Are CoCo Bonds a Good Substitute for Equity? Evidence from European Banks

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Abstract

Following the 2008–9 financial crisis, large banks increasingly issued contingent convertible bonds (CoCo bonds) to increase their capital buffers — a policy supported by national bank regulators. This paper examines if the issuance of CoCo bonds provides the same reduction in bank default risk as the corresponding issuance of common equity by analyzing the premium reduction in (single name) credit default swaps (CDS) around the corresponding issuance announcement events. We find that the default risk reduction associated with issuance crucially depends on the CoCo bond's design features: Only CoCo bond designs with permanent write-down features provide a default risk reduction similar to equity. CoCo bonds with equity conversion features come with a lower subsequent volatility of the bank asset value, but are inferior to equity in terms of their default risk reduction.

JEL Classification: G21, G13, G28, G32

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1 Introduction

In July 2011, the Basel Committee of Banking Supervision announced that global systemically important financial institutions (G-SIFIs) would be permitted to use contingent convertible bonds (CoCo bonds) to meet additional capital requirements introduced in the Basel III reforms.[1] By the end of 2015, approximately 730 CoCo bonds had been issued by 301 large European banks with a face value of more than $521 billions (Avdjiev *et al.*, 2017). The extensive use of contingent capital raises the important question if this new form of bank represents an indeed an adequate equity substitute?

The use of CoCo bonds has been controversial. From a theoretical corporate finance perspective, the public benefit of CoCo capital as an equity substitute is questionable as the tax reduction for the issuing bank represents only a private benefit. In the absence of capital market frictions, CoCo bonds provide no clear welfare benefits relative to common equity (Admati, DeMarzo, and Hellwig, 2013). Some economists have advocated the use of CoCo bonds (e.g. Flannery, 2002; McDonald, 2010; Penacchi, Vermaelen and Wolff, 2011) even if their benefits relative to common equity is somewhat elusive. At a political level, the tax benefits of CoCo bonds may have rendered compromise on higher capital buffers more acceptable to banks and their capital owners (Herring and Calomaris, 2011). Thus, a favorable regulatory treatment of CoCo bonds can be justified as a second best policy under political constrains.

The critique of CoCo bonds has centered on various incentive and design problems: First, the decision process of triggering the debt to equity conversion may be subject to manipulation and/or delay — rendering CoCo bonds a "gone concern" instrument. At favorable conversion rates, equity owners may have an interest in delaying the conversion of CoCo bonds into common equity as this dilutes the equity stakes of the incumbent equity owners. Conversion triggers are typically defined based on accounting measures of solvency and the timing of the conversion may significantly diverge from the largely unobservable economic solvency of a bank. If bank default can occur prior to the equity conversion of CoCo bonds, then such CoCo bonds with equity conversion features are unlikely to provide the same default protection as common equity (Koziol and Lawrenz, 2012).

[1] These additional capital buffers are set by national bank regulators. For example, the Swiss Financial Market Supervisory Authority (FINMA) allows large Swiss banks to finance up to 9% of a required 19% total capital ratio with CoCo bonds.

Second, many CoCo bonds substitute equity conversion by a permanent or temporary write-down of the bond's face value. While this avoids the dilution of equity stakes and also takes away management incentives for delayed conversion, such write-downs can create a substantial value transfer to equity owners and a corresponding incentive to increase bank asset risk. Thus, a larger share of CoCo bonds with a write-own feature could make bank assets more risky (Berg and Kaserer, 2015).

Third, CoCo bond issuance could also have the opposite effect on bank risk taking if the CoCo bonds convert into equity. Shareholders could have an interest to avoid equity conversion and therefore delusion of their equity stake. This is particularly the case if the equity conversion factor is favorable to CoCo bond owners. In this case, banks may choose to reduce asset risk to avoid triggering CoCo bond conversion.

