Instabilities of two-layered CoCo capital structures

Working paper

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Abstract

In this paper we develop a theoretical model of bank runs, using cash-in-the-market pricing, to analyze the effects of different layers of CoCo debt. Contingent Convertible Bonds (CoCos) are promoted by regulators as a bail-in mechanism in times of distress. CoCo debt is debt which converts into equity or is written down at pre-specified trigger levels which indicate a bad state of the bank. Basel III imposes a minimum requirement for the trigger level (low trigger). Only a few large banks world-wide hold both high (above minimum requirement) and low trigger going concern CoCos on their balance sheet, either by choice or by regulation. We analyze the effects of CoCo conversion for banks with a two-layer CoCo capital structure. We find that this structure can be detrimental for the bank's financial health, due to premature conversion and runs on equity. We argue that initial capital structure matters for the range of inefficient conversion, and provide an argument against market-based triggers. In contrast with existing literature, we show that book-based trigger CoCos can provide a first best outcome, as long as they incorporate expected credit losses. Our main insights can be generalized to any event with a strong informational value, not only to a high trigger CoCo conversion.

Keywords: contingent convertible bonds, capital structure, bank runs, policy
JEL Classification: G21, G32, G38

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Legend

$\theta \sim Unif[0,1]$ – value of fundamentals, uniformly distributed between 0 and 1

$\theta_i \in Unif[\theta - \varepsilon, \theta + \varepsilon]$ – noisy signal at $t = 1$ of market participant $i \in \{1, 2, ..., n\}$

B – face value of senior debt

τ_H – trigger level of high trigger CoCos

C_H – face value of high trigger CoCos

τ_L – trigger level of low trigger CoCos

C_L – face value of low trigger CoCos

$I = 1$ – initial investment in risky assets

e_t^m – market value of equity evaluated at $t = \{, 0, 1, 2\}$

e_t^b – book value of equity evaluated at $t = \{0, 1, 2\}$

$f_R(\theta),\ F_R(\theta)$ – probability distribution function (pdf), and cumulative distribution function of returns on risky asset; Expected returns R

$f_{R_L}(\theta)$ – pdf after shock to assets; Expected returns $R_L < R$

$l < 1$ – early liquidation value of long term asset per unit of investment at $t = \{0, 1\}$

β_t – fraction of assets that the bank decides to liquidate at $t = \{0, 1\}$

c – cash stored ex-ante by risk neutral investors

e_{-1} – wealth invested ex-ante by risk neutral investors in bank equity

W – total wealth of investors ex-ante

P_t^m – market clearing price per share at time t

n_{max} – total number of shares in the market at $t = 1$

$\lambda(\theta)$ – proportion of investors which face a liquidity shock at $t = 1$

$\lambda_1(\theta)$ – proportion of investors which are not hit by the liquidity shock, but still sell equity at $t = 1$

CET_t – core equity to risk weighted assets ratio evaluated at time t

1 Introduction

In 2013, the Swiss National Bank (SNB) imposed additional requirements on bank capitalization for Systemically Important Financial Institutions (SIFIs) on top of the Basel III regulation. Besides increased minimum levels of capitalization, a distinct element of Basel III, as compared to regulations in the past, is the introduction of Contingent Convertible bonds (CoCos). This security is meant to act as a bail-in mechanism for banks in times of distress: it acts as a bond, but either converts immediately into equity or is (partially) written down if the bank reaches, or is below, a pre-specified threshold which signals a poor financial state of the issuing body.

A key feature of CoCos is the conversion threshold. The minimum level imposed by Basel III is a trigger level of 5.125% of core equity as percentage of risk weighted assets. The Swiss National Bank required a higher capitalization level of going-concern CoCos and unlike Basel III, a higher minimum trigger level (7%) for systemically important institutions. A going-concern CoCo will help recapitalise the bank when the bank it is still solvent[1]. The CoCo initial public offerings (IPOs) of the two SIFI Swiss banks – Credit Suisse AG and UBS AG – indicate that the banks still work towards filling in the minimum requirements on high trigger CoCos, but they still hold, or even issue, new low trigger CoCos on their balance sheet. At the same time, few other world-wide major banks issue at least two different going concern CoCo layers on the same balance sheet, without having to fulfill a regulatory requirement on it[2] . We will further refer to the minimum conversion requirement (5.125%) as a low trigger, and to the higher one (7%) as a high trigger.

The novelty of a bank having two different going-concern CoCos layers in matter of trigger level in the capital structure has not yet been discussed in the literature. Nonetheless, it has already been incorporated in the European Banking Authority report (EBAReport, 2016) [3].

To the best of our knowledge, this paper is the first theoretical work to analyze

[1]The going concern CoCos are part of Additional Tier 1 capital. In contrast, the gone-concern CoCos convert when the bank is already bankrupt.

[2]To the best of our knowledge, as of March 2018, the banks which hold both high and low trigger AT1 European CoCos are: HSBC Holdings Plc., Raiffeisen Group Switzerland, Credit Suisse AG, UBS AG, Swedebank, Nordea Bank, UniCredit S.p.A., Banco de Sabadell SA, Banco Santander.

[3] The report stipulates the possibility that both CoCos are hit simultaneously.The sequencing is as follows: " losses corresponding to the amount required to go back to 5.125% should be absorbed by both the low trigger and the high trigger instruments on a pro rata basis. Losses above 5.125% will only be supported by the high trigger instrument" (Art. 96).

the effects of CoCo conversion for banks with this type of multiple buffer CoCo strategy. We show how a two-layered CoCo capital structure with market based triggers leads to multiplicity of equilibria, no equilibrium or a unique (inefficient) equilibrium for CoCo conversion in times of distress. For that we use market reactions to unexpected shocks to the economy, limited cash in the market (Allen and Gale, 1994), and noisy information in a global games framework (Goldstein and Pauzner, 2005). We further compare the optimality of different types of CoCo designs and show which one minimizes the inefficient conversion space. By 'inefficient' we mean that conversion occurs above the intrinsic conversion threshold.

The results are driven firstly by the bank's decision in times of distress. We model the bank's choices as a constrained maximisation problem. The bank maximizes the value of equity while maintaining a minimum level of equity to assets ratio. The trade-off is between asset substitution, in the form of costly early liquidation of assets, and recapitalizing through CoCo debt conversion. In order to maintain a particular equity to assets ratio, the bank in our model can either increase their equity base or decrease their asset side. Empirical evidence indicates that shrinking the balance sheet through asset liquidation is commonly done (Association for Financial Markets in Europe, 2016). Moreover, in times of distress equity is expensive to issue.

We model the high trigger conversion as providing a strong signal to the market that the bank is in a fragile state, which is in line with existing literature (Chan and van Wijnbergen, 2017). Equity holders are affected by initial CoCo issuance and later on by asset pricing volatility due to the news impact that CoCos can create. Another key friction that drives our results is that the signaling value of CoCos can create a downward spiral on equity. Insofar, the focus in the literature has been placed on depositor bank runs (Chan and van Wijnbergen, 2015). Fire sales in the banking system are usually done on the asset side (Diamond and Rajan, 2011; Acharya et al., 2009), but we argue that negative signals in the market can lead to fire sales of equity as well.

Lastly, we introduce cash-in-the-market pricing in the CoCos literature: in times of distress there is not enough cash available in the market which in turn will depress the market prices of equity. This, combined with the strong informational value of CoCo conversion amplifies our results. The noisy information about the state of the economy pin down the market equilibrium.

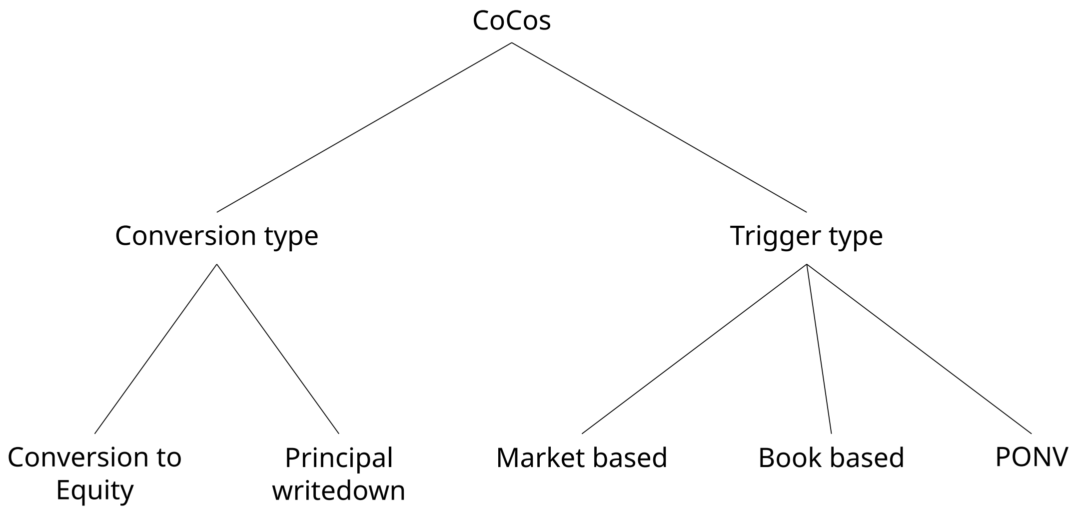
We find that market based triggers, even though very popular in academic literature, may harm the issuing bank. This happens either directly, through inefficient conversion of CoCos, or indirectly through an artificial speculative attack to force conversion by equity holders. We show that two CoCo layers on the same balance sheet is detrimental to the financial health of the bank, as the second (low trigger) CoCo may not act as an additional buffer. Instead, the high trigger CoCo can create a negative externality of low CoCo conversion as well through the equity holders reaction. In contrast, we argue that book based triggers can be a effective bail-in mechanisms as long as the value of assets is evaluated accurately by the issuing bank, and it incorporates expected losses. If the accounting value only accounts for occurred losses, as it is currently stipulated in the International Financial Reporting Standards (IFRS), then going concern CoCos do not fulfill any function on loss absorbing capacities before it is too late.

The paper is structured as follows. First, we present a brief literature review on the definition of a CoCo and how this paper is embedded in the existent literature. In section 2 we define the baseline model and economy. In section 3 we analyze market based triggers, which we further distinguish in positive or negative wealth transfer to shareholders, and solve for the unique equilibrium using a backward-induction solution concept. In section 4 we focus on book value triggers, which we separate according to their measure of risk weighted assets. Lastly, a comparison between the four cases follows in the discussion and conclusion section, where we present policy implications. In the appendix there are additional proofs and numerical results not contained in the main body, and interpretations of a few natural extensions of the paper.

