. & Bhatia, M., 1997. CreditMetricsTM – Technical Document. *JP Morgan*, p.212. Available at: http://www.ma.hw.ac.uk/~mcneil/F79CR/CMTD1.pdf.

Hale, T. & Mccrum, D., 2015. Deutsche's riskiest bonds in spotlight. *Financial Times*, (November 10, 2015).

Henderson Global Investors, ., 2014. *The rise of the CoCo – a primer on bank capital*,

Henriques, R., Goulden, J. & Granger, A., 2006. A Framework for Valuing Financial Hybrids. *European Credit Framework*, (September).

Hillion, P. & Vermaelen, T., 2004. Death spiral convertibles $. , 71, pp.381–415.

Hull, J., Predescu, M. & White, A., 2004. The relationship between credit default swap spreads, bond yields, and credit rating announcements. *Journal of Banking & Finance*, 28(11), pp.2789–2811. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0378426604001098.

J.P.Morgan, 2015. Global Banks Credit Quarterly The AT1 Edition. *Global Credit Research*, (April), pp.1–62.

Jafry, Y. & Schuermann, T., 2004. Measurement, estimation and comparison of credit migration matrices. *Journal of Banking and Finance*, 28(11), pp.2603–2639.

Kaijser, J., 2013. CRD IV capital buffers. *De Nederlandsche Bank*.

Katz, S., 2014. The Price and Adjustment Process of Bonds to Rating Reclassifications: A Test of Bond Market Efficiency. *The Journal of Finance*, 29(December 2012), p.15213.

Kidd, D., 2011. The Sharpe Ratio and the Information Ratio. *Investment Performance Measurement*, (1), pp.1–4.

King, P. & Tarbert, H., 2011. *Basel III : An Overview*, Available at: http://ubc.summon.serialssolutions.com.

Koziol, C. & Lawrenz, J., 2012. Contingent convertibles . Solving or seeding the next banking crisis ? *Journal of Banking and Finance*, 36(1), pp.90–104. Available at:

http://dx.doi.org/10.1016/j.jbankfin.2011.06.009.

Kuritzkes, B.A. & Scott, H., 2009. Markets are the best judge of bank capital. *Financial Times*.

Lambert, P., 2014. *Financial Institutions Ratings Bank Capital Instruments*,

Lambert, P., Villalobos, J. & Theodore, S., 2014. *AT1 Capital Instruments Background and key risks for investors*,

Leung, M. et al., 2012. *Regulatory capital eligibility requirements for banks : the changing landscape*,

Maes, S. & Schoutens, W., 2012. Contingent Capital: An In-Depth Discussion. *Economic Notes*, 41(1-2), pp.59–79.

McCarthy, J., 2014. " New style " Basel III-compliant bank subordinated debt and Additional Tier 1 securities / hybrids are higher risk. *FIIG Research*, (August), pp.1–5.

McDonald, R.L., 2013. Contingent capital with a dual price trigger. *Journal of Financial Stability*, 9(2), pp.230–241. Available at: http://dx.doi.org/10.1016/j.jfs.2011.11.001.

Moody's Investor Services, 2007. *CDO Research Data Feed Glossary of Terms*,

Muenstermann, B., 2014. Everybody loves CoCos, or do they...? *J.P. Morgan Asset Management. Global Fixed Income Blog*.

Öfinger, S., 2012. A Valuation Concept for Coco Bonds. *Bachelor Thesis. University of St. Gallen (HSG) Graduate School of Business, Economics, Law and Social Sciences*.

Patrick, K., CoCos and Bail-Ins Introduction : An Alternative to Bail-Ins.

Pazarbasioglu, C. et al., 2012. Contingent Capital: Economic Rationale and Design Features. *Building a More Resilient Financial Sector: Reforms …*. Available at: http://books.google.com/books?hl=en&lr=&id=zHcFiqREor0C&oi=fnd&pg=PA161&dq=Contingent+Capital+:+Economic+Rationale+and+Design+Features&ots=4eDAxs4h0s&sig=vFSNbEx2iJ4L4CapPW_njNrQ9KE.

