Bank Financing with Structured Products – How to make Contingent Convertibles work

Marc Crummenerl and Christian Koziol

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In the aftermath of the 2008 financial crisis, contingent convertible bonds have been proposed as the panacea for distressed financial institutions. However, few CoCo bonds have been issued so far. We review the literature and explore different rationales why banks might be reluctant to issue CoCo bonds. In the second part of our analysis, we introduce a simple continuous-time framework to investigate the effect of the CoCo bond design on risk-taking and loan granting incentives. We find that both the conversion ratio and the conversion threshold need to be sufficiently high such that there is a wealth transfer from equity holders to debt holders at conversion. This particular CoCo bond design successfully mitigates the asset substitution problem as well as a credit crunch. Consequently, the regulator should not only advocate the mandatory use of CoCo bonds, but also prescribe the specific design which ensures a punitive wealth transfer at conversion.

Nach der Finanzkrise im Jahr 2008 wurden Contingent Convertible Bonds (CoCos) als Wundermittel gegen Bankenkrisen gepriesen. Jedoch wurden bislang nur wenige CoCos emittiert. In diesem Beitrag untersuchen wir verschiedene Begründungen warum Banken mit der Emission von CoCos bislang eher zögerlich waren. Zudem untersuchen wir in einem zeitstetigen Modell wie sich die Ausgestaltung der Produktmerkmale auf die Risikoanreize und die Kreditvergabe der emittierenden Bank auswirkt. Um Risikoerhöhungen und eine Kreditklemme zu vermeiden sollten CoCos so gestaltet werden, dass ein Vermögenstransfer von den Aktionären zu den Fremdkapitalgebern bei Wandlung der CoCos entsteht. Dies kann durch die Wahl eines hohen Wandlungsverhältnisses und einer hohen Wandlungsschwelle erreicht werden. Insofern sollten Regulatoren, die wie in der Schweiz die Banken zu der Emission von CoCos verpflichten wollen, auch die entsprechende Ausgestaltung der Kontrakte im Blick behalten.

1. Introduction

Contingent convertible bonds – also known as CoCo bonds – play an important role in the debate on banking stability. Regulators especially favor this modern financing instrument for banks. This is not surprising, because the idea behind CoCo bonds is that they provide banks with additional capital in case they suffer from unfavorable conditions.

Hence, it is no longer the government or the taxpayer who are in charge of saving distressed financial institutions. The banks and the capital market are taking care of themselves. Furthermore, the fact that banks' liabilities vanish in case of financial distress seems to decrease the default probability at first glance. A potential reduction of the default probability would be a highly desirable property not only from the regulatory point of view.

Despite an intensive public debate, rather few CoCo bonds have been issued so far. Remarkably, the latest issues by UBS, Barclays, KBC and Swiss Re all have a conversion ratio equal to zero in common. This feature economically means that CoCo bond holders are left with nothing when a conversion event occurs. This anecdotal evidence raises three questions: (1) Why are banks so reluctant to issue CoCo bonds? (2) Why do banks choose a low or even zero conversion ratio? (3) What are the implications for the regulator from this issuance behavior?

The goal of this paper is to shed light on these three major questions regarding CoCo bonds and their issuances. Several answers to the first question can already be found in the highly diverse literature. Many different aspects are discussed such as the risk-taking behavior induced by CoCos, the interaction between a credit crunch and CoCos, the incentives of capital market participants to manipulate prices in order to enforce or prevent a conversion, and the uniqueness of asset prices. We aim at surveying this broad literature and relating the main arguments for and against an issuance of CoCo bonds to each other. Besides Coco bonds, there are other types of prominent bank financing instruments such as retailed structured products which are of a similar nature. In addition, we briefly refer to the features of these financing products.

In order to tackle the second and third question, we nest two aspects of the literature, namely the risk-taking incentives of banks and the likelihood of a credit crunch. Apparently, the design of CoCo bonds might drive the risk-taking and loan granting behavior of banks. The introduction of a continuous-time framework allows us to analyze the severity of these incentives for different CoCo bond designs. Risk taking is attractive for example for managers who are paid with stock options or for those who are interested in empire building if a higher risk is associated with a higher equity value.

The model explains that a high conversion ratio mitigates the bank's risk-taking incentives and simultaneously enhances its loan granting behavior. To accomplish this effect, the high conversion ratio has to be combined with a sufficiently high trigger level such that there is a wealth transfer from equity holders to debt holders at conversion. In addition, these two parameters should be higher for banks with a high leverage ratio. For this reason, regulators who advocate the use of CoCo bonds should also prescribe the specific product design to avoid distorted incentives.

The remainder of the paper is organized as follows. Section 2 introduces the products and gives an overview of the issued CoCo bonds so far. Section 3 surveys the literature on CoCo bonds. In section 4, we introduce the model and show how CoCo bonds impact the risk-taking and loan-granting incentives of banks. Section 5 concludes.

2. Product overview

In this section, we shortly introduce how CoCo bonds work. They have all the properties of usual subordinated debt. The bank pays a coupon on the CoCo bond's face value, whereby the interest rate is usually higher compared to ordinary debt. In addition, CoCo bonds are equipped with a trigger mechanism. When the predefined trigger event occurs, the debt is converted into equity. Similar to ordinary convertible bonds, the nominal amount of outstanding shares increases at conversion. The conversion ratio determines how many shares the CoCo bond holders receive. The crucial difference to ordinary convertible bonds is that conversion is mandatory in case of the trigger event. This event can be defined with respect to market based capital ratios or accounting data. In some instances, the conversion is also at the discretion of the regulatory authority.

Banks have been hesitant to issue CoCos so far. *Table 1* shows a summary of the most important recent issuances and their contractual designs. We observe two waves of CoCo bond issuances. The first wave closely followed the financial crisis after the default of Lehman Brothers. Llyods was the first bank to issue CoCo bonds. The second more recent wave consists of CoCo bonds, which all exhibit a conversion ratio of zero. We also observe a predominance of Swiss issuers, who are likely to issue the CoCo bonds due to the prospective regulatory requirement in their country.