1.1 Related literature

Contingent Convertible bonds have two key characteristics: the trigger which determines the conversion, and the type of conversion they will incur. A summary can be found in Figure 1. The loss absorption mechanism can be either conversion to equity (CE hereafter) or a principal write-down (PWD hereafter). To generalize, let the conversion rate be $\psi \in [0, \infty)$, per unit of CoCo, with conversion price $\frac{1}{\psi}$(Chan and van Wijnbergen, 2017). The PWD CoCos are a limiting case, with conversion rate $\psi = 0$.

Figure 1



The trigger can be mechanical and/or discretionary. The discretionary trigger is activated at the point of non-viability of a bank (PONV). This feature allows the supervisor to force conversion if it considers it as a necessary step in preventing insolvency[4]. The mechanical trigger imposes conversion at a pre-specified ratio of core capital to risk weighted assets (RWA). The key distinction between market and book based triggers is in measuring the value of core capital and RWA. Book value can be effective in terms of timely recapitalization if it is measured correctly, and at a high frequency, while market value could capture inconsistent accounting valuations. We understand by correct measurement an accurate evaluation of asset value, which incorporates tail-risk events.

Under Basel III, CoCos can qualify as Additional Tier 1 (AT1 hereafter) or Tier 2 (T2) capital. To qualify as AT1 under European Law, the CoCos need to, among others: have a PONV clause, absorb losses on a going-concern basis, be perpetual

[4]Effects of conversion on equity holders or market prices are unclear, as the very first conversion happened only in June 2017 at Banco Popular, a Spanish bank which was taken over by Santander (Smith, 2017). The decision of a full writedown was made under PONV and imposed by the Single Resolution Board, part of the EU Banking Union. Financial Times argued that the conversion had little spillovers in the market, and some CoCo holders already accused the authority of lack of transparency and valuation of the resolution (Beardsworth, 2017). In this paper we abstract from a PONV clause, and do not model its additional effects on conversion prices.

instruments and have a minimum trigger level of 5.125% of Core equity tier 1 (CET1) to RWA. Countries can stipulate additional conditions to the European Law minimum requirements. For instance, Denmark and UK imposed a minimum trigger level of 7% for AT1 instruments. The Swiss national supervisors request at least 6 percent of 'low-trigger' AT1 or T2 CoCos and an additional 4.3 percent of 'high-trigger' AT1 CoCos (Swiss Financial Market Supervisory Authority, 2015). Tier 2 CoCos and further regulatory requirements are beyond the scope of this paper, but a more comprehensive analysis can be found in Avdjiev et al. (2013), Avdijev et al. (2017) and Kiewiet et al. (2017).

The dominant views on the CoCo issuance are either for meeting regulatory requirements (Avdjiev et al., 2013) or emerging as an optimal capital structure of a bank for risk shifting incentives. Our paper belongs to the former strain, where banks issue them only to meet regulatory requirements, and have additional bail-in buffers.

We show how CoCo design matters when a bank has to comply with regulatory requirements on an equity ratio, as it is currently stipulated in the Basel III regulations. To that end, we model decisions that are taken in industry, but have not yet been accounted for in the CoCos literature. We incorporate the pro-cyclicality of limited cash with returns on assets, and assess how this co-movement affects equity. The focus in the literature has been on depositor runs (see Chan and van Wijnbergen (2015)), managerial risk shifting incentives (see Glasserman and Nouri (2012), Zeng (2014), Martynova and Perotti (2015) and Chan and van Wijnbergen (2017)). The closest models to our framework are the ones by Avdijev et al. (2017) and Chan and van Wijnbergen (2015).

If market participants have noisy information about the true state of nature, methodologies on self-fulfilling crisis use global strategic complementarities or adverse selection (impatient and patient agents with need to withdraw) (Morris and Shin, 1998; Diamond and Dybvig, 1983; Goldstein and Pauzner, 2005). We employ the bank-run methodology of Goldstein and Pauzner (2005) to prove uniqueness of the inefficient equilibrium, below which crises are self-fulfilling. A similar approach based on global games has been done by Chan and van Wijnbergen (2015) on depositor runs, but our focus is on equity. To the best of our knowledge, we are the first to introduce limited cash availability in the market in a CoCos model. We exemplify the impact of market liquidity on pricing stocks using the liquidity shocks from the seminal paper of Allen and Gale (1994).

The existent debate in the literature on trigger levels focuses almost exclusively on market based triggers. Glasserman and Nouri (2012) and Derksen et al. (2018) develop valuation models in continuous time for CoCos based on book value. Nonetheless, in industry all financial institutions have a book-based trigger. In Europe market based triggers are outlawed by the Capital Requirements Regulation (CRR). The downward equity spiral aspect was previously modeled in continuous time by Sundaresan and Wang (2015). They argue against regulation which uses a CoCo trigger based on market value, because it can create instability in the market and lead to multiplicity of equillibria in pricing the assets. Their multiple equillibria were obtained using discrete time, and were further ruled out in continuous time (Glassserman and Nouri, 2016). Albul et al. (2015) find closed form solutions of CoCo prices in continuous time of optimal capital structure when market trigger CoCos are a choice variable. Their objective function is maximizing equity value, and show how different structures affect leverage, bankruptcy costs and tax benefits.

2 Setup

The model has three periods $t = \{0,\ 1,\ 2\}$, a bank, three types of agents: private investors, passive bank debt holders,a bank manager, and two main frictions: cash in the market pricing of equity and an unexpected shock to asset returns. The economy is described by its fundamentals $\theta \in [0, 1]$, where a low value of θ indicates a bad state of the world. The true $\theta \sim Unif[0, 1]$ is realized at $t = 1$, but each market participant $i \in \{1, 2, 3, ..., n\}$ only obtains then noisy information about its value, drawn from a uniform distribution $\theta_i \in Unif[\theta - \varepsilon, \theta + \varepsilon]$. We denote the noisy signal obtained by the bank manager with θ_B drawn from the same distribution. We write the expected value of X at time t as conditional expectation on time: $E[X|t]$ throughout the paper.

2.1 Bank structure

We assume an exogenous bank capital structure, in place before $t = 0$. This ex-ante moment we denote by t = -1. Liabilities [5] on the balance sheet are: senior debt with face value B, CoCos with a high trigger level τ_H with face value C_H, and

[5] We assume throughout deposit insurance, and so we do not consider depositor runs. We abstract from this matter by completely excluding demandable debt in the capital structure of the bank.

conversion rate ψ_H, low trigger CoCos with value C_L, and conversion rate ψ_L and equity e_{-1} - see Table 1. The bank invests ex-ante an amount I in a risky asset with expected returns $R > I$ at $t = 2$. We normalize I to 1. Ex-ante the bank raised equity $e_{-1} = I - B - C_H - C_L$. Further, let e_t^m denote the market value of equity evaluated at $t = \{0, 1, 2\}$, and e_t^b the corresponding book value at time t. We assume that the bank does not hold any cash ex-ante [6]. The returns on the

Table 1

Financial structure ex-ante	
Assets	**Liabilities**
I	B Senior debt C_L Low trigger CoCos C_H High trigger CoCos e_{-1} Equity

long term risky asset have a general probability distribution function $f_R(\theta)$, with a cumulative distribution function $F_R(\theta)$[7]. Investing $I = 1$ ex-ante has expected value: $E[I|t = -1] = \int_{\theta=0}^{\theta=1} I\theta f_R(\theta)d\theta = R > 1$.The long term risky asset can be liquidated early at $t = 0$ or $t = 1$. The costly liquidation value per unit of investment is $l < 1$. Additionally, there is a roll-over short term risk-less asset (cash), with no excess returns. At $t = 0$ there is an unexpected shock to assets, which decreases the expected value of returns to the risky asset from R to R_L. We model this as a probability zero shock (not taken into account earlier) to the pdf of returns of the long term asset from $f_R(\theta)$ to $f_{R_L}(\theta)$: $E[I|t = 0 \wedge R_L] = R_L < R$. The bank manager is privately informed on the size of the shock on long term assets, and incorporates the new information in the value of risk weighted assets before any other agent can take a decision [8].

2.2 Agents and information structure

There are three types agents of in the economy. There is a unit mass risk-neutral investors with wealth $W = c + e_{-1}$ divided ex-ante between cash c and equity e_{-1}.

[6] We solved the model with cash on the balance sheet of the bank, but the main results remain the same.

[7] For the purpose of this setup the shape of the distribution function does not affect the results.

[8] We assume that the bank has incentives to reveal truthfully, as otherwise it faces large sanctions once the regulator finds out for instance.

They are the only ones to hold bank equity. Fraction $\lambda(\theta) \in [0,1]$ is hit by a liquidity shock at $t = 1$. These investors know ex-ante the existence of the idiosyncratic shock, but they do not know the magnitude (as it is dependent on yet unknown θ), and they cannot infer the true θ from the shock realization. The investor decisions to sell or buy bank equity at the intermediate stage will determine market equilibrium share prices. Secondly, there is a bank manager with no initial wealth, which has as purpose to maximize share value while meeting regulatory requirements of the bank at $t = \{0, 1\}$. In case of need, the bank manager's choice is between costly early liquidation of risky assets or CoCo conversion. The third type of agents are passive bond holders, which hold debt in the bank either in the form of senior debt or Contingent Convertible Bonds. They do not play an active role in the subsequent analysis, as their behavior on the secondary market does not influence equilibrium outcomes in this setting.

The value of fundamentals affect the long term risky asset returns at $t = 2$, and the size of the idiosyncratic shock which affects part of the investors at $t = 1$.

To summarize, there are two exogenous signals in the economy. At $t = 0$ there is a probability zero shock (not accounted for in the initial bank market valuation) to the distribution of returns to the long term asset, which is only observed by the manager. Other market participants can only observe it through the reported value of risk weighted assets. The second signal is represented by the noisy information about θ at $t = 1$. Moreover, at $t = 1$ all agents know that each agent observes a signal at most ε away from the true state. The shock to assets and the state of the fundamentals are uncorrelated.

2.3 Market clearing and cash in the market

P_t^m is the market clearing price per share at time t, and n_{max} is the total number of shares in the market, and is defined as

$$n_{max} = \begin{cases} 1 & \text{if no conversion} \\ 1 + \psi_H C_H & \text{if only } C_H \text{ converts} \\ 1 + \psi_H C_H + \psi_L C_L & \text{if both } C_L, C_H \text{ convert} \end{cases} \quad (1)$$

At $t = 0$, the bank manager observes the shock in distribution to the asset side. He incorporates it in the value of risk weighted assets. As there is too little information about the state of the world - θ is unknown, and none of the investors is hit by a shock yet, we assume that equity is traded at fundamental value.