The objective of this paper is to shed light on the effective bank default relief provided by CoCo bonds and compare it to equity. Our analysis proceeds in four steps: First, we estimate an enhanced option pricing (Merton-type) model which captures the non-linear relationship between bank capital structure, bank asset risk and CDS default spreads. Additional linear pricing proxies for the market conditions and bank liquidity are added to improve the empirical fit. We show that such a model provides a reasonable benchmark for the expected CDS spread reduction of a bank's equity capital increase. Second, we compare the predicted to the observed spread reduction for both equity and CoCo bond issuances, respectively. Under the null hypothesis that CoCo bonds and common equity are functionally equivalent in reducing bank default risk and bank asset risk is unchanged by the issuance, we expect to see *ceteris paribus* a similar reduction in CDS spreads. Third, we disaggregate issuance events by the design features of the CoCo bonds and test for functional equity equivalence across different types of CoCo bonds. Fourth, we explore evidence for the risk shifting hypothesis associated with CoCo bond which allow for permanent write-down. Here we test if a capital structure based on particular CoCo bonds correlates with a higher return volatility of bank assets after issuance.

Our identification strategy is predicated on the surprise effect of an issuance announcement and we measure the CDS premium reduction around this announcement similar to any other event study. But even if the announcement of a capital increase represents a surprise or news event, its particular form (i.e. equity versus CoCo capital and the CoCo bond design) may be bank specific. We account for this endogeneity in two different ways. In Section 4.3, we use alternatively bank type and bank fixed effects which control for any unobserved bank heterogeneity in the choice of capital measures. In Section 4.4, we estimate probit and multinomial probit models to predict the bank-specific issuance choice based on bank characteristics and replace the actual with the predicted capital measure. Yet our inference turns out to be robust to concerns about endogenous issuance choice.

We highlight that the assumption of a similar "surprise effect" across different capital measures is an essential assumption for our analysis: If for example CoCo issuance of a particular design are easier to anticipate by market participants than others, then CDS premium changes around announcements should differ across CoCo bonds even under functional equivalence of the respective capital measures. But we have no particular reason to expect that the "surprise effect" of a capital measure is design dependent. Mindful of this working hypothesis, we summarize our findings as follows:

1. We find that equity issuances are associated with a CDS spread reduction which account for 80-90% of the predicted value of a Merton-type model. This suggest that CDS spread are generally a good proxy for the effect of capital measures on bank default risk.[2]

2. In a pooled sample of both equity and CoCo issuance announcements, the latter do not match the CDS spread reduction of equity issuances. The default risk reduction of CoCo bonds remains economically and statistically significantly lower even if we use fixed effects to control for unobserved bank heterogeneity. The weaker CDS spread reduction associated with CoCo bond issuances is also confirmed if we use an instrumental variable approach which replaces the observed issuances choice with the predicted choice of a (multinomial) probit model.

3. Distinguishing CoCo bond issuance by their design feature shows considerable heterogeneity in the CDS spread effect of various CoCo bond types. CoCo bonds converting into equity perform worst in terms of their associated default risk reduction, whereas CoCo bonds with a permanent write-down feature match the average default risk reduction of common equity issuances.

[2]It also means that equity issuances are generally not anticipated by the market as much of the CDS premium adjustment occurs within our event window.

4. We find no evidence that CoCo bond capital come with increased bank asset return volatility — even if we consider CoCo bonds with permanent write-down features. However, CoCo bonds converting into equity show a subsequent decrease (rather than increase) of bank asset volatility.

These empirical results inform the policy debate about CoCo bonds and their desirable design features. CoCo bonds with a permanent write-down feature come with a larger default risk reduction and appear clearly preferable to CoCo bonds converting into equity. A plausible explanation is that write-down features imply no equity dilution and make their conversion incentive-compatible with shareholder and management interests. As a consequence, there should be no risk of delayed conversion or write-down: The debt relief for the bank is immediate, full and permanent. CoCo bonds with write-down features are thus a "going concern" instrument. By contrast, timely CoCo bond conversion into equity is much less incentive compatible with shareholder interests, which could prolong bank distress, increases bank default risk, and reduces the effective benefit of equity convertible CoCo capital. Such bonds could represent bail-in capital in a "gone concern", but they do not reduce bank default risk commensurable to common equity.[3]

A number of theoretical papers have emphasized the adverse risk shifting incentive implied by write-down features in CoCo bonds [see Hilscher and Raviv (2014), Berg and Kaserer (2015), Chan and van Wijnbergen (2016)]. Yet, our data do not provide any evidence for such a channel: Following the issuance of such write-down CoCo bonds, bank asset return risk is not higher than before in a statistically significant manner. Presumably, any risk shifting would have to be paid for by higher issuance costs of such CoCo bonds at the next roll-over date of the bonds. Hence such risk-shifting incentives could be economically insignificant. On the other hand, CoCo bonds converting into equity at a high trigger threaten equity owners with a dilution of their shares, with potential repercussions for bank governance and ownership control. This could explain why we observe lower bank asset risk after equity convertible CoCo bonds become part of the liability structure. A similar interpretation is advanced by Hori and Ceron (b, 2016), who independently find lower bank asset risk after issuance of CoCo bonds converting into equity.