Issuer	Date	Curr.	Notional	Coupon	Years	Trigger	WD	Type
Lloyds	Nov-09	GBP USD JPY EUR	4.65bn 2.52bn 37.00bn 2.36bn	7.588-16.125% 7.875-8.5% 6.75-8.07% 6.385-15%	10-23 11 11-13 10-11	CR < 5% CR < 5% CR < 5% CR < 5%	38% 38% 38% 38%	a a a a
Rabobank	Mar-10	EUR	1.25bn	6.875%	10	ER < 7%	75%	b
Credit Suisse 1	Oct-13	CHF USD	2.5bn 3.5bn	9.0% 9.5%	n.a. n.a.	CR < 7% CR < 7%	33% 33%	a a
Credit Suisse 2	Feb-11	USD	2.0bn	7.875%	30	CR < 7%	37%	a
Credit Suisse 3	Jul-12	USD	1.725bn	9.5%	n.a.	CR < 7%	25%	a
Credit Suisse 4	Mar-12	USD	0.75bn	7.125%	n.a.	CR < 7%	38%	a
UBS	Aug-12	USD	2.0bn	7.625%	10	CR < 5%	100%	c
Barclays	Nov-12	USD	3.0bn	7.625%	10	CR < 7%	100%	c
KBC Group	Jan-13	USD	1.0bn	8%	10	CR < 7%	100%	c
Swiss Re	Mar-13	USD	0.75bn	6.375%	11.5	SR < 125%	100%	c

The table shows the issued CoCo bonds since 2009 and their contractual design. The trigger mechanisms are defined as follows: CR denotes the tier 1 capital ratio, ER denotes the equity ratio and SR denotes the Solvency ratio. Lloyds issued a range of different tranches with different coupons, currencies and maturities. The write down WD or wealth transfer at conversion for Rabobank and all issuances from 2012/2013 are determined in the respective indentures. Wealth transfer estimates in the cases of and Lloyds are taken from *Berg and Kaserer* (2012). Credit Suisse 1, 2, 3 & 4 are estimated applying the same method with current values from the Q2/2013 report. We note that *Berg and Kaserer* found no wealth transfers for Credit Suisse 1 & 2. We repeat the calculations with actual data from year 2013 for Credit Suisse 2. Credit Suisse 1 will be issued in 2013. For the calculation of wealth transfer, we assumed the same contractual design as for Credit Suisse 1.

Table 1: Recent Contingent Bond Issuance

We use the write down at conversion (see column 8 of *table 1*) to categorize the different contingent debt claims into three types. The type is indicated in column 9 of the same table.

(a) *Classic CoCo bonds* are characterized by an increase in the number of outstanding shares upon conversion. The associated wealth transfers are estimated based on the method of *Berg and Kaserer* (2012).
(b) *Write-down bonds* do not convert into equity when the trigger event occurs. Instead, they are written down to a predefined value and the remaining amount becomes due immediately.
(c) *Total-loss bonds* are an extreme case of write-down bonds. The claims are written down to zero in case of a trigger event. In other words, contingent bond holders are left with nothing when the trigger event occurs.

Strictly speaking, write-down bonds and total-loss bonds are not convertible bonds. However, we included these products in the overview since they rely on the same trigger mechanism and induce similar incentives. In most cases, bond holders incur a wealth loss. CoCo bond holders incur this loss by receiving a share of the firm which is worth less than the value of the plain bond. The holders of write-down bonds incur the loss by a reduction of the face value. Total-loss bond holders are completely wiped out.

Apparently, banks prefer low conversion ratios (see columns 8 of *table 1*). In section 4.2, we provide a rationale for this behavior and demonstrate the incentive effects induced by this particular design.

3. Recurring themes in the literature

Contingent capital has been mentioned in the literature as an effective tool to stabilize financial markets in distress. *Flannery* (2005, 2010) argues in favor of contingent capital since risk-taking costs are internalized rather than shifted towards tax payers in a public bail-out. *Acharya et al.* (2009) describe CoCo bonds as "clearly a good idea". Furthermore, we find favorable mentions of these instruments in policy recommendations such as *Stein* (2004), *Kaplan* (2009) and *Duffie* (2009).

In the following, we highlight three issues, which have been in the focus of the recent literature. First, we discuss risk-shifting incentives as a possible threat amplified by contingent capital. Second, we examine whether CoCo bonds can alleviate credit crunches. And third, we analyze to what extent CoCo bonds create incentives for either claim holder to manipulate prices and force a conversion. In addition, we also relate CoCo bonds to similar structured products which are used by banks for funding purposes.

3.1 Risk-shifting incentives

At first glance, contingent capital seems to be a universally beneficial financial instrument. In good states of the economy, the CoCo bond holders receive a coupon just like ordinary subordinated debt holders. In bad states of the economy, a potentially costly default is prevented by converting the CoCo bonds into new equity. However, it is exactly this feature which might have negative repercussions. The bank's managers anticipate the conversion and take it into account when making investment decisions. Consequently, the managers might be inclined to increase the riskiness of the bank's assets since the bank has additional downside protection provided by the CoCo bonds.

Straight debt is often argued to be an optimal financing contract since it causes an exchange of control rights in bad economic states, which equity holders prefer to avoid. This disciplining effect of straight debt is possibly weakened by CoCo bonds since the conversion mechanism postpones the transfer of control rights. Both *Flannery* (2005) *and Pennacchi et al.* (2011) already hint at this possible elimination of disciplining effects and recognize the existence of risk-shifting incentives.

In the following, we discuss the model of *Koziol and Lawrenz* (2012), who employ a continuous-time framework in order to formally examine the effects of contingent capital on banks' risk-taking incentives. The bank's assets follow a Geometric Brownian motion. On the liabilities side, the bank takes government-insured deposits and issues debt, which can be either straight debt or contingent convertible debt. Both debt contracts are consol bonds with fixed coupon payments. The conversion trigger of the CoCo bonds is set such that conversion occurs at the time when the default threshold of the pure debt firm would be breached. The introduction of the classical trade-off between tax benefits of debt and bankruptcy costs allows to derive an optimal capital structure.

Koziol and Lawrenz (2012) consider two cases. In the first case, asset risk is contractible. If equity holders do not have discretion over the choice of risk, an issuance of CoCos increases the bank's debt capacity. This implies that the advantages of debt financing, such as tax shields, can be exploited to a larger extent under CoCo financing. At the same time, the default probability as well as the present value of distress costs are decreased by substituting straight debt with CoCo bonds. Hence, CoCo bonds are not only individually beneficial for the bank's equity holders but also socially optimal for the whole economy.

In the second case, contracts are incomplete in the sense that the bank is not able to commit to a specific asset risk. As a consequence, CoCo bonds always distort risk-taking incentives if the claims are already part of the bank's capital structure. If the bank faces low financial constraints, it is always willing to increase the risk both with straight debt financing as well as with CoCo financing. If financial constraints are high, a bank financed with non-convertible debt prefers to reduce the asset risk. However, an issuer of CoCo bonds might still prefer to increase the asset risk. Hence, CoCo bonds have the potential to magnify risk-taking incentives, but never reduce them.

Investors, however, anticipate such a risk increase and demand a compensation. So are CoCo bonds still desirable from the equity holders' perspective? Two main effects impact the answer to this question. First, CoCo bonds always increase risk-taking incentives when compared to straight debt. This increases the probability of default and thus expected distress costs. Second, contingent capital relaxes financial constraints and enables banks to take advantage of tax benefits to a larger extend. While the former decreases the firm value, the latter increases it. If risk-shifting opportunities are low, a CoCo issuance might still result in a higher firm value. If risk-taking opportunities are high, however, the effect of relaxed financial constraints is overcompensated by higher expected distress costs and the firm value decreases.