At $t = 1$ the market clearing price of shares is endogenously determined by the cash availability in the market, and by how many investors sell. This setup of cash in the market pricing is based on Allen and Gale (1994). Proportion $\lambda(\theta)$ of initial investors face at $t = 1$ a liquidity shock, and they have to consume. The function $\lambda(\theta) : [0, 1] \to [0, 1]$ is continuous and monotonically decreasing in θ. This captures that more investors require liquidity as the economic state worsens. All investors hit by the shock sell their stake in the bank, regardless of the market price. There are investors which are not hit by the liquidity shock, but they still decide to sell equity at $t = 1$. They amount to $\lambda_1(\theta) < 1 - \lambda(\theta)$. In equilibrium, $\lambda_1(\theta)$ is endogenously determined and depends on the expected returns at $t = 2$, market price at $t = 1$ and the noisy signal of θ. Thus, there are three types of investors at $t = 1$: $\lambda(\theta)$ of early investors who are hit by a shock and have to sell, $\lambda_1(\theta)$ late investors who are not hit by a shock but still decide to sell (panicked agents), and $1 - \lambda(\theta) - \lambda_1(\theta)$ who are not hit by a shock and do not sell, but instead buy all the equity in the market. The available cash in the market is determined by the late investors which wait for dividend payments: $[1 - \lambda_1(\theta) - \lambda(\theta)]c$. Their preference of buying equity is trivially satisfied, as in case the equity sells at fundamental value they are indifferent, and if it sells at a depressed price then they are better off buying, given their beliefs. Market clearing condition at $t = 1$ must satisfy:

$$P_t^m(\theta) \cdot [\lambda(\theta) + \lambda_1(\theta)]e_{-1} \leq [1 - \lambda(\theta) - \lambda_1(\theta)]c \tag{2}$$

The price per share P_t^m multiplied with all the shares sold in the market must be lower then or equal to the available cash in the market.

Corollary 1. *At $t = 1$, the market clearing price in the stock market is:*

$$P_1^m(\lambda(\theta), \lambda_1(\theta)) = \min\Big[\frac{e_1^b}{n_{max}}, \frac{[1 - \lambda(\theta) - \lambda_1(\theta)]c}{[\lambda(\theta) + \lambda_1(\theta)]e_{-1} \cdot n_{max}}\Big] \tag{3}$$

where n_{max} is the number of shares in the market at $t = 0$, and e_1^b represents the book (intrinsic) value of equity at $t = 1$.

We can interpret this condition as: shares are either traded at fundamental value, or below it.

2.4 Regulatory requirements

The bank has to satisfy at all times a regulatory requirement of having a core equity to risk weighted assets ratio $CET_t = E[\frac{\text{value of equity}}{\text{risk weighted assets}}|t]$ above a fixed threshold τ_L. More generally, we can define the CET ratio at time t as

$$CET_t = \frac{e_t^{b/m}}{E[I|t]} \tag{4}$$

where e_t can be either the expected book value of equity e_t^b, defined as expected returns minus liabilities, or as the market value of equity where $e_t^m = P_t^m \cdot n_{max}$, depending on the CoCo structure as we will explain in the next paragraph. In case of distress, the ratio can be maintained either by costly liquidation of long term assets, or by letting CoCo conversion take place. The other alternative is issuing new equity, but we argue that this is the least appealing for the bank in times of crisis, due to underpricing and dilution of existing shareholders.

The trigger level $0 < \tau_L < \tau_H < 1$ of CoCos is evaluated at CET_t, either market or book based. There are two variables which determine the correspondence of CET to the trigger level: the size of the shock R_L, and the state of the fundamentals θ.

At $t = 0$, the ratio is $CET_0(\theta|R_L \wedge t = 0) = \frac{e_0^b}{\int_{\theta=0}^{\theta=1} If_{R_L}(\theta)\theta d\theta}$. We simplify our analysis, and keep the shock size fixed, such that $\tau_L < CET_0(\theta|R_L \wedge t = 0) < \tau_H$: in other words, such that the ratio falls below the high trigger, but still above the low trigger threshold. We denote by $\theta_H \in (0,1)$ the corresponding values of fundamentals such that conditional on a high CoCo initial conversion, at $t = 1$ is:
$CET_1(\theta_H|R_L) = \frac{e_1^b}{\int_{\theta-\varepsilon}^{\theta+\varepsilon} If_{R_L}(\theta)\theta d\theta} = \tau_L$.

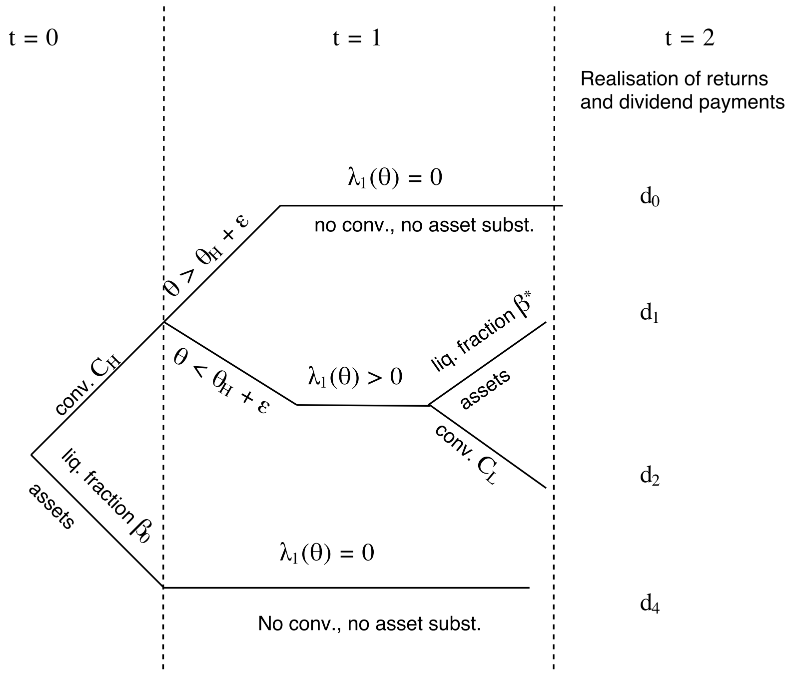
2.5 Timeline summary

The decision of the bank manager is summarized in Figure 2, and a summary of the timeline is displayed in Figure 3. Ex-ante, the bank raises funds, and investors allocate their portfolio $W = c + e_{-1}$.

At $t = 0$ the probability distribution of long term assets faces a probability zero shock observed only by the bank, which decreases expected value of returns with

Figure 2

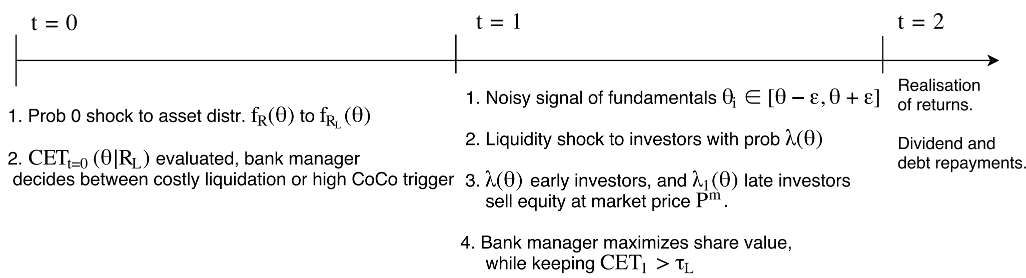
Decision tree for bank manager



$\Delta_R = R - R_L$. Further, the bank incorporates this information in its CET evaluation, which book based becomes: $CET_0 = \frac{\int_{\theta=0}^{\theta=1} I f_{R_L}(\theta)\theta d\theta - B - C_L - C_H}{\int_{\theta=0}^{\theta=1} I f_{R_L}(\theta)\theta d\theta} < \tau_H$. The bank must maximize expected share value while re-establishing the CET ratio either by asset substitution or high CoCo conversion. The trade-off is between lower returns at $t = 2$ versus possible runs on equity at $t = 1$, seen through a positive value of $\lambda_1(\theta)$. CoCo conversion signals to the market that returns are lower than initially expected which influence the behaviour of equity holders at $t = 1$.

At $t = 1$, the true state of the fundamentals θ is realized. Each investor $i \in \{1, 2, ...n\}$ and the bank B obtain noisy signals $\theta_i = \theta + \varepsilon_i \in [\theta - \varepsilon, \theta + \varepsilon]$, where ε_i is drawn from a uniform distribution $Unif[-\varepsilon, \varepsilon]$. Investors $\lambda(\theta)$ hit by a shock sell their equity. The consumption decision of the late investors depends on the market price of equity today versus the expected dividend payments of tomorrow, which depend on conversion, own signal θ_i, and how many other market participants sell at $t = 1$. This framework which will further drive our cash-in-the-market pricing results is based on the seminal work of Allen and Gale (1994). After the markets clear, and the price of equity is determined, the bank manager re-evaluates the CET_1 ratio, and

Figure 3: Timeline



has as purpose to maximize share value, while maintaining $CET_1 \geq \tau_L$ as before. Without loss of generality, we can assume that there is limited cash in the market for $\theta < \theta_H + \varepsilon$.

At $t = 2$ returns on the long term asset are realized and debt and dividend payments are made.

3 Equilibrium analysis

We solve for equilibrium using backward induction, and derive the optimal strategy of the bank manager at $t = (0, 1)$, and of late investors $\lambda_1^*(\theta)$. Our aim is to analyze the optimal decision at $t = 0$ from Figure 2. To do so, we start calculating the equilibrium outcome of each decision branch at $t = 1$. We begin with the market based CoCos in section 3.1, followed by the book based case in 3.2.

3.1 Market based trigger

Decision at $t = 1$

In the market based trigger case, CET_1 is evaluated in the market. Once the equilibrium price $P_1^m(\lambda(\theta), \lambda_1(\theta))$ is determined on the market, the bank manager best response is:

$$\max_{\beta_1,\mathbb{1}_c} \frac{e_1^b}{n_{max}} = \frac{(1-\mathbb{1}_c\beta_1)E[I|t=1\wedge R_L]+\mathbb{1}_c\beta_1 l-\mathbb{1}_c C_L-B}{n_{max}} \quad \text{s.t.} \tag{5}$$

$$CET_1(\theta) = \frac{P_1^m(\lambda(\theta),\lambda_1(\theta))\cdot n_{max}}{(1-\mathbb{1}_c\beta_1)E[I|t=1\wedge R_L]} \geq \tau_L \tag{6}$$

where $\beta_1 \in [0,1]$ is the liquidation fraction at $t=1$, $l<1$ liquidation value per unit of investment and

$$\mathbb{1}_c = \begin{cases} 0 & \text{if conversion of low CoCo} \\ 1 & \text{otherwise} \end{cases}$$

Liquidation is a form of asset substitution, which allows the bank to diminish the overall value of risk weighted assets, which in turn will increase the CET ratio. *Ceteris paribus*, we assume that the bank has a preference towards liquidating assets first, as it permits the low trigger CoCo buffer to be used in case of *force majeure* in the future. Another explanation for delaying conversion is high reputational costs for the bank.