We know of only one other paper in the literature which undertakes a comprehensive analysis

[3]Hesse (2018) documents that CoCo bonds with write-down features require a higher price tend to have higher yields, than Co

of various CoCo issuances on CDS spreads: Avdjiev *et al.* (2017) use the same data as we do. Yet these authors only show a qualitative effect of CoCo issuances on (lower) CDS spreads. In particular, they do not seek to benchmark the quantitative default risk reduction of various CoCo designs *relative* to common equity issuances. As CoCo capital serves as a regulatory substitute for equity, we believe any policy relevant comparison must benchmark the CDS implied default rate relief of CoCos against that of equity. The main contribution of our paper is to develop and implement a (semi-structural) framework which allows a meaningful comparison across capital measures.[4]

Various papers have examined the issuance choice of bank. Avdjiev *et al.* (2017) show that larger and better-capitalized banks are more likely to prefer CoCo bond over common equity issuances. Roman Goncharenko *et al.* (2018) highlight that riskier banks prefer common equity when faced with capital needs. Our own analysis confirms these results. Larger and less leveraged banks tend to find CoCo bonds particularly attractive relative to common equity. This dependence of issuing choices on bank characteristics suggest that the relationship between default risk and capital structure is contingent on the bank type. We try to address this endogeneity concern by augmenting our regressions with bank type and bank fixed effects (Section 4.3) and modelling the capital choice in a two-stage least square estimation (Section 4.4).

The paper is organized as follows. We outline the empirical strategy, state the hypotheses, and discuss endogeneity issues in Section 2. Section 3 describes the data and basic summary statistics. In Section 4 we present the results and Section 5 concludes.

2 Empirical Strategy

2.1 Merton Model as Theoretical Benchmark

We use the parsimonious Merton Model (1974) to calculate the probability of bank default. The default probability depends on only four structural parameters, namely the bank's asset

[4] By the term semi-structural we mean that our econometric framework accounts for the non-linear relationship between the various bank and issuance parameters in a Merton-type model with a solvency barrier. A fully structural model would also seek to endogenize the default decision itself in a Leland-type model. Yet volontary "optimal" default prior to insolvency may not represent a very realistic proposition for bank default and is therefore ignore in our framework.

value A_t at market prices, its asset volatility σ_A, the nominal value of debt claims K, and the time horizon T over which the default probability is calculated. The liability side of a bank is composed of *Equity*, contingent capital convertible into equity denoted as *CoCo*, bank debt *BD*, and bank *Deposits*. The total value of bank assets then follows as

$$A_t = Equity_t + CoCo_t + BD_t + Deposits.$$

The Merton model assumes that the bank asset value follows a geometric Brownian motion

$$dA_t = \mu_A A_t dt + \sigma_A A_t dW_t, \qquad A_0 > 0,$$

where μ_A is the mean rate of return on the assets and σ_A the (constant) asset volatility.

The combined value of both common and contingent equity at some future maturity date T depends on the difference between A_T and the debt claims $K = BD + Deposits$. We assume that the bank is subject to an asset or solvability review at time T and is forced to default if the value of bank assets is lower than the value of (nominal) debt claims, $A_T < K$. In this case both equity holders and CoCo owners (by then converted into equity owners or written down) obtain a zero payoff. The combined value of the equity and CoCo claim can be expressed as $(A_T - K)^+ = \max(0, A_T - K)$, which is equivalent to a European call option on the firm's assets. The particular design features of the CoCo bonds (equity conversion versus write-down) can influences the distribution of this payoff, but not its total value.