In addition, *Koziol and Lawrenz* (2012) provide evidence that the issuance of CoCo bonds can simultaneously increase the firm value as well as the probability of default. This clearly undermines regulators' intentions to reduce risk-taking incentive of distressed financial institutions. In this case, the individually rational behavior of the bank has adverse, destabilizing effects on the whole financial system.

3.2 Procyclicality of lending and credit crunches

Contingent convertibles are foremost discussed in the context of bank stability. However, their use might also be able to mitigate another important problem in the financial sector: procyclical lending and credit crunches.

Intuitively, when the state of the economy worsens, the risks of banks increase, e.g. market volatility is hiking and non-performing loans are accumulating. Hence, banks can reduce their risk profile by either selling or hedging some of their risky investments and loans, or by constraining new business. Since the first is usually difficult and expensive during times of economic crisis, banks regularly stick to the latter. This results in procyclical lending behavior and even credit crunches, when banks fully cease lending to new customers.

How can contingent convertibles help? When the driving motive for banks not to grant new loans in bad times is the fear of financial distress, any financial instrument which reduces default risk or lowers cost associated to situations of financial distress also helps regarding the credit crunch issue. Hence, contingent capital is an obvious candidate for the solution of this problem.

In the following, we introduce the model of *Crummenerl et al.* (2014), who analyze a regulated financial institution in a world without taxes and bankruptcy costs. The bank inherits a risky loan portfolio, whose payoff depends on the realization of the future state of the economy as either good (with probability p) or bad (with probability $1 - p$). The bank is considering to grant an additional (uncorrelated) risky loan. Thereby, the bank needs to take into account that it might have to recapitalize in the future to meet a Basel-type regulatory capital requirement.

Furthermore, the model incorporates adjustment costs in case the bank needs to reduce its debt ratio in the future due to the regulatory constraint. These costs can be interpreted as increased search or marketing costs. They represent the fact that banks cannot readily finance themselves in times of financial distress. Importantly, the adjustment costs do not occur when banks convert their outstanding CoCo bonds into new equity.

The important result from *Modigliani and Miller* (1958) tells us that the loan decision is independent of the economic state in a frictionless world, i.e. when recapitalization is always available at fair terms. The adjustment costs now link the loan decision to the economic outlook. Banks have an incentive not to grant a loan today if they thereby reduce the likelihood of expensive capital structure adjustments tomorrow. A credit crunch occurs when the probability $1 - p$ of the bad state of the economy is high and when the bank is highly levered.

In this setup, CoCo bonds are a tool to avoid costly recapitalization. If the conversion of the CoCo bonds is on fair terms and if a sufficient amount of CoCo bonds is available, banks prefer to convert the CoCo bonds when the regulatory constraint is breached. In this case, the bank never incurs the adjustment cost and consequently always provides the additional loan. The credit crunch is successfully mitigated.

An important caveat to this finding is that it presumes that CoCo bonds are already issued by the bank, i.e. the issuance decision is exogenous. The key question is now whether banks want to issue them in the first place.

Crummenerl et al. (2014) model the issuance of CoCos in the following way: The bank has an outstanding amount of debt. If it decides to issue CoCo bonds, it first has to buy back outstanding debt at fair terms. This amount is replaced by contingent capital, which is priced to have zero NPV. As a consequence, the nominal amount of debt remains unchanged. It is also ensured that the amount of issued CoCo bonds is sufficient to avoid a costly capital increase in the future. Hence, the above result holds that banks always grant the additional loan when CoCo bonds are available. The bank has two further choices. It can decide against CoCo bonds and still grant the loan. Or it can decide against CoCos and against the loan, i.e. a credit crunch occurs.

There are three rationales driving the decision of the bank:

- *Adjustment costs:* The bank saves expected adjustment costs in the case of CoCo financing if there is a positive probability of a capital increase.
- *Debt repurchase:* Banks issuing CoCos have to buy back debt in $t = 0$ when the price is likely to be higher than it would be in $t = 1$ in times of distress. For banks issuing an additional loan, the expected necessary reduction of the debt level is higher if regulatory capital requirements are breached due to the higher risk-weighted assets.
- *Risk-shifting:* An additional loan decision increases the equity value due to the higher overall risk of the bank's loan portfolio.

The avoidance of adjustment costs benefits the issuance of CoCos, while the risk-shifting incentives favor an affirmative loan decision. The costly debt repurchase is to the disadvantage of both, since the repurchase takes place based on future expectations.

The bank's decision depends on the outlook on the future state of the economy, i.e. the probability p, and the current debt level of the bank. For very low debt levels, the bank affirms the loan and no contingent capital is required. There are some debt levels for which the bank would not have granted the loan, but now decides to issue CoCos. In these instances, a credit crunch is successfully mitigated. This result contrasts the finding of *Albul et al.* (2010), who argue that banks are never willing to issue contingent capital voluntarily. However, when the debt level further increases, the bank is not willing to issue CoCos and does not grant the loan.

In addition, the benefits of CoCo bonds vanish with an increase in the probability p of the good state, i.e. when banks have an optimistic view of the economy. Hence, banks are not issuing CoCo bonds in good times or when a bubble potentially occurs, which can both be interpreted as a high expectation of the probability p.

In summary, CoCo bonds increase the debt capacity of the financial system and they are a well desired instrument in bad states of the economy. Despite these benefits, banks are not willing to issue contingent capital in good times. Even though some issuances of CoCo bonds by large banks can be observed, they are far from being established as a standard instrument of bank financing. These findings put regulators in a dilemma. If they consider contingent capital as an appropriate instrument to prevent credit crunches, they have to prescribe a mandatory issuance of these claims. This comes at a cost which has to be borne by the bank's owners.

3.3 Incentives to force a conversion

The conversion trigger mechanism plays a crucial role in the design of contingent capital. As we have seen in section 2, most of the CoCo issues so far have triggers based on accounting numbers. These accounting numbers seem to be a good choice: they are compiled based on common rules, they are not distorted by irrational market movements and they are frequently monitored by regulators. The most common measure used to trigger the conversion of CoCo bonds is the tier 1 capital ratio, which relates the bank's core book equity to its risk-weighted assets.

However, accounting numbers have two major disadvantages. First, they are backward looking. Thus, they include information about the economic prospects of the bank only to the extent to which this information can be deduced from the bank's past performance. Second, the management does have some discretion, e.g. over how and when to account for impairment losses. Needless to say, the books can also be manipulated by the management, like in the cases of Enron and Lehman Brothers. As a consequence of these two disadvantages, conversion might happen too late.