For $E[I|t=1\wedge R_L]<l$ it can readily be seen that the value of equity is maximised if the bank liquidates all risky assets [9]. This is a corner solution which brings little insight and so we will not treat this case further.

If $E[I|t=1\wedge R_L]>l$, the value of equity is decreasing in the liquidation fraction β_1 and increasing in the value of fundamentals θ. Thus the overall costs of bank to maintain $CET_1 \geq \tau_L$ increase as $\lambda_1(\theta)$ increases, because the bank has to liquidate more of the long-term assets. The bank will maximize the value of equity by minimizing the fraction of risky assets that it has to liquidate. Conditional on liquidation, the share value will be maximized when the constraint will be minimized, and hence binding.

Proposition 1. *The bank's best response liquidation fraction of long term risky assets is given by*

$$\beta_1^*(\lambda(\theta),\lambda(\theta_1)) = 1-\frac{[1-\lambda(\theta)-\lambda_1(\theta)]\ c}{\tau_L[\lambda(\theta)+\lambda_1(\theta)]e_{-1}E[I|t=1\wedge R_L]} \tag{7}$$

The bank lets the low CoCos convert instead of liquidating long term assets if

[9] If the bank could further shift the distribution of returns, a moral hazard problem could arise as banks have incentives to 'gamble' and continue with their long term assets due to limited liability (see Martynova and Perotti (2015); Chan and van Wijnbergen (2017)).

$\lambda_1(\theta) \geq \lambda_1^*(\theta)$ sell their equity, where $\lambda_1^*(\theta) \in (0, 1-\lambda(\theta))$ is the bank's indifference point between converting and liquidating:

$$\lambda_1^*(\theta) = \frac{c(1-\lambda(\theta)) + \lambda(\theta)(A-1)e_{-1}\tau_L E[I|t=1 \wedge R_L]}{c - (A-1)e_{-1}\tau_L E[I|t=1 \wedge R_L]} \tag{8}$$

where $A = \frac{E[I|t=1 \wedge R_L]-C_L-B}{E[I|t=1 \wedge R_L]-l} - \frac{(E[I|t=1 \wedge R_L]-B)(1+\psi_H C_H)}{(E[I|t=1 \wedge R_L]-l)(1+\psi_H C_H+\psi_L C_L)}$.

The proof can be found in the appendix. Intuitively, the optimal $\lambda_1^*(\theta)$ depends on the initial capital structure, and dilution. There are three possible cases.

First, if the optimal threshold between conversion and liquidation $\lambda_1^*(\theta) < 0$, then liquidating all assets always yields a lower value than CoCo conversion. In this case, bank converts first and share value always increases if conversion occurs.

Secondly, the interior solution $\lambda_1^*(\theta) \in [0, 1-\lambda_1(\theta)]$ guarantees that the bank liquidates first, and converts if $\lambda_1(\theta) > \lambda_1^*(\theta)$. In this case, the trade-off between dilution and costly liquidation depends on market price of shares. After conversion, if the ratio still falls below τ_L bank manager liquidates

$$\beta_{1,C}^* = 1 - \frac{P_1^m(\lambda(\theta), \lambda_1(\theta))[1+\psi_H C_H + \psi_L C_L]}{\tau_L E[I|t=1 \wedge R_L]} \tag{9}$$

Otherwise, if $\lambda_1^*(\theta) > 1-\lambda(\theta)$, then liquidating all assets is always preferred to CoCo conversion. An interpretation could be that dilution is so large for shareholders, that conversion becomes a solution of last resort.

Let $\bar{\psi_L}$ be the "neutral conversion" at which there is a zero wealth transfer from low CoCo holders to equity holders (Chan and van Wijnbergen, 2017). For $\psi_L < \bar{\psi_L}$ shareholders benefit from conversion, and for $\psi_L > \bar{\psi_L}$ the wealth transfer from CoCo holders to equity is negative.

Corollary 2. *The neutral conversion, with a zero wealth transfer between low trigger CoCo holders to equity holders is*

$$\bar{\psi_L} = \frac{(\beta_1^* - \beta_{1,C}^*)(E[I|t=1 \wedge R_L] - l) - C_L \cdot (1+\psi_H C_H)}{C_L(1-\beta_1^*)E[I|t=1 \wedge R_L] + \beta_1^* l - C_L - B} \tag{10}$$

A derivation of the parameter can be found in the appendix.

Corollary 3. *If $\theta < \theta_H + \varepsilon$ and the long term risky assets face a negative shock $R_L < R$, then:*

(i) $\frac{\partial \beta_1^*}{\partial \psi_H} < 0$ *The higher the fraction of initial dilution, less liquidation is necessary at the optimum;*

(ii)$\frac{\partial \beta_1^*}{\partial c} < 0$ *More cash (less initial equity investment) there is in the market, less liquidation needed, as the equity is traded closer to its fundamental value;*

(iii) $\frac{\partial \beta_1^*}{\partial R_L} < 0$ *The smaller the shock to assets, less liquidation is necessary;*

(iv) $\frac{\partial \lambda_1^*}{\partial \psi_L} > 0$ *As the dilution fraction decreases, bank postpones conversion;*

(v) $\frac{\partial \lambda_1^*}{\partial \tau_L} < 0$ *The higher the minimum regulatory requirements, bank converts faster;*

(vi) $\frac{\partial \lambda_1^*}{\partial C_L}$

- *For* $\psi_L < \bar{\psi_L}$*:* $\frac{\partial \lambda_1^*}{\partial C_L} < 0$ *The larger the low CoCo layer, the bank manager converts faster;*

- *For* $\psi_L > \bar{\psi_L}$*, the bank manager waits longer for conversion;*

Proposition 2. *The bank's best response* $\beta_1^*(\lambda(\theta))$ *is an interior solution (defined as* $0 < \beta_1^*(\lambda_1(\theta)) < 1$ *and* $0 < \lambda_1^*(\theta) < 1 - \lambda(\theta)$ *), up to a maximum amount of cash in the market* $(1 - \lambda(\theta) - \lambda_1(\theta))c$*, and a maximum value of expected returns* $E[I|t = 1 \wedge R_L]$*.*

The proof and full solution can be found in the Appendix. Intuitively, if there is more cash available, equity will trade at fundamental value. Alternatively, if returns are high enough in expectation, there is no need to liquidate any assets to begin with.

3.1.1 Investor behavior at $t = 1$

The bank best responds to the decision of equity holders. If $\theta > \theta_H + \varepsilon$, the incentive compatibility constraint of equity holders to wait until $t = 2$ is always met, as the shares trade at fundamental price. The number of equity holders not hit by a liquidity shock that sell in equilibrium is $\lambda_1(\theta) = 0$.

If $\theta < \theta_L - \varepsilon$, equity holders will sell regardless of the beliefs about the behavior of other equity holders, because conversion is imminent and returns will be very low. Thus, in this region the fraction of late investors who sell is $\lambda_1(\theta) = 1 - \lambda(\theta)$. We build further on the methodology of Goldstein and Pauzner (2005) and we stay close to their notation.

In the intermediate region of fundamentals $\theta_L - \varepsilon < \theta < \theta_H + \varepsilon$, the expected payoffs for each share are summarized in Table 2,where $\beta_1^*,\ \beta_{1,C}^*$ are the bank's best response functions derived earlier.

Table 2: Waiting versus Selling for $\theta_L - \varepsilon < \theta < \theta_H + \varepsilon$

Sell in	$\lambda_1(\theta) < \lambda_1^*(\theta)$	$\lambda_1(\theta) \geq \lambda_1(\theta)^*$
t=1	$P_1^m(\lambda_1(\theta))$	$P_1^m(\lambda_1(\theta))$
t=2	$d_1 = \frac{(1-\beta_1^*)E[I\vert t=1\wedge R_L]+\beta_1^* l - C_L - B}{1+\psi_H C_H}$	$d_2 = \frac{(1-\beta_{1,C}^*)E[I\vert t=1\wedge R_L]+\beta_{1,C}^* l - B}{1+\psi_H C_H+\psi_L C_L}$

Following Goldstein and Pauzner (2005), we denote by $v(\lambda_1(\theta)) : (0, 1-\lambda(\theta)) \to \mathbf{R}$ the function that captures the value of waiting until $t = 2$ minus value of selling at $t = 1$ for equity holders:

$$v(\lambda_1(\theta)) = \begin{cases} \frac{(1-\beta_1^*)E[I|t=1\wedge R_L]+\beta_1^* l - C_L - B}{1+\psi_H C_H} - P_1^m(\lambda_1(\theta)) & \text{if } \lambda_1(\theta) < \lambda_1^*(\theta) \\ \frac{(1-\beta_{1,C}^*)E[I|t=1\wedge R_L]+\beta_{1,C}^* l - B}{1+\psi_H C_H+\psi_L C_L} - P_1^m(\lambda_1(\theta)) & \lambda_1(\theta) \geq \lambda_1^*(\theta) \end{cases} \tag{11}$$

The proofs of unique equilibrium in Morris and Shin (1998); Goldstein and Pauzner (2005) relate to how agents interact with each other. The decisions are global strategic complementarities if the incentive to take a specific action is monotonically increasing with the number of agents who take the same action (Goldstein and Pauzner, 2005). In contrast, strategic substitutes are when the action incentives of an agent are monotonically decreasing with the number of agents who take that decision.

Depending on the initial capital and CoCo design, there can be one, multiple or no indifference points in investor's value of waiting minus value of selling: $v(\lambda(\theta)) = 0$. More precisely, if $v(\lambda_1(\theta)) > 0\ \forall\ \lambda_1(\theta) \in [0, 1-\lambda(\theta)]$ then in equilibrium $\lambda_1(\theta) = 0$, as all late investors prefer to wait. Multiple equilibria arise if $\exists$ at least $\lambda_{11}(\theta), \lambda_{12}(\theta) \in [0, 1-\lambda(\theta)],\quad \lambda_{11}(\theta) \neq \lambda_{12}(\theta)$ such that $v(\lambda_{11}(\theta)) = v(\lambda_{12}(\theta)) = 0$. We guarantee a unique equilibrium if $\exists^* \lambda_1(\theta) \in (0, 1-\lambda(\theta))$ s.t. $v(\lambda_1(\theta)) = 0$. We further assume a capital structure that allows for a unique equilibrium. Our model does not allow for closed form solutions, so we are able to provide numerical solutions or confidence intervals which have only a single crossing in the Appendix.