Pennacchi, G.G., Vermaelen, T. & Wolff, C.C.P., 2011. *Contingent Capital: The Case for COERCs*, Available at: files/37/Pennacchi_2011.pdf.

Rajan, R., 2009. More capital will not stop the next crisis. *Financial Times*, pp.19002–19002. Available at: http://www.ft.com/cms/s/0/a830fcf6-aed1-11de-96d7-

00144feabdc0.html#axzz3jkBRlW5y.

Rappoport, P., 2001a. Rock-Bottom Spread Mechanics. *JP Morgan, Investment Strategies*, (August), pp.17–28.

Rappoport, P., 2001b. *Rock-Bottom Spreads*,

Rappoport, P., 2001c. Valunig Credit Fundamentals: Rock-Bottoms Spreads. *Investment Research*.

REGULATION (EU) No 575/2013, 2013. *REGULATION (EU) No 575/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL*,

Rozansky, G., 2010. The Loss Absorbency Requirement and "Contingent Capital" Under Basel III. *EuroWatch. Thomson Reuters*, 23, pp.1–5.

S&P, 2014. *2013 Annual Global Corporate Default Study And Rating Transitions*,

S&P, 2015. *2014 Annual Global Corporate Default Study And Rating Transitions*,

Schaffner, B., 2010. A Valuation Framework for Pricing Hybrid Bonds. *Master's thesis. University of St. Gallen (HSG) Graduate School of Business, Economics, Law and Social Sciences*.

Schuermann, T., 2007. Credit Migration Matrices. *Encyclopedia of Quantitative Risk Assesment*, pp.1–14.

Shearman&Sterling, 2013. Basel III Framework : US / EU Comparison. , (August), p.3.

De Spiegeleer, J. & Schoutens, W., 2014a. CoCo Bonds With Extension Risk. *Wilmott*, 2014(71), pp.78–91. Available at: http://doi.wiley.com/10.1002/wilm.10331.

De Spiegeleer, J. & Schoutens, W., 2014b. "Contingent Convertibles" The World of CoCos. In *Presentation*.

De Spiegeleer, J. & Schoutens, W., 2013. Multiple trigger CoCos: Contingent debt without death spiral risk. *Financial Markets, Institutions and Instruments*, 22(2), pp.129–141.

De Spiegeleer, J. & Schoutens, W., 2011. Pricing Contingent Convertibles : A Derivatives Approach. *Journal of Derivatives*, (March), pp.1–34.

De Spiegeleer, J. & Schoutens, W., 2009. Steering a Bank Around a Death Spiral: Multiple

Trigger CoCos. *Willmott Magazine*, (December).

Squam Lake Working Group on Financial Regulation, ., 2009. *An Expedited Resolution Mechanism for Distressed Financial Firms : Regulatory Hybrid Securities*,

Standard & Poor's, 2012. How A Bail-In Tool Could Affect Our Ratings On EU Banks. *RatingsDirect Global Credit Portal*, (44), pp.1–11. Available at: www.standardandpoors.com/ratingsdirect.

State Street Global Advisors, 2015. *Bank Bail-In Regimes : No Longer a " Bailout " for Bank Credit Ratings*,

U.S. CFTC. U.S SEC, 2010. *FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010*,

Veiteberg, V.G., Bysveen, F.T. & Rosef, B.H., 2012. *Pricing Contingent Convertible Capital: An Empirical Approach*.

Welsh, C. & Fried, J., 2011. *CRD IV : the European response to Basel III and the impact on tier 1 and tier 2 bank capital*,

Wilkens, S. & Bethke, N., 2014. Contingent Convertible (CoCo) Bonds: A First Empirical Assessment of Selected Pricing Models. *Financial Analysts Journal*, 70(2), pp.59–78.