The alternative to using accounting numbers is to resort to market based triggers. Since the asset value process is not directly observable, the only available measure is the bank's share price. When markets are efficient, the share price appropriately reflects all available information on the future prospects of the bank. However, if the trigger mechanism is based on the share price, which in turn is influenced by the time and terms of conversion, distortions in the pricing of the bank's shares might arise. This issue is highlighted by *Sundaresan and Wang* (2013) as well as *Albul et al.* (2010).

In the following, we introduce a simple example from *Sundaresan and Wang* (2013) to illustrate the impact of market based triggers on equilibrium pricing. Assuming that conversion can only occur at maturity, they consider the conditions for conversion and no-conversion of the CoCo bonds. The CoCo bonds are not converted if the asset value A after all payments to non-convertible debt holders is higher than the conversion threshold K plus the payment C to CoCo bond holders, i.e. $A > K + C$. When the CoCo bonds are converted, the CoCo bond holders receive m new shares. The number of shares prior to conversion is denoted by n. After conversion, the asset value meets a second condition of the form $A \leq \left(1 + \frac{m}{n}\right) \cdot K$.

Sundaresan and Wang (2013) distinguish two cases. In the first case, there is a wealth transfer at conversion towards the debt holders, i.e. $\frac{m}{n} \cdot K > C$. As a result, the two above conditions can be met at the same time for some asset values. This leads to two equilibrium prices, which depend on the beliefs of investors. In one equilibrium, all investors believe that conversion does not occur. In the second equilibrium, all investors believe that conversion occurs, which causes the equity value to hit the trigger threshold. *Sundaresan and Wang* (2013) generalize this result in a continuous-time setting and show that multiple equity values are possible well before a potential conversion.

In the second case, there is a wealth transfer at conversion from debt holders to equity holders, i.e. $\frac{m}{n} \cdot K < C$ In this case, there exists a range of asset values for which both of the above conditions are simultaneously not met. This result is caused by the wealth transfer to equity holders, which causes the share price to rise at conversion. However, if the share price is close to trigger level, the expected increase after conversion lifts the share price above the trigger threshold and conversion is prevented. The consequence is that an equilibrium share price does not exist at all for some asset values.

Apparently, the issue of multiple or no equilibrium share prices is caused by the wealth transfer at conversion. *Albul et al.* (2010) propose a constant adjustment of conversion ratios in order to ensure that the market value of the debt claim is at any point in time equal to the market value of received shares at conversion. However, this approach is difficult to implement. *Sundaresan and Wang* (2013) propose a continuous adjustment of the coupon to the rate of short-term risky bank obligations. Thus, the market value of the debt claim remains close to par and a conversion ratio can be determined upon CoCo issuance. This ensures that CoCo holders receive the equivalent of their bond market value (par) in shares when the (equity-)trigger is breached.

The avoidance of multiple equilibrium prices is important since they give rise to manipulation incentives for claim holders. *Albul et al.* (2010) show that equity holders have incentives to drive down the share price and force a conversion if conversion ratios are sufficiently low. For example, managers might distribute false negative information to lower the price. The opposite is true if there is a wealth transfer from equity holders to CoCo bond holders at conversion. In line with *Duffie* (2009) and *McDonald* (2011), the authors argue that CoCo bond holders might engage into short-selling activities in order to trigger a conversion and benefit when the fair share price is restored. If wealth transfers cannot be avoided completely, *McDonald* (2011) proposes to retire the outstanding CoCo bonds gradually and randomly to limit the gains of manipulations.

We have shown that the practical implementation of the trigger mechanism is crucial and might potentially lead to some issues such as distorted equilibrium prices and manipulation incentives. The key determinant of these incentives is the wealth transfer at conversion, which depends on the conversion ratio as well as the conversion threshold. The analysis in the following section further deepens our understanding of these important parameter choices.

3.4 Related products for bank financing

During the recent financial crisis, another typical bank financing instrument gained public attention. After the default of the prominent issuer Lehman Brothers in September 2008, retail structured products caused losses to investors especially in Germany and Hong Kong. Nevertheless, the market for these products still has a sizable volume, e.g. EUR 90.2 bn in Germany as of end 2013.

Retail structured products are subordinated debt contracts, whose payoff is contingent on the development of an arbitrary underlying, e.g. stock prices, interest rates or commodities. Hence, retail structured products have a similar character as CoCo bonds because the redemption of both depend on specific states of the world. For this reason, a bank financing with retailed structured products might exhibit parallels to CoCo bonds. However, retailed structured products are even more flexible than CoCo bonds as the payoff at maturity can be any function of any arbitrary source of uncertainty. Very prominent examples are principal protected notes and discount notes. Since the use of the proceeds from issuing retail structured products is not restricted, these products are also a meaningful source of bank funding.

This observation gives rise to the question – corresponding to that for CoCo bonds – how retail structured products impact the risk choice and stability of the issuing financial institution. In particular, the payoff of discount notes has a similar feature like CoCo bonds in the sense that the repayment is reduced in bad states of the economy, which might weaken the disciplining effect of debt.

Crummenerl and Koziol (2014) use a Merton-type model with taxes and bankruptcy costs to formally analyze the risk-taking incentives induced by retail structure products. In a setting with complete contracts, i.e. when the leverage ratio of the bank is contractible, retail structured products of any shape have a universally beneficial effect. They increase the firm value and simultaneously reduce the probability of default. However, when contracts are incomplete, the bank has an incentive to increase its leverage ratio, which might result in an increase of the default probability.

These findings show that regulators should be concerned with potential risk-shifting incentives caused by all different types of contingent claims issued by financial institutions. In this context, a simple and effective way to regulate issuers of retail structured products is to address the friction of incomplete contracts by imposing a regulatory restriction on the leverage ratio.

4. Optimal design of CoCo bonds

We have highlighted three arguments why banks are reluctant to issue CoCo bonds. First, shareholders might want to avoid risk-shifting incentives for managers. Second, we have shown that it might not be optimal for banks to issue CoCo bonds in good times even though they help to mitigate a credit crunch in bad times. And third, shareholders might want to avoid situations in which claim holders have an incentive to manipulate prices.

Despite these concerns, we observe some issuances of CoCo bonds (see overview in *table 1*). Some of those have been issued voluntarily by banks in the aftermath of the financial crisis, i.e. in a severe state of the economy. And others have been issued more recently to fulfill prospective regulatory requirements, e.g. in Switzerland. These recent issues have a very low or even zero conversion ratio in common. We now pursue the question why banks are choosing this particular design and what the regulatory implications from this behavior are.

In the following, we introduce a simple continuous-time framework of a bank financed with CoCo bonds and equity. We analyze how the product design of the CoCo bonds, i.e. the choice of the conversion ratio and the trigger level, impact the severity of the risk-taking incentives and credit crunch effects caused by CoCo bonds.