Lemma 1. *For dilutive CoCos $\psi_L > \bar{\psi_L}$, the necessary and sufficient condition for* *late investor decisions to be* ***strategic complementarities*** *is that* $v(\lambda_1(\theta))$ *is piecewise monotonically decreasing on the intervals* $(0, \lambda_1^*(\theta))$ *and* $[\lambda_1^*(\theta), 1 - \lambda(\theta))$

We further proceed to derive the unique equilibrium threshold θ^* above which all agents with a signal $\theta_i > \theta^*$ decide to wait for payoff payments at $t = 2$ and sell if $\theta_i < \theta^*$.

Lower and upper dominance regions

Outside the intermediate region, there is a range of extremely good or extremely bad fundamentals, where the behavior of equity holders is independent on the others decision.

We guarantee that the *lower dominance region* is nonempty if $\theta_L > 2\varepsilon$. The lower bound for θ_L is established if even for the lowest possible returns today, the equity holder is not willing to wait for payoffs: $P^m(\theta_L) \geq d_2(\theta_L)$. The lowest possible market price is obtained if all equity holders sell: $\lambda_1(\theta) = 1 - \lambda(\theta)$. A complete proof can be found in the Appendix.

The condition for a non-empty lower dominance region is implicitly defined from the following inequality, which can be trivially solved for any monotonically increasing functional form of $F_{R_L}(.)$:

$$F(\theta_L - \varepsilon) - F(\theta_L + \varepsilon) = B > 0 \tag{12}$$

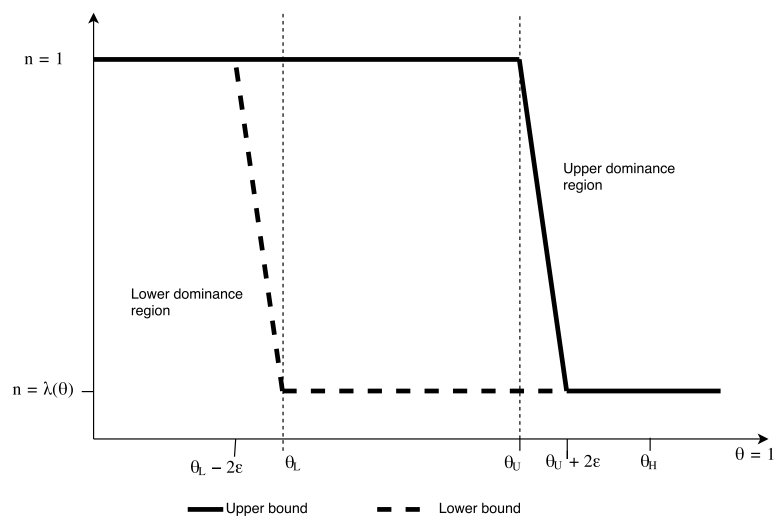
Let $\theta_U \leq \theta_H$ be the upper bound of fundamentals, above which the expected utility of waiting for residual payments is always at least as large as the expected utility of selling equity at $t = 1$, regardless of how many shares are traded in the market. This condition is trivially satisfied, due to our earlier assumption that for $\theta > \theta_H + \varepsilon$ shares trade at fundamental value, independent on how many shares are sold. In the upper dominance region $CET_1(\theta|R_L) \geq CET_1(\theta_H|R_L) > \tau_H$ fundamentals are strong enough that the bank will be able to pay back the debt without further asset substitution or conversion and the ones who bought equity at t=0 will make a positive profit at t=2.

Corollary 4. *A late investor always sells if she observes a signal* $\theta_i \leq \theta_L - \varepsilon$*. A late investor never sells at* $t = 1$ *if she observes a signal* $\theta_i \geq \theta_U + \varepsilon$*.*

When $\theta < \theta_L - 2\varepsilon$, all agents are guaranteed to obtain a signal $\theta_i < \theta_L - \varepsilon$, and thus all equity holders sell their shares at $t = 1$: $\lambda^*(\theta) = 1 - \lambda(\theta)$, independent on the actions of others. Symmetrically, for $\theta > \theta_H + 2\varepsilon$, all agents obtain a signal $\theta_i > \theta_H + \varepsilon$ and thus no equity holder sells at $t = 1$.

The distribution of ε is uniform over $[0, 1]$ and in the interval $[\theta_L - 2\varepsilon, \theta_L]$ the fraction of equity holders which observe signals below $\theta_L - \varepsilon$ decreases linearly at a rate of $\frac{1}{2\varepsilon}$[10] - see Figure 4. Similarly, in the region $[\theta_U, \theta_U + 2\varepsilon]$, the proportion of agents who receive signals $\theta_i > \theta_U + \varepsilon$ increases at rate $\frac{1}{2\varepsilon}$.Figure 4 follows the same format of Goldstein and Pauzner (2005). The solid line represents the upper bound from the upper dominance region: the maximum number of equity holders that sell. The dotted line denotes the lower bound of equity holders which sell. On the intervals $[0, \theta_L - 2\varepsilon]$ and $[\theta_U + 2\varepsilon, 1]$, the segments fully overlap.

Figure 4: Proportion of equity holders that sell



3.1.2 Unique equilibrium

Theorem 2. *Under single crossing conditions for $v(\lambda_1(\theta)) = 0$, there is a unique equilibrium θ^* below which a late investor with signal $\theta_i < \theta^*$ sells all her shares at $t = 1$, and otherwise waits for residual payments at $t = 2$.*

A sketch of the proof based on Goldstein and Pauzner (2005) is presented in the Appendix. Their proof uses the continuity property of $v(\lambda_1(\theta))$, which does not generally hold in our case. We can prove that the unique equilibrium exists if $v(\lambda_1(\theta)) = 0$ only once.

[10]Which is derived from the corresponding probability density function.

The equilibrium value θ^* is defined such that an equity holder with signal θ^* is indifferent between selling at $t = 1$ or waiting for dividend payments over all possible values of $\lambda_1(\theta^*)$. The threshold θ^* is implicitly defined from:

$$\int_{\lambda_1(\theta^*)=0}^{\lambda_1(\theta^*)=\lambda_1^*(\theta^*)} (d_1(\theta^*) - P_1^m(\lambda_1(\theta^*))d\lambda_1 + \int_{\lambda_1(\theta^*)=\lambda_1^*(\theta^*)}^{1-\lambda(\theta)} (d_2(\theta^*) - P_1^m(\lambda_1(\theta^*)))d\lambda_1 = 0 \tag{13}$$

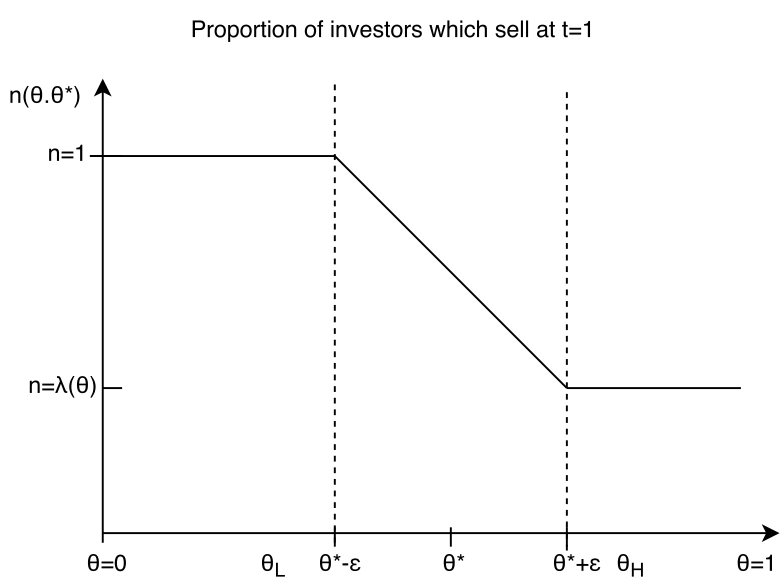
Corollary 5. *The proportion of total equity holders that sell, as a function of fundamentals is given by:*

$$n(\theta, \theta^*) = \begin{cases} 1 & \theta < \theta^* - \varepsilon \\ \lambda(\theta) + (1 - \lambda(\theta))\frac{\theta^* - \theta + \varepsilon}{2\varepsilon} & \theta^* - \varepsilon \le \theta \le \theta^* + \varepsilon \\ \lambda(\theta) & \theta > \theta^* + \varepsilon \end{cases} \tag{14}$$

Goldstein and Pauzner (2005) call the corresponding intermediate region from Figure 4: $\theta \in (\theta_L - 2\varepsilon, \theta_U + 2\varepsilon)$ as the panic based runs region. In our model this is the critical region which leads to multiple inefficiencies.

In case of uniformly distributed errors, the proportion of equity which sell in equilibrium is depicted in Figure 5.

Figure 5



if $\lambda_1(\theta)$ is high enough, the bank converts when in fact the fundamental value of $CET_1 > \tau_L$. This conversion is inefficient for CoCo holders, and the effect is ambiguous for equity holders. If dilution offsets the gains of conversion, then it has a negative effect for equity holders. Otherwise, if $\lambda_1(\theta) < \lambda_1^*(\theta)$ then it leads to inefficient liquidation which is harmful for existing equity holders.

If CoCos are non-dilutive $\psi_L < \bar{\psi_L}$, then the decisions to sell of late investors are **strategic substitutes**. In this case, the CoCos are not artificially triggered, as long as shareholders cannot sort sell their equity. The possibility of re-purchasing, combined with limited cash in the market pricing, CoCos with dilution $\psi_L < \bar{\psi_L}$ are not a good loss absorption mechanism, as it creates incentives for shareholders to force CoCo conversion by short-selling their equity. Note that an extreme case of non-dilution is given by principal writedown CoCos.