We highlight our assumption of a solvability review at a fixed date T differs from the classical Leland model (Leland, 1994; Leland and Toft, 1996) in which shareholders can liquidate a firm at any time subject to a limited liability constraint requiring a positive equity value. Imposing a positive equity value at any time prior to T and giving shareholders an early liquidation option both tends to increase the probability that default occurs up to date T. Chen *et. al.* (2017) show how the Leland framework can be extended to firms with contingent (equity) convertible capital. The solution then has to distinguish the case of early liquidation prior to conversion (when CoCo bonds become like common debt) from the case of "timely" conversion where contingent capital indeed works as a capital buffer. From an empirical point of view, it is highly questionable if the early liquidation option has much relevance for bank capital as the costs to default can be considered extremely high for equity owners. This means that for bank equity owners the salvage value of early liquidation always tends to be lower than the expected value of continued operation. At the same time, limited liability constraints may not be binding at all times either because of regulatory forbearance, a lack of asset value transparency or valuation at accounting rather than market values. As we seek only an empirical mapping of a bank's capital structure and asset risk into a default risk probability, we abstract from the Leland model (and its extensions) and derive predicted default probabilities for an exogenous fixed solvability review date equal to the CDS maturity date.

Formally, the likelihood of a default event (at horizon T) determines the predicted CDS spread (under competitive pricing) as

$$\widehat{CDS}_t = \frac{1}{T-t} \ln \left[e^{r(T-t)} \frac{A_t}{K} \left(1 - \Phi[d_1]\right) + \Phi[d_2] \right],$$

where r is the risk-free rate, Φ is the cumulative normal distribution function and parameters d_1 and d_2 are defined as

$$d_1 = \frac{\ln\left(\frac{A_t}{K}\right) + (r + \frac{\sigma_A^2}{2})(T-t)}{\sigma_A \sqrt{T-t}} \quad \text{and} \quad d_2 = \frac{\ln\left(\frac{A_t}{K}\right) + (r - \frac{\sigma_A^2}{2})(T-t)}{\sigma_A \sqrt{T-t}}.$$

A critical input for the calculation of the default spread is the bank's asset volatility σ_A^2. To calculate asset volatility, we aggregate the market value of all bank liabilities and assume that bank deposits (*Deposits*) are riskless. Let N^X denote the number of outstanding securities and P^X their respective (end of the day) price for equity (*Equity*), CoCo bonds (*CoCo*), and ordinary bonds (*Bond*), respectively. The market value of banks assets follows as

$$A_t = N_t^{Equity} P_t^{Equity} + N_t^{CoCo} P_t^{CoCo} + N_t^{Bond} P_t^{Bond} + Deposits.$$

As bank bond prices are not always available at a daily frequency, we approximate the default risk discount on bank bonds by the CDS spread, hence $P_t^{Bond} = 1 - CDS_t$. For a log asset return defined as $R_t = \ln A_t - \ln A_{t-1}$, we calculate bank asset volatility based on the realized volatility over the last 60 trading days as

$$\sigma_{j,t}^{A} = \sqrt{\frac{252 \times 5}{60} \sum_{i=1}^{60} R_{j,t-i}^{2}}$$

and assume that this estimated contemporaneous volatility persists into the future, hence $E(\sigma_{j,t+k}^{A}) = \sigma_{j,t}^{A}$ for $k > 1$.

Two different measurement issues deserve to be highlighted. First, the previous literature has used two other methods to deduce asset volatility outlined in the Appendix [Schaefer and Strebulaev (2008), Feldhütter and Strebulaev (2017)]. However, these methods make further simplifying assumptions about the correlation structure of different bank liabilities and appear less appropriate in a setting with CoCo liabilities. Second, the assumption of asset volatility persistence could be relaxed in favor of a GARCH model allowing for a prediction of the future path of asset volatility. Yet, this would require cumbersome numerical solutions to the Merton model. Instead we take as simpler approach by adding the CBOE volatility index (*VIX)* as a linear control variable to the CDS pricing equation. This can capture time varying expectations about future asset volatility.

2.2 Hypotheses

The Merton model provides a simple structural link between the probability of default and capital structure under a given bank asset risk. It allows us to predict the (log) CDS spread

$$\ln \widehat{CDS}_{j,t} = \ln f(A_{j,t}, K_j, T-t, r, \sigma_j^A) \tag{1}$$

based on measurable structural bank parameters $A_{j,t}, K_j, T-t, r, \sigma_j^A$.