Both of these effects are crucial for regulators' decisions with regard to a mandatory introduction of these instruments as banks' capital. Regulators are interested in stabilizing financial markets in distressed situations and providing the economy with necessary liquidity when it is most needed. Contingent capital is often mentioned as being the magic remedy in financial downturns. We show that this view has to be taken with caution, since the induced incentives strongly depend on the design of CoCo bonds. The desired incentive effects of reduced risk-taking and increased loan granting only occur if there is a wealth transfer from equity holders to CoCo holders at conversion.

4.1 Model framework

We consider a bank with assets V, which follow a diffusion process of the following form:

$$\frac{dV}{V} = \mu \, dt + \sigma \, dz, \tag{1}$$

where μ denotes the expected return of the assets, σ is the volatility of asset returns and z is a standard Wiener process.

The bank has two claims outstanding: contingent convertible debt and equity. As long as the bank is solvent, the CoCo bond holders receive an instantaneous coupon payment of c. In case the trigger event occurs, i.e. the asset value decreases below the conversion threshold $VC < V$, the CoCo bonds are converted into equity and the bank continues as an unlevered entity. Upon conversion, the CoCo bond holders receive a share γ of the equity and the old equity holders retain a share $1 - \gamma$ of the bank's equity. The capital structure is determined at time $t = 0$ and remains static thereafter.

Applying the pricing approach of *Leland* (1994), the CoCo bond value D at time $t = 0$ amounts to

$$D = \frac{c}{r} + \left(\frac{V}{VC}\right)^{-\frac{2r}{\sigma^2}} \cdot \left(\gamma \cdot VC - \frac{c}{r}\right). \tag{2}$$

The first term $\frac{c}{r}$ gives the value of a risk-free consol bond with coupon payments c, where r is the risk-free rate. The second term gives the value of the conversion feature. When conversion occurs, the bond holders get a fraction γ of the assets, which have value VC at the time of conversion. The bond holders lose the coupon payments. Hence, $\gamma \cdot VC - \frac{c}{r}$ corresponds to the wealth transfer from equity holders to bond holders at the time of conversion. The factor $\left(\frac{V}{VC}\right)^{-\frac{2r}{\sigma^2}}$ corresponds the value of 1 EUR at the time of conversion discounted to time $t = 0$.

Denoting the discount factor $\theta \equiv \left(\frac{V}{VC}\right)^{-\frac{2r}{\sigma^2}}$, we can rewrite equation (2) as

$$D = (1 - \theta) \cdot \frac{c}{r} + \theta \cdot \gamma \cdot VC. \tag{3}$$

We can interpret θ as a measure for the default risk of the bank. The bond value is equal to the value $\frac{c}{r}$ of the risk-free cash flow weighted with the factor $1 - \theta$ plus the value $\gamma \cdot VC$ of the received assets at conversion weighted with the factor θ.

Since we do not consider tax-benefits of debt and bankruptcy costs, the equity value S can be expressed as

$$S = V - D. \tag{4}$$

To ensure comparability between banks with different CoCo designs, we keep the leverage ratio constant. So when the CoCo design represented by γ and VC as well as the debt level D are fixed, the coupon rate c is determined as

$$c = (D - \theta \cdot \gamma \cdot VC) \cdot \frac{r}{1 - \theta}. \tag{5}$$

The coupon payment strictly increases with the bank's leverage ratio and strictly decreases with the conversion ratio γ. *Figure 1* plots the coupon depending on the conversion ratio γ for three different volatility levels. The three lines cross each other at $\hat{\gamma} = \frac{D}{VC}$, which implies that there is no wealth transfer between the claim holders for this particular conversion ratio. Hence, the debt holders demand the same coupon independent of the volatility. For values of $\gamma < \hat{\gamma}$, there is a wealth transfer from the debt holders to equity holders at conversion. Consequently, a higher volatility, which makes conversion more likely, is compensated by a higher coupon payment. In the reverse case when $\gamma > \hat{\gamma}$, the bond holders benefit from conversion and a higher volatility results in a lower coupon payment.

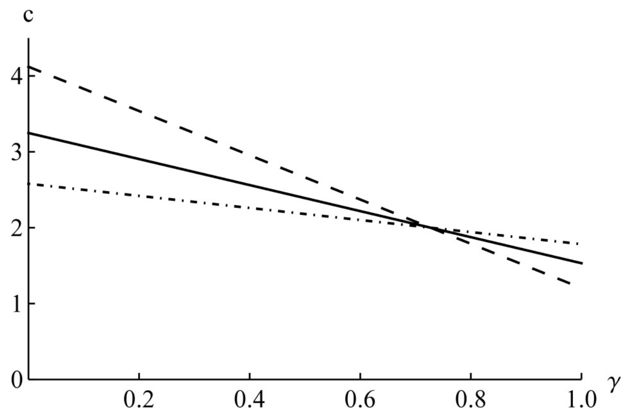

Figure 1: Coupon for different volatility levels (The plot shows the instantaneous coupon payment c for a debt value D = 40 and trigger level of VC = 55 depending on the conversion ratio γ for three different volatility levels of $\sigma = 0.20$ (dot-dashed line), $\sigma = 0.25$ (solid line), $\sigma = 0.30$ (dashed line). The remaining parameters are $V = 100$ and $r = 0.05$)

4.2 Why do banks choose low conversion ratios?

In the first step of our analysis, we evaluate the equity holders' risk-shifting incentives. We have to distinguish between two fundamental cases: a bank before and after the issuance of CoCo bonds. In our model, we assume complete and frictionless markets. If all products are fairly priced, CoCo bond holders anticipate the behavior of banks and price the claims accordingly. Hence, a market friction is required to explain the issuance of CoCo bonds.

Of course there are reasons why the bank's management might want to deviate from the optimal policy for the shareholders. This can for example be the case when the bank managers are paid with stock options and thus benefit from an increase of the bank's business risk. Furthermore, managers might be interested in empire building and acquire more risky and even unprofitable businesses.

However, we abstract from these issues for the remainder of this analysis. We assume that the CoCo bonds have already been issued and that the bank's managers are able to change the riskiness of the assets, i.e. risk is not contractible by the bond holders. We examine the induced incentive effects of different designs of CoCos, which crucially depend on the associated wealth transfer at conversion.

We first inspect the first derivative of the equity value S with respect to the asset volatility σ, which is given by

$$\frac{\partial S}{\partial \sigma} = -\left(\gamma \cdot VC - \frac{c}{r}\right) \cdot \frac{4\theta \cdot r \cdot ln\left(\frac{V}{VC}\right)}{\sigma^3}. \qquad (6)$$

The term in brackets corresponds to the wealth transfer to debt holders at conversion and determines the sign of the derivative. If the wealth transfer is positive, equity holders have an incentive to avoid conversion and reduce risk. In the opposite case, equity holders benefit from conversion. Hence, it becomes worthwhile for equity holders to increase the likelihood of conversion by investing in more risky projects.