Proposition 3. *Under the assumption that equity holders cannot re-buy their shares and CoCos are non-dilutive $\psi_L < \bar{\psi_L}$, the threshold equilibrium θ^*_{nd} below which all equity holders sell is $\theta^*_{nd} = \theta_L - \varepsilon$. The number of equity holders who sell as a function of fundamentals is:*

$$n_{nd}(\theta, \theta^*) = \begin{cases} 1 & \theta \leq \theta^* - \varepsilon \\ \frac{\theta^* - \theta + \varepsilon}{2\varepsilon} & \theta^* - \varepsilon < \theta < \theta^* + \varepsilon \\ 0 & \theta > \theta^* + \varepsilon \end{cases} \tag{15}$$

To summarize, in case of high CoCo conversion at $t = 0$, the equilibrium expected dividend payments at $t = 1$ are given by:

$$d_0(\theta) = \frac{E[I|t = 1 \wedge R_L] - C_L - B}{1 + \psi_H C_H} \text{ if } \theta > \theta_H + \varepsilon \tag{16}$$

$$d_1(\theta) = \frac{(1 - \beta_1^*)E[I|t = 1 \wedge R_L] + \beta_1^* l - C_L - B}{1 + \psi_H C_H} \text{ if } \theta_H + \varepsilon > \theta > \theta^* \tag{17}$$

$$d_2(\theta) = \frac{(1 - \beta_{1,C}^*)E[I|t = 1 \wedge R_L] + \beta_{1,C}^* l - B}{1 + \psi_H C_H + \psi_L C_L} \text{ if } \theta^* > \theta > \theta_L - \varepsilon \tag{18}$$

$$d_3(\theta) = 0 \text{ if } \theta < \theta_L - \varepsilon \tag{19}$$

where

$$\beta_1^*(\lambda(\theta), \lambda(\theta_1)) = 1 - \frac{[1 - \lambda(\theta)c]}{\tau_L \lambda(\theta) e_{-1} E[I|t = 1 \wedge R_L]}$$
$$\beta_{1,C}^*(\lambda(\theta), \lambda(\theta_1)) = 1$$

3.1.3 Decision at $t = 1$ in case of initial asset substitution

Insofar we treated the case where the high trigger CoCo has been converted at $t = 0$, which signaled to the market bad asset quality, which in turn led to inefficient conversion. In case of initial asset substitution at $t = 0$, now there are two CoCos which can convert. We assume that unlike CoCo conversion, asset substitution is not observed by the market. Thus, no signalling take place about the state of of fundamentals. There will be no panic based agents who intend to sell, and so $\lambda_1(\theta) = 0$. This simplifying assumption does not chance the key results, but rather provides a more intuitive perspective on the trade-off between asset substitution and conversion.

Corollary 6. *Regardless of the state of fundamentals, there is never a need for CoCo conversion or further asset substitution at $t = 1$ if the bank manager liquidates at $t = 0$ a minimum of:*

$$\beta_0^* = \frac{C_H + C_L + B - \delta(1 - \tau_H)}{l - \delta(1 - \tau_H)} \tag{20}$$

where δ is an infinitesimally positive value, close to 0.

The intuition of this result is that even in the worst state of fundamentals, the CET_1 ratio is still above τ_H- complete derivation can be found in the appendix.

3.1.4 Decision at $t = 0$

Once the shock is observed by the bank manager, he will have to report the value of risk weighted assets and the book value CET. The trade-off that he faces is between reporting truthfully $CET_0 < \tau_H$, or engaging in asset substitution which will lead to a higher CET ratio and a lower reported value of risk weighted assets. Both will further drive in the market prices at fundamental value, but the former leads to conversion of high trigger CoCos, while the latter will not lead to any conversion.

In case of asset substitution, the bank must liquidate a minimum fraction β_0 to restore the CET requirement:

$$CET_0 = \frac{(1-\beta_0)E[I|t=0 \wedge R_L] + \beta_0 l - C_L - C_H - B}{(1-\beta_0))E[I|t=0 \wedge R_L]} > \tau_H$$

Incorporating $E[I|t = 0 \wedge R_L] = R_L$, the liquidation necessary for the high CoCo not to be converted is:

$$\beta_0 = \frac{R_L(1-\tau_H) - C_L - B - C_H}{R_L(1-\tau_H) - l}$$

This insures that at $t = 1$ only fraction $\lambda(\theta)$ sell and there are no panicked agents in the market: $\lambda_1(\theta) = 0$. For this value of β_0, the value of fundamentals at $t = 1$ can lead to further CoCo conversion but shares will still be trading at fundamental value. To further restrict the case space at $t = 1$ we assume a liquidation of β_0^*, as described in Corollary 6[11].

In case of initial asset substitution, expected dividends at $t = 2$ are:

$$d_4(\theta) = \frac{(1-\beta_0^*)E[I|t=1 \wedge R_L] + \beta_0^* l - C_L - C_H - B}{1} \quad \forall \theta \in (0,1] \tag{21}$$

At $t = 0$ overall expected dividend payments in case of conversion yield:

$$\begin{aligned} e_0^{\text{conv}} = &\int_{\theta=\theta_H+\varepsilon}^{\theta=1} Pr(\theta > \theta_H + \varepsilon) d_0(\theta) d\theta + \int_{\theta=\theta^*}^{\theta=\theta_H+\varepsilon} Pr(\theta^* < \theta < \theta_H + \varepsilon) d_1(\theta) d\theta + \\ &\int_{\theta=\theta_L-\varepsilon}^{\theta=\theta^*} Pr(\theta_L - \varepsilon < \theta < \theta^*) d_2(\theta) d\theta + \int_{\theta=0}^{\theta=\theta_L-\varepsilon} Pr(\theta < \theta_L - \varepsilon) d_3(\theta) d\theta \end{aligned}$$

and in case of asset substitution:

$$e_0^{\text{subst}} = \int_{\theta=0}^{\theta=1} d_4(\theta) d\theta$$

The manager prefers conversion if $e_0^{\text{conv}} > e_0^{\text{subst}}$. This time, the trade-off is driven

[11] For completeness we should re-derive the cases for conversion $CET_1 > \tau_H$; $\tau_L < CET_1 < \tau_H$; $CET_1 < \tau_L$ and calculate dividend payments. Nonetheless, the key intuition and results for this paper will not change, so we abstract from this matter and keep it in a simpler format.

by the functional form of expected returns, and the distance between θ^* and $\theta_H,\ \theta_L$. The most efficient conversion space from an optimal bail-in perspective is achieved for $\lambda_1(\theta) = 0$, thus if $\theta^* = \theta_L - \varepsilon$. For a distribution of returns with fat tails, conversion dominates initial asset substitution, due to the limited liability property of the bank. In contrast, for a uniform distribution of returns, we find that the driver of results is θ^*: a lower value of θ^* leads to an increasing value of e_0^{conv}.

3.2 Book value trigger

The equity holders behavior crucially depends on the type of conversion, as shown in the market case. Nonetheless, the market price behavior is not reflected in the book value CET ratio. Under equal issuance costs, if the bank tries to protect existent equity holders it should issue non dilutive CoCos.

Although all CoCos issued so far are book-value based, there is very little research on book value CET ratio. Glasserman and Nouri (2012) and Derksen et al. (2018) develop a valuation model for CoCos, when the CET ratio is book based. Due to the lack of existing stylized equations in discrete time of what constitutes the book value of equity, for the scope of this paper we inspire from current regulation. The International Financial Reporting Standard (IFRS) makes a distinction between occurred and expected credit loss. The regulation which was in place until 1st of January 2018 states that only occurred losses should be incorporated in the balance sheets of banks. Nonetheless, under the new IFRS 9 rules with effect from 2018 firms have to incorporate expected credit loss in their balances (IFRS9, 2014). More precisely, they have to change the accounting value if "the credit risk increases significantly and the resulting credit quality is not considered to be low credit risk" (IFRS9, 2014). For brevity and consistency with the earlier section, we further incorporate the expected credit loss as expected lower returns in the book value of equity.

Given the lack of literature on defining the book value, we construct two different cases: (i) the book value defined as the liquidation value of assets minus liabilities; (ii) the book value as the (discounted) expected value of long term assets minus liabilities. The two versions yield almost identical insights, and so we only focus on (ii)[12].

[12] Complete derivations for the other case are available upon request.

3.2.1 Occurred credit loss

In this case, $CET_0 = CET_1 = \frac{E[I|t=-1\wedge R]-B-C_L-C_H}{E[I|t=-1\wedge R]}$, as the bank does not readjust its expectations regarding the returns of long term risky assets. Even though the bank can observe a negative idiosyncratic shock to asset distribution f_{R_L} and/or bad state of fundamentals, the expected losses in long term returns have not yet incurred and thus not accounted for in the book value. In these circumstances, bad fundamentals will not reflect in the accounting value, and so the CoCos will never be converted before low returns are incurred at $t = 2$.

In this case, the risk associated with CoCos is much lower than the one priced for, as only in case of bankruptcy $E[I|R_L] < B + C_L + C_H$ the CoCo holders will not recover their full investment.

3.2.2 Expected credit loss

We incorporate the expected credit loss by defining the book value as expected returns on assets minus liabilities. At $t = 0$, the expected credit loss is incorporated by adjusting the expected returns.

In case of an idiosyncratic shock to the asset distribution, the new book value is: $CET_0 = 1 - \frac{C_H+C_L+B}{\int_{\theta=0}^{\theta=1} I\theta f_{R_L}(\theta)d\theta} < \tau_H$. High CoCos are converted. At $t = 1$ the bank manager with signal θ_B readjusts the CET value to: $CET_1(\theta_B) = 1 - \frac{C_H+C_L+B}{\int_{\theta_B-\varepsilon}^{\theta_B+\varepsilon} I\theta f_{R_L}(\theta)d\theta}$. Note that in the market case the ratio was evaluated at θ which was the market average, but here only θ_B matters in evaluation. Any fluctuation in $P_1^m(\lambda(\theta), \lambda_1(\theta))$ will not change the CET ratio, as it is book based, so investor behavior does not change the manager's response.

The bank's manager optimization problem at $t = 1$ is to maximize share value while maintaining the CET ratio above τ_L:

$$\max_{\beta_1, \mathbb{1}_c} \frac{e_1^b}{n_{max}} = \frac{(1-\mathbb{1}_c\beta_1)E[I|t=1\wedge R_L \wedge \theta_B] + \mathbb{1}_c\beta_1 l - \mathbb{1}_c C_L - B}{n_{max}} \quad \text{s.t.} \tag{22}$$

$$CET_1(\theta) = \frac{e_1^b}{(1-\mathbb{1}_c\beta_1)E[I|t=1\wedge R_L\wedge\theta_B]} \geq \tau_L \tag{23}$$

Corollary 7. *The bank's best response is independent on the number of equity holders which sell, and is given by:*$\beta_{1,BV}^* = \min\left((\frac{B-E[I|t=1\wedge R_L\wedge\theta_B](1-\tau_L)}{l-E[I|t=1\wedge R_L\wedge\theta_B](1-\tau_L)})^+, 1\right)$, *if* $CET_1 < \tau_L$, *and* 0 *otherwise*

In the intermediate region: $\theta_L - \varepsilon < \theta < \theta_H + \varepsilon$ the value of waiting minus selling for an investor not hit by liquidity shock is:

$$v(\lambda_1(\theta)) = \Big[\frac{E[I|t=1 \wedge R_L] - B - C_L}{n_{max}} - P_1^m(\lambda_1(\theta))e_{-1}\Big] \tag{24}$$

Lemma 3. *The decision of equity holders are global strategic substitutes regardless of the type of conversion, as* $\frac{\partial v(\lambda_1(\theta))}{\partial \lambda_1} > 0$.