The exact structure of a bank's asset portfolio and its value are usually not transparent to outside bank investor. Banks can therefore face liquidity problems even if they are still solvent. Inversely, insolvent banks can continue to exist if their true asset value is overestimated (or uncertain) and the bank disposes of sufficient liquidity. The considerations suggests that liquidity related measures of a bank's capital structure may influence the observed (log) CDS spread, $\ln CDS_{j,t}$. Moreover, investors' sentiment about future market risk significantly influences the (log) CDS spread. A generalized model of CDS premia is therefore of the form

$$\ln CDS_{j,t} = \beta \ln \widehat{CDS}_{j,t} + \boldsymbol{\phi} \boldsymbol{Z}_{j,t} + \epsilon_{jt} \quad , \tag{2}$$

where the coefficients $\beta \approx 1$ captures the role of the fundamental parameters and $\boldsymbol{\phi Z}_{j,t}$ represent the influence of three additional factors influencing default risk (Galil *et al.*, 2014). We use the CBOE volatility index, the so-called *VIX*, as a measure of market expectations of near-term volatility. The influence of *Bank Liquidity* on default risk is captured by a liquidity measure defined as the ratio of cash (and cash equivalents assets) to total deposits. Finally, *Market Yield* represents the 5 year spot yield of government bonds in the respective bank domicile. In Section 4.1, we first estimate this general model of CDS premium determination.

Next, we consider the role of capital issuance events e by bank j on its CDS spread. The capital increase is announced on day $t_{A(e)}$. Under the null hypothesis that the equity conversion or write-down process work without frictions, a capital increase $\Delta Cap_{j,e}$ of common equity or an alternative CoCo bond issuances should have the same effect on the CDS spread. For simplicity, we ignore value differences created by the different tax treatment of CoCo bond coupon payments relative to dividend payments on common equity and assume

$$\Delta Cap_{j,e} = \begin{cases} \Delta Equity_{j,e} & \text{if} \quad \text{event } e \text{ is an equity issuance} \\ \Delta CoCo_{j,e} & \text{if} \quad \text{event } e \text{ is a CoCo bond issuance} \end{cases} . \tag{3}$$

The predicted pre-and post-issuance (log) CDS spread follows from the Merton model as

$$\ln \widehat{CDS}^{pre}_{j,e,t} = \ln f(A_{j,t}, K_j, T-t, r, \sigma^A_j) \tag{4}$$

$$\ln \widehat{CDS}^{post}_{j,e,t} = \ln f(A_{j,t} + \Delta Cap_{j,e}, K_j, T-t, r, \sigma^A_j), \tag{5}$$

where we assume that the capital increase does not alter the asset volatility σ^A_j. The linear pricing model and an efficient CDS price reaction to the issuance announcement implies

$$\ln CDS_{j,e,t} = \beta \ln \widehat{CDS}^{pre}_{j,e,t} + \gamma_{Cap} \Delta \ln \widehat{CDS}_{j,e,t} \times D^{Cap}_{j,e,t} + \boldsymbol{\phi} \boldsymbol{Z}_{j,t} + \epsilon_{j,e,t} \ , \tag{6}$$

where the predicted CDS premium reduction is defined as

$$\Delta \ln \widehat{CDS}_{j,e,t} = \ln \widehat{CDS}^{post}_{j,e,t} - \ln \widehat{CDS}^{pre}_{j,e,t} \tag{7}$$

and the event dummy $D^{Cap}_{j,e,t}$ is is defined as

$$D^{Cap}_{j,e,t} = \begin{cases} 1 & \text{if} \quad t \geq t_{A(e)} \\ 0 & \text{if} \quad t < t_{A(e)} \end{cases} . \tag{8}$$

For each capital measure, we consider an event window of 40 days $[t - t_{A(e)} = -20, -19, -18, ...19, 20]$ around the issuance announcement day. As capital measures come either as CoCo capital increase or ordinary equity capital increase we can also distinguish them and measure a differential CDS spread decrease. We will distinguish, whether the bank announced CoCo bond issuance or equity issuance by splitting the dummy $D^{Cap}_{j,e,t}$ into $D^{CoCo}_{j,e,t}$ and $D^{Equity}_{j,e,t}$, respectively, according to the issuance type. The extended specification then takes the form

$$\begin{aligned} \ln CDS_{j,e,t} \quad = \quad & \beta \ln \widehat{CDS}^{pre}_{j,e,t} + \gamma_{Equity} \left[\Delta \ln \widehat{CDS}_{j,e,t} \times D