If we assume that the debt level is fixed and plug in equation (5) for the coupon, the derivative simplifies to

$$\frac{\partial S}{\partial \sigma} = -(\gamma \cdot VC - D) \cdot \frac{r}{1-\theta}. \tag{7}$$

Again, the term in brackets determines the sign of the derivative. This term is positive for high conversion ratios above the threshold $\hat{\gamma} = \frac{D}{VC}$ and negative for low conversion ratios below this threshold. Hence, we can conclude our first important finding that the low or even zero conversion ratio of the recently issued CoCo bonds amplify the risk-shifting incentives of equity holders. The case of $\gamma = 0$ corresponds the total-loss bond design discussed in section 2.

We further illustrate this point by analyzing the classical asset substitution problem. The bank starts with a low initial asset volatility σ_l. The bank can accept a new project with net present value ΔV, which changes the total asset volatility to a higher volatility $\sigma_h > \sigma_l$. The asset substitution problem occurs if the equity holders are willing to accept negative NPV projects, i.e. $\Delta V < 0$, under the new risk environment σ_h.

We are now solving for the critical change ΔV^* in the asset value, such that the equity holders achieve exactly the same equity value as under the low risk environment, i.e.

$$S(V, \sigma_l) = S(V + \Delta V^*, \sigma_h). \tag{8}$$

We demonstrate the result numerically in *figure 2*. The graph shows the critical asset value change ΔV^* for three different volatility levels σ_h depending on the conversion ratio γ. In line with our previous finding, we see that the critical NPV is negative for conversion ratios below the threshold $\hat{\gamma} = \frac{D}{VC}$. The critical NPV monotonously increases with γ and is positive above $\hat{\gamma}$. The effect is more pronounced, i.e. the curves are steeper, for high values of σ_h.

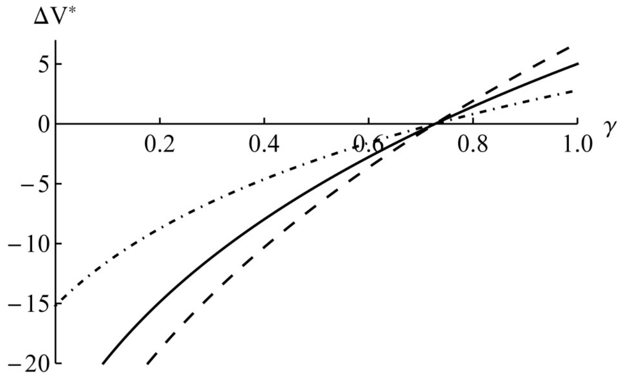

Figure 2: Asset Substitution Problem (The plot shows the critical asset value change ΔV^* for a debt value $D = 40$ and a trigger level of $VC = 55$ depending on the conversion ratio γ for three opportunities to increase the asset risk from $\sigma_l = 0.25$ to $\sigma_h = 0.30$ (dot-dashed line), $\sigma_h = 0.35$ (solid line), $\sigma_h = 0.40$ (dashed line). The remaining parameters are $V = 100$ and $r = 0.05$)

Our results show that the impact of CoCo bonds on risk-taking incentives strongly depend on the conversion ratio and the associated wealth transfer. If banks are inclined to increase their risk, they benefit from low conversion ratios, which imply a wealth transfer from bond holders when conversion occurs. An increase of the asset volatility makes a conversion more likely. Hence, equity holders have strong incentives to force a conversion.

From the regulatory point of view, this effect is rather undesired. As we have shown, the risk-taking incentives diminish if the conversion ratio increases. For high conversion ratios, the asset substitution problem is fully mitigated and banks have incentives to reduce risk. Therefore, regulators clearly prefer high conversion ratios with regard to the stability of the financial system.

4.3 Does the CoCo design affect lending behavior?

In the second step of our analysis, we focus on the loan granting behavior of banks. We have already discussed in section 3.2 that CoCo bonds can help to mitigate a credit crunch. In the following, we examine how the product design choices influence loan-granting incentives. Again, our results show that loan granting incentives highly depend on the wealth transfer at conversion.[1]

The equity holders are considering an out-of-pocket investment at time $t = 0$, which can be interpreted as granting an additional loan. The investment requires an upfront payment of I and increases the asset value by $I \cdot (1 + y)$, where y denotes the return of the investment. The asset risk remains unchanged. We determine the critical required return y^* on the investment such that equity holders are indifferent between holding the amount

1 In contrast, *Crummenerl et al.* (2014) focus on one specific CoCo bond design. The conversion ratio is determined in $t = 0$ such that the expected value of the CoCo bond is the same with or without the conversion feature.

I in cash and injecting the money into the bank to finance the additional loan, i.e. we solve the condition

$$S(V, \sigma) + I = S(V + I \cdot (1 + y^*), \sigma). \quad (9)$$

The bank is only willing to grant loans with a return above y^*. A positive critical return y^* implies that loans with a low but positive NPV, i.e. with return $y \in (0, y^*)$, which should be granted from the social planner's perspective, are not approved by the bank. Hence, a credit crunch occurs. In contrast, critical returns below zero indicate that equity holders are willing to accept loans which decrease the asset value. Arguably, it is not desirable from the social planner's perspective that negative NPV loans are granted. However, the bank provides sufficient liquidity to the financial system and a credit crunch is prevented.

Figure 3 demonstrates the effects on lending behavior for three different volatility levels. The plot shows the critical return y^* depending on the conversion ratio γ. The required critical return is positive for low conversion and monotonously decreases with the conversion ratio. The critical return is zero for $\hat{\gamma} = \frac{D}{VC}$ and negative for high conversion ratios. The effect is more pronounced, i.e. the curves are steeper, for high volatility levels σ.

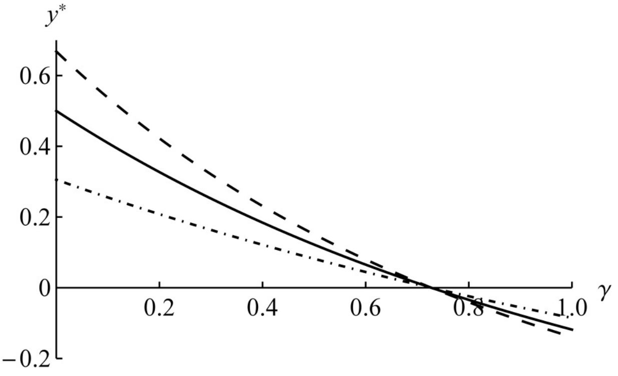

Figure 3: Critical required return (The plot shows the required critical return y^* for a debt value $D = 40$ and a trigger level of $VC = 55$ depending on the conversion ratio γ for three different volatility levels of $\sigma = 0.20$ (dot-dashed line), $\sigma = 0.25$ (solid line), $\sigma = 0.30$ (dashed line). The remaining parameters are $V = 100$ and $r = 0.05$)

The key observation is that CoCo bonds with low conversion ratios exacerbate liquidity dry-outs. Again, the critical factor is the wealth transfer from equity holders to debt holders at conversion. For low conversion ratios below $\hat{\gamma}$, the associated wealth transfer is negative. Hence, it is not in the interest of equity holders to grow the assets and thereby reduce the likelihood of conversion. Consequently, they only take on additional investments which offer a high return.