As a consequence, equity holders have no incentive to sell at the intermediate stage, so $\lambda_1(\theta) = 0 \ \forall \theta \in (\theta_L + \varepsilon, \theta_H - \varepsilon)$.

Proposition 4. *In case of a book value trigger, the threshold equilibrium* θ^*_{BV} *below which all equity holders sell is* $\theta^*_{BV} = \theta_L - \varepsilon$. *The number of equity holders who sell as a function of fundamentals reported by the bank is:*

$$n_{BV}(\theta_B, \theta^*) = \begin{cases} 1 & \theta_B \leq \theta^* - \varepsilon \\ \frac{\theta^* - \theta_B + \varepsilon}{2\varepsilon} & \theta^* - \varepsilon < \theta_B < \theta^* + \varepsilon \\ 0 & \theta_B > \theta^* + \varepsilon \end{cases} \tag{25}$$

Now the fundamental value of equity, and thus the CET ratio relies heavily on θ_B, the bank's signal. If this is significantly different than the true θ, then CoCos are not a successful bail-in mechanism. A CoCo conversion provides a negative signal to market participants and depositors about the asset quality of the bank. Banks have incentives to avoid this stage, and thus they might overstate θ_B. It is not incentive compatible for the bank to state their true observed value of the fundamentals. An advantage of this structure is limited market volatility due to lack of excessive trading, as compared to the market based case.

4 Discussion and Conclusion

4.1 CoCo structure comparison

We further draw a comparison between the four types of CoCos we analyzed: market based trigger- dilutive or non-dilutive; occurred losses book value and expected losses book value, conditional on the high trigger CoCo conversion at $t = 0$. Throughout

Figure 6: CoCo design summary comparison

CoCo design/effects on conversion	**Market based trigger low CoCos**		**Book based trigger low CoCos**	
	Dilutive $\Psi_L > \overline{\Psi_L}$	*Non-dilutive* $\Psi_L < \overline{\Psi_L}$	*Expected credit loss*	*Occurred credit loss*
Inefficient conversion equilibrium	✓	✗	✓	Depends
Relies heavily on bank's valuation	✗	✗	✓	✓
Perverse incentives in secondary market	✓	✓	✗	✗
Shareholder strategic behaviour	Strategic complements	Strategic substitutes	-	-
Initial capital structure matters for outcome	✓	✓	✗	✗

the paper we assume deposit insurance, and going concern situations. Thus, it is guaranteed that depositors and senior debt will be re-payed. Hence, only CoCo and equity holders are affected on the bank's side. From a policy perspective, we are concerned with the bail-in capacity of CoCos.

As long as equity holders cannot re-buy their shares, and the dilution ψ_L benefits shareholders $\psi_L < \bar{\psi}_L$, market based triggers are the most effective bail-in mechanism. The true value of equity is correctly assessed by the market(average over the uniform is θ), and equity holders have no incentives to sell at $t = 1$ as their decisions are *strategic substitutes*. The CoCos are never inefficiently triggered, and the first best is achieved for all parties. The same effect can be reached with book value triggers which account for expected losses, as long as the bank correctly assesses the value of its assets. Moreover, this case can bring more flexibility in issuance, as both conversion to equity and principal write-down would reach the same effect from a loss absorption perspective. The wealth effect is ambiguous for equity and CoCo holders, and depends on the dilutive properties of CoCos.

In matter of effectiveness, the conversion to equity market trigger CoCos are second to last. We show that they have the highest range of inefficient conversion and early liquidation of long term risky assets, which is dependent on the initial bank capital structure. The CoCo holders have a higher probability of loss due to the *strategic complementarities* decision of equity holders. Existent shareholders can benefit if face value of conversion offsets its dilutive effects.

The least effective loss absorption mechanism is the book value occurred losses trigger, as it does not have the capacity to absorb losses ex-ante. It is the most beneficial type of CoCos for both equity holders and CoCo holders, as they do not incur losses before the realization of returns (at $t = 2$). The latter ones, even though it effectively has no bail-in capacity before it is too late, are coincidently the most used types of CoCos in practice. An example to support this claim is the write-down of Banco Popular's CoCos which was imposed by the regulator once the bank was already insolvent. One can argue that if the conversion would have taken place earlier, the bank could have maintained solvency.

4.2 Conclusion

The Swiss government is the first to introduce more stringent capital requirements for systemically important banks, and this is reflected through a mandatory quota on High trigger AT1 CoCos (Swiss Financial Market Supervisory Authority, 2015). Even though not mandatory, several large banks in the international market hold simultaneously high and low trigger CoCos on their balance sheet. In this context, this paper focuses on the signalling function of CoCos on the financial state of the issuing bank, and analyses the effects of multiple trigger CoCos on market participants and loss absorption capacities. The most obvious advantage of this structure is the creation of multiple bail-in buffers in case of distress. In contrast, once a conversion is observed, it will subsequently create tensions in the market. An example in that sense is the high share price volatility of Deutsche Bank in 2016, after it was speculated that it cannot meet its CoCo coupons.

We show that the Basel III capital requirement on CET1 to RWA ratio can lead to inefficient liquidation of long term risky assets and/or conversion of the low CoCos. Insofar, CoCo research focused on depositor bank runs, but we argue that equity holder behavior can influence conversion as well. We develop a model which makes use of cash-in-the-market pricing of equity, noisy market signals about fundamentals, and an idiosyncratic asset shock observed initially only by the bank. We assume a fixed capital structure, and postulate that the bank's aim is to maximize individual value of shares, while fulfilling the CET regulatory requirements. We evaluate possible CoCo structures, and employ a backward induction equilibrium concept. We solve for the minimum number of equity sellers needed for automatic conversion, and for the unique threshold equilibrium of fundamentals below which shareholders decide to sell. To do so, we draw from the bank run methodology of Goldstein and Pauzner (2005), and modify it to account for the special discontinuity feature created by conversion.

We find that the initial capital structure matters for the scope of inefficient conversions in the market based case triggers. From a social planner perspective, we conclude that market triggers are the least effective. If conversion benefits shareholders, they would have incentives to force inefficient conversion. The dilutive CoCos case ($\psi_L > \bar{\psi_L}$) could lead to 'panic-based' conversions. In contrast, for the book value case, the role of shareholders is limited, and CoCos can act as an effective bail-in mechanism if the bank assesses accurately the asset value and incorporates expected losses in their evaluation. Due to possible underpricing of equity in times of distress or very early inefficient asset substitution, we conclude that the bank has an ex-ante incentive not to issue market based CoCos.

We use the high trigger CoCo conversion as a signaling mechanism, but we argue that similar conclusions are achieved with other types of strong market signals that alert the market on the bank's solvency. Thus, the example has a high degree of generality, and the comparison between the four types of CoCos would still be the same regardless of the type of shock which alerts the market on expected low bank returns. More generally, we provide a formal argument against market based triggers.

Throughout the paper we assume the bank capital structure as fixed, consider simplified types of CoCos and impose additional restrictions for uniqueness of equilibrium. A major point for further research is to determine the optimal capital structure which will minimize the scope of market inefficiencies, and implicitly maximize the capacity of CoCos to act as effective loss absorbing buffers. Moreover, there is a current debate on the pricing equilibrium of equity, as conversion creates a simultaneity issue which can lead to multiple equillibria. In this paper we simplify the pricing issue through cash in the market pricing and fixed conversion rates, but there is scope for a continuous time analysis in this framework which endogenizes the market price and issuance costs even further.

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A Proofs of lemmas and propositions

A.1 Proof of Proposition 1

It can trivially be seen that the value of equity is decreasing in liquidation value β. Thus, the max problem is obtained for binding constraint in (5):

$$\frac{P^m(\lambda(\theta),\lambda_1(\theta))\cdot n_{max}}{(1-\beta)E_{t=1}[I|R_L]} = \tau_L \iff$$
$$\frac{\frac{[1-\lambda(\theta)-\lambda_1(\theta)]c}{[\lambda(\theta)+\lambda_1(\theta)]e_{-1}\cdot n_{max}}\cdot n_{max}}{(1-\beta)E_{t=1}[I|R_L]} = \tau_L \iff$$
$$\beta^*(\lambda(\theta),\lambda(\theta_1)) = 1 - \frac{[1-\lambda(\theta)-\lambda_1(\theta)]\ c}{\tau_L[\lambda(\theta)+\lambda_1(\theta)]e_{-1}E_{t=1}[I|R_L]}$$

From the bank manager perspective, the indifference point between conversion and liquidation is at:

$$\frac{(1-\beta^*)E_{t=1}[I|R_L]+\beta^* r - C_L - B}{1+\psi_H C_H} = \frac{E_{t=1}[I|R_L]-B}{1+\psi_H C_H+\psi_L C_L}$$

Plugging in $\beta^*(\lambda(\theta),\lambda(\theta_1))$ and solving for $\lambda_1(\theta)$ immediately yields the threshold $\lambda_1^*(\theta)$ from proposition 1.

A.2 Derivation of Corollary 2

The neutral conversion, with a zero wealth transfer between equity holders and CoCo holders is given at the point where the share value in case of conversion is the same as under optimal liquidation:

$$\frac{(1-\beta_C^*)E_1[I|R_L]+\beta_C^* l - B}{1+\psi_H C_H+\psi_L C_L} = \frac{(1-\beta^*)E_1[I|R_L]+\beta^* l - C_L - B}{1+\psi_H C_H}$$

Rewriting the function in terms of ψ_L yields the result from the corollary.

A.3 Solution of Proposition 2

The condition for an interior solution is given by the following system of equations:

$$\begin{cases} 0 < \frac{(1-\lambda(\theta)-\lambda_1(\theta)c}{(\lambda(\theta)+\lambda_1(\theta)e_{-1}\tau_L E_{t=1}[I|R_L]} < 1 \\ 0 < \lambda_1(\theta) < 1-\lambda(\theta) \end{cases} \tag{26}$$

This system of inequalities, alongside with economic sensible assumptions, such as $E_{t=1}[I|R_L] > 0$ and $0 < \tau_L < 1$ is solved for:

$$\left(e_{-1} > 0 \land E_{t=1}[I|R_L] > 0 \land 0 < \lambda_1(\theta) < 1 - \lambda(\theta) \land 0 < c < \frac{e_{-1}E_{t=1}[I|R_L]\tau_L(\lambda(\theta)+\lambda_1(\theta))}{1-\lambda(\theta)-\lambda_1(\theta)}\right)$$

Note that $e_{-1} + c = W$ from the initial portfolio allocation. Thus, the maximum amount of cash in the market, as a function of expected returns is given by:

$$c = \frac{E_{t=1}[I|R_L]\tau_L W(\lambda(\theta)+\lambda_1(\theta))}{1-\lambda(\theta)-\lambda_1(\theta)+(\lambda(\theta)+\lambda_1(\theta))E_{t=1}[I|R_L]\tau_L}$$

Alternatively, we can write the solution to the system as:

$$0 < E_1[I|R_L] \leq \frac{(1-\lambda(\theta))c}{\lambda(\theta)\tau_L(W-c)} \land \frac{c\lambda(\theta) - c\lambda(\theta)E_1[I|R_L]\tau_L - c + \lambda(\theta)E_1[I|R_L]\tau_L W}{cE_1[I|R_L]\tau_L - cE_1[I|R_L]\tau W} < \lambda_1 < 1-\lambda$$

$$\lor$$

$$E_1[I|R_L] > \frac{c\lambda - c}{c\lambda\tau_L - \lambda\tau_L W} \land 0 < \lambda_1 < 1-\lambda$$

A.4 Existence conditions for Lemma 1

By inserting β^*, β^*_C and P^m in the value of waiting versus selling function, we re-written as:

$$v(\lambda_1(\theta)) = \begin{cases} -\frac{\frac{c\left(B-\frac{1}{\lambda+\lambda_1}-l+1\right)+W(r-B)}{c-W} - \frac{c(\lambda+\lambda_1-1)(l-R)}{e_{-1}R\tau_L(\lambda+\lambda_1)} + C_L}{C_H\psi_H+1} & \text{if } \lambda_1(\theta) < \lambda_1^*(\theta) \\ -\frac{B-l\left(\frac{c(\lambda+\lambda_1-1)}{e_{-1}R\tau_L(\lambda+\lambda_1)}+1\right)+\frac{c(\lambda+\lambda_1-1)}{e_{-1}\tau_L(\lambda+\lambda_1)}+\frac{c(\lambda+\lambda_1-1)}{(\lambda+\lambda_1)(c-W)}}{C_H\psi_H+C_L\psi_L+1} & \lambda_1(\theta) \geq \lambda_1^*(\theta) \end{cases}$$

Which further simplify in:

$$v(\lambda_1(\theta)) = \begin{cases} \frac{\frac{c\left(B-\frac{1}{\lambda+\lambda_1}+1-l\right)+W(r-B)}{e_{-1}} + \frac{c(1-\lambda-\lambda_1)(l-R)}{e_{-1}R\tau_L(\lambda+\lambda_1)} - C_L}{1+C_H\psi_H} & \text{if } \lambda_1(\theta) < \lambda_1^*(\theta) \\ \frac{\frac{lc(1-\lambda-\lambda_1)}{(\lambda+\lambda_1)e_{-1}E_{t=1}[I|R_L]\tau_L} - B + l}{1+C_H\psi_H+C_L\psi_L} & \lambda_1(\theta) \geq \lambda_1^*(\theta) \end{cases}$$

To evaluate the condition for monotonically decreasing piecewise function, we take the partial derivatives in respect to $\lambda_1(\theta)$, and obtain:

$$\frac{\partial v(\lambda_1(\theta))}{\partial \lambda_1} = \begin{cases} c\frac{\frac{1}{(\lambda+\lambda_1)^2 e_{-1} - \frac{(R-l)\tau_L(\lambda+\lambda_1)}{e_{-1}R\tau_L(\lambda+\lambda_1)^2}}}{1+C_H\psi_H} & \text{if } \lambda_1(\theta) < \lambda_1^*(\theta) \\ c\frac{\frac{1}{(\lambda+\lambda_1)^2 e_{-1} - \frac{(R-l)\tau_L(\lambda+\lambda_1)}{e_{-1}R\tau_L(\lambda+\lambda_1)^2}}}{1+C_H\psi_H+C_L\psi_L} & \lambda_1(\theta) \geq \lambda_1^*(\theta) \end{cases}$$

The derivatives have to be negative on both intervals, which simplifies on the entire domain to the following condition:

$$\frac{1}{(\lambda+\lambda_1)^2 e_{-1}} - \frac{(R-l)\tau_L(\lambda+\lambda_1)}{e_{-1}E_1[I|R_L]\tau_L(\lambda+\lambda_1)^2} < 0 \iff$$
$$1 - \frac{(E_1[I|R_L]-l)(\lambda_1+\lambda)}{R} < 0 \iff$$
$$E_1[I|R_L] < \frac{l(\lambda_1+\lambda)}{1+\lambda_1+\lambda}$$

Note that the restriction for strategic complementarities depends on very few parameters: expected value of returns, liquidation value of total assets, and equity sold in the market.

A.5 Condition for non-empty lower dominance region - section 3

Under the worst circumstances, all equity holders sell. Thus,the indifference condition between waiting for dividend payments or selling is:

$$\frac{\int_{\theta_L-\varepsilon}^{\theta_L+\varepsilon}\theta dF_{R_L}(\theta) - B}{1+\psi_H C_H+\psi_L C_L} = \frac{[1-\lambda(\theta)-\lambda_1(\theta)]c}{(\lambda(\theta)+\lambda_1(\theta)e_{-1}(1+\psi_H C_H+\psi_L C_L)}$$

In the worst case, $\lambda(\theta)+\lambda_1(\theta)=1$. The integral on the left hand side is a standard Riemann-Stieltjes integral,. Thus we can evaluate it as:

$$F(\theta_L-\varepsilon) - F(\theta_L+\varepsilon) - B = 0 \iff$$
$$F(\theta_L-\varepsilon) - F(\theta_L+\varepsilon) = B$$

Given that the senior debt $B > 0$, the region is trivially non-empty.

A.6 Proof of Theorem 2

Here we briefly reconstruct the two part proof of uniqueness of equilibrium from Goldstein and Pauzner (2005), which uses the single crossing condition. The conditions and the proof follows largely the same structure, except for the discontinuity point between the value of waiting versus selling at the CoCo conversion trigger. Further we modify the proof presented in Goldstein and Pauzner (2005) pp 1311 to allow for this discontinuity. Please see the complete 3 part proof with the adjoint lemma's in Goldstein and Pauzner (2005) pp 1311-1314. **Part I. If there is an equilibrium, then it is a threshold equilibrium**.

Strategy profiles

Let $n(\theta,\theta')$ be a function that denotes the proportion of agents who sell their equity at signals below θ', and wait for payoffs at $t=2$ otherwise when the true state of nature is θ

$$n(\theta, \theta') = \begin{cases} 1 & \theta > \theta^* + 2\varepsilon \\ \frac{1}{2} + \frac{\theta}{2\varepsilon} & \theta^* - \varepsilon \leq \theta \leq \theta^* + \varepsilon \\ 0 & \theta < \theta^* - 2\varepsilon \end{cases}$$

Let $\Delta(\theta_i, \tilde{n}(n))$ be the utility differential from waiting for payoffs at $t = 2$ or selling in $t = 1$, when an equity holders observes signal θ_i and holds beliefs $\tilde{n}$. The posterior distribution of θ is Unif $[\theta_i - \varepsilon, \theta_i + \varepsilon]$. By treating $\tilde{n}$ as a number, we can write the utility differential as:

$$\Delta(\theta_i, n(\theta)) = \frac{1}{2\varepsilon} \int_{\theta_i - \varepsilon}^{\theta_i + \varepsilon} v(n(\theta)) d\theta$$

where

$$F_\theta(n) = prob[\tilde{n}(\theta) \leq n]$$

This utility differential is the average of the value of waiting over the uncertainty range $[\theta_i - \varepsilon, \theta_i + \varepsilon]$. $\Delta(\theta_i, n())$ is always negative in the lower dominance region $\theta' < \theta_L - \varepsilon$, and always non-negative in the upper dominance region $\theta' > \theta_U + \varepsilon$. θ' is an equilibrium is any value below θ' gives a negative utility differential, and any value above gives a larger utility differential than the indifference point. Note that unlike global strategic complementarities, the utility differential after the single crossing does not necessarily have to be positive.

At a discontinuity point caused by conversion, the utility differential will be the sum of the region before conversion, and the region after. **Lemma 1**: (i) $\Delta(\theta_i, n())$ is piecewise continuous in θ_i for intervals $(\lambda(\theta), \lambda^*(\theta))$ and $(\lambda^*(\theta)), 1]$ where $\lambda^*(\theta)$ is the threshold at which the bank is indifferent between converting and liquidating. (ii) Monotonic transformations make the function continuous and nondecreasing. (iii) Function $\Delta(\theta_i, n())$ is strictly increasing is $\theta_i < \theta_H + \varepsilon$ and $\tilde{n}(\theta) < n^*(\theta)$.

The solution concept is a Bayesian equilibrium, where an agent sells at $t = 1$ if $\Delta(\theta_i, \tilde{n}()) < 0$ and waits otherwise.

Part II. There exists a unique threshold equilibrium.

A threshold equilibrium at θ^* is a unique equilibrium if conditional on all equity holders using the same threshold θ^*, it is optimal for the agent to sell its shares if he observes a signal $\theta_i < \theta^*$, and otherwise wait for residual payments at $t = 2$.

At this stage Goldstein and Pauzner (2005) show that there is exactly one threshold equilibrium by continuity of $\Delta(\theta_i, n())$. We escape the lack of continuity in our model, by imposing the additional conditions from Proposition **??**, which ensure single crossing of the utility differential. The proof of uniqueness follows the steps presented in Goldstein and Pauzner (2005), and we redirect further the interested reader to pages 1313-1324.

A.7 Derivation of Corollary 6

There is never a conversion choice at $t = 1$ if and only if $CET_1^L > \tau_H \; \forall \theta \in (0, 1]$. Let δ be the admissible lower bound of expected returns on long term assets, with a direct correspondence to θ, through $\int_{\theta - varepsilon}^{\theta + \varepsilon} \theta f_{R_L}(\theta) d\theta = \delta$. The condition must hold even for the worst case of fundamentals, thus also for δ. At θ, the condition reads:

$$\frac{(1-\beta_0)\delta + \beta_0 l - C_L - C_H - B}{(1-\beta_0)\delta} > \tau_H \iff$$

$$\beta_0 > \frac{C_H + C_L + B - \delta(1-\tau_H)}{l - \delta(1-\tau_H)}$$