The opposite is true for high conversion ratios above $\hat{\gamma}$. In this case, the wealth transfer is to the benefit of the CoCo bond holders and the equity holders prefer to avoid conversion. Hence, they inject cash into the bank to grow the asset value and thereby decrease the likelihood of conversion. Intuitively, they prefer to lose a small amount of value today rather than losing a large amount of value at conversion. Hence, they are even willing to undertake negative NPV projects.

We conclude that CoCo bonds with high conversion ratios prevent a credit crunch and thus should be advocated by regulators. This finding is also in line with our results on the risk-shifting issue. A wealth transfer from equity holders to bond holders at conversion is the key feature, which a CoCo bond should possess from the regulatory perspective. This penalizing effect of conversion mitigates not only the risk-shifting incentive of equity holders but also ensures the liquidity supply of the financial system.

This finding is especially striking given that most of the recent issues of contingent debt are total-loss bonds (i.e. $\gamma = 0$). At first glance, these products have a very favorable property from the regulatory point of view, since the debt completely vanishes in the event of default. Hence, banks with total-loss bonds cannot default. However, it is desirable for equity holders to trigger the event which causes the wipe-out of debt holders. The result is a paradoxical situation, in which a credit crunch occurs even though the bank is not subject to default risk.

4.4 How does the trigger level change incentives?

We have shown that the wealth transfer at conversion determines the incentives for equity holders to increase risk and to invest in new projects. So far, we have analyzed the impact of the conversion ratio, but the wealth transfer is also impacted by the trigger level, which by definition coincides with the value of the assets at conversion. A higher trigger level thus implies a shift of wealth towards the debt holders.

The trigger level also changes incentives through another channel. The likelihood of conversion increases ceteris paribus with the trigger level, i.e. $\frac{\partial \theta}{\partial VC} > 0$. Whenever wealth is transferred to debt holders at conversion, e.g. for high conversion ratios, equity holders dislike high trigger levels since they make a conversion more likely. Whenever the wealth transfer is to the benefit of the equity holders, e.g. for low conversion ratios, the effect of the trigger level is ambiguous. Equity holders benefit from a higher likelihood of conversion, but higher trigger levels also reduce the benefit when conversion occurs.

4.4.1 Trigger level and risk-shifting

To analyze the impact of the trigger level on the risk-shifting incentives, we again first inspect the derivative of the equity value S with respect to the volatility σ. Rewriting equation (7) gives

$$\frac{\partial S}{\partial \sigma} = -\left(\gamma \cdot \frac{VC}{V} - \frac{D}{V}\right) \cdot \frac{r \cdot V}{1 - \theta}. \quad (10)$$

The wealth transfer to the debt holder, i.e. the term in brackets, is now expressed in percentage terms of the initial asset value V. To mitigate the risk-shifting incentives of the equity holders, the share of initial wealth $\gamma \cdot \frac{VC}{V}$, which is transferred to debt holders at conversion, has to exceed the leverage ratio $\frac{D}{V}$ of the bank. The wealth transferred to debt holders strictly increases with the trigger level VC. Hence, regulators should not only prefer high conversion ratios but also high trigger levels. In particular, the critical trigger level for the derivative to be negative increases with the leverage of the bank. Therefore, highly levered banks should issue CoCo bonds with higher trigger levels compared to banks with low debt ratios. The likelihood of conversion, which is factored into θ, impacts the magnitude of incentives, but not the direction.

In the following, we examine the role of the trigger level in more detail for a bank with a low conversion ratio of $\gamma = 0.25$ and a bank with a high conversion ratio of $\gamma = 0.75$. We again consider the asset substitution problem described in section 4.2. *Figure 4* shows the critical asset value change ΔV^* depending on the trigger level as percentage of initial assets, i.e. $\frac{VC}{V}$. The claims are priced such that the leverage ratio $\frac{D}{V}$ is constant.

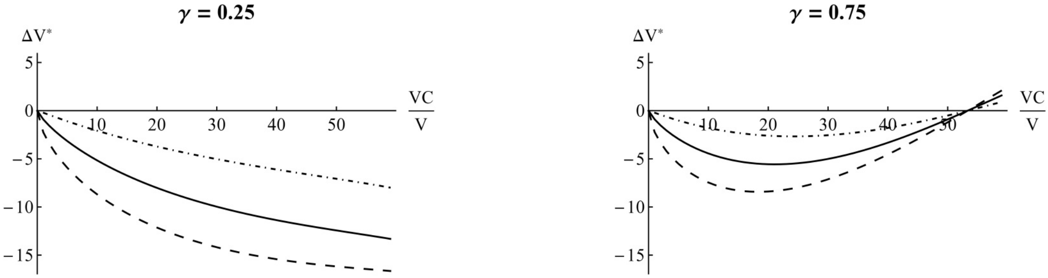

Figure 4: Asset substitution and trigger level (The plot shows the critical asset value change ΔV^* for a debt value $D = 40$ and two conversion ratios of $\gamma = 0.25$ (left) and $\gamma = 0.75$ (right). The critical asset value is plotted depending on the relative trigger level $\frac{VC}{V}$ for three opportunities to increase the asset risk from $\sigma_l = 0.25$ to $\sigma_h = 0.30$ (dot-dashed line), $\sigma_h = 0.35$ (solid line), $\sigma_h = 0.40$ (dashed line). The remaining parameters are $V = 100$ and $r = 0.05$)

We first analyze the asset substitution for the bank with the low conversion ratio of $\gamma = 0.25$, which is depicted on the left of *figure 4*. Consistent with our previous finding, the critical NPV is negative. It monotonously decreases with the trigger level. The low conversion ratio ensures that the wealth transfer remains to the benefit of the equity holders even when the trigger level increases. At the same time, the likelihood of conversion increases as well. In sum, a higher trigger level worsens the asset substitution problem.

We observe a different pattern for the bank with the high conversion ratio of $\gamma = 0.75$, which is pictured on the right of *figure 4*. For low trigger levels, equity holders still have the incentive to engage in asset substitution. The wealth transfer still benefits the equity holders and conversion is very unlikely. For high trigger levels, the critical asset value increases with the trigger level. It becomes positive for values of VC above $\frac{D}{\gamma}$, for which the wealth transfer changes to the benefit of the CoCo bond holders.

We conclude that the interaction between the two product parameters needs to be taken into account to mitigate the asset substitution problem. Both the conversion ratio and the trigger level should be sufficiently high, such that $\gamma \cdot \frac{VC}{V} > \frac{D}{V}$. In particular, the conversion ratio γ should be higher than the leverage ratio of the bank.

Given the product parameters are fixed, equity holders can potentially increase the leverage of the bank, which again could make asset substitution worthwhile. This could be prevented either by a covenant of the CoCo bond or by a regulatory restriction of the bank's leverage, as recently proposed by the Dodd-Frank Act in the US.

4.4.2 Trigger level and loan granting

We have shown in section 4.3 that the loan granting incentives also depend on the wealth transfer associated with the CoCo bond. We again consider the critical required return y^* of a new investment. When this critical return is positive, banks are rejecting some positive NPV projects which offer a lower return than y^*. This is what we call a credit crunch situation. *Figure 5* shows the critical required return for conversion ratios of $\gamma = 0.25$ and $\gamma = 0.75$.

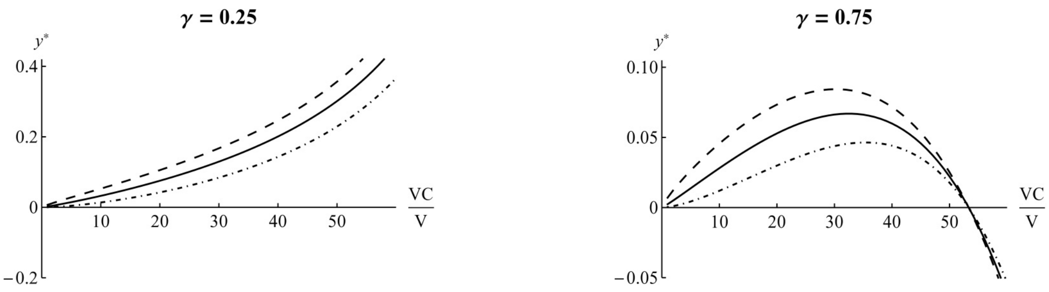

Figure 5: Loan granting and trigger level (The plot shows the required critical return y^* for a debt value $D = 40$ and two conversion ratios of $\gamma = 0.25$ (left) and $\gamma = 0.75$ (right). The critical return is plotted depending on the relative trigger level $\frac{VC}{V}$ for three different volatility levels of $\sigma = 0.20$ (dot-dashed line), $\sigma = 0.25$ (solid line), $\sigma = 0.30$ (dashed line). The remaining parameters are $V = 100$ and $r = 0.05$)

In the low conversion rate scenario, which is depicted on the left of *figure 5*, the credit crunch problem always occurs and worsens with an increase in the trigger level. The critical return increases monotonously with the trigger level. Equity holders always benefit from conversion. The likelihood of conversion increases with the trigger level, which equity holders like. Hence, they are not willing to grow the balance sheet of the bank, which would increase the distance to the trigger level. When an investment is undertaken, equity holders demand high returns to be compensated for the lower likelihood of conversion.

We again observe a different pattern for the high conversion rate scenario, which is depicted on the right of *figure 5*. The credit crunch still occurs for low conversion ratios, since the wealth transfer is to the benefit of the equity holders. With an increase of the trigger level, the likelihood of conversion increases, which equity holders like. Hence, the critical return increases with the trigger level. But at the same time, an increase in the trigger level reduces the wealth transfer, which causes the critical return to decline when the trigger level is further increased. For trigger levels above $\frac{D}{\gamma}$, the wealth transfer switches over to the benefit of debt holders. In this case, the equity holders dislike conversion and prefer to grow the balance sheet of the bank to avoid it, which mitigates the credit crunch problem.

From a social planner's perspective, it is desirable that positive NPV projects are always financed. Hence, the social planner should design the CoCo bond such that the associated wealth transfer is equal to zero, i.e. $\gamma \cdot VC = \frac{c}{r}$. This mitigates the credit crunch problem, but also ensures that negative NPV projects are not undertaken. We have also shown in the previous section that the asset substitution problem does not occur when there is no wealth transfer at conversion.

5. Conclusion

The financial crisis emerging in 2008 illustrated the need for a more stable banking system and gave rise to the idea of contingent convertible debt. These novel financing instruments seem to be a universal remedy at first glance, since they prevent bankruptcy and keep banks alive in times of financial crisis. However, only few CoCo bonds have been issued so far. We review the literature on CoCo bonds and explore different rationales why banks might be reluctant to issue CoCo bonds. First, shareholders might want to avoid risk-shifting incentives for managers. Second, we have shown that it might not be optimal for banks to issue CoCo bonds in good times even though they help to mitigate a credit crunch in bad times. Finally, shareholders might want to avoid situations in which claim holders have an incentive to manipulate the share price of the bank to enforce or prevent a conversion.

We also observe that the more recent issues of CoCo bonds are total-loss bonds, i.e. they had a conversion ratio of zero. We introduce a simple continuous-time framework to investigate why banks prefer this particular CoCo bond design. In specific, we look at the choice of the conversion ratio and the trigger level as well as the interaction between these two. We find that whenever there is a wealth transfer at conversion to the benefit of the equity holders, e.g. when the conversion ratio is very low, the equity holders have an incentive to engage in risk-shifting behavior. We conclude that the CoCo bonds might have been issued for this purpose in the first place, since they are a good tool to eliminate the downside risk for the bank. We show that CoCo bonds which are designed to have a wealth transfer to equity holders at conversion also cause a reduction of credit supply, since the bank is not willing to finance all positive NPV projects.

We finally discuss the regulatory implications regarding the design of CoCo bonds. We find that a regulator, who is concerned with risk-shifting and who wants to prevent credit crunches, should advocate a CoCo bond design which ensures a punitive or no wealth transfer at conversion. This implies that the conversion ratio as well as the trigger level should be sufficiently high. In addition, the leverage of the bank needs to be taken into account. The conversion feature should be designed stricter for banks with high leverage ratios. These findings are especially relevant for regulators, who plan to oblige banks to issue CoCo bonds. Recent examples from Switzerland suggest that banks facing a mandatory introduction are choosing the product parameters to their advantage. Hence, mandatory introduction rules should also prescribe the specific product design to make the CoCo bonds work.

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Marc Crummenerl, Dipl.-Kfm., is research fellow at the Department of Finance at the University of Tübingen.

Address: University of Tübingen, Department of Finance, Nauklerstraße 47, 72074 Tübingen, Phone: +49 (0)7071/29-78176, e-mail: marc.crummenerl@uni-tuebingen.de

Christian Koziol, Prof. Dr., is head of the Department of Finance at the University of Tübingen.

Address: University of Tübingen, Department of Finance, Nauklerstraße 47, 72074 Tübingen, Phone: +49 (0)7071/29-78158, e-mail: christian.koziol@uni-tuebingen.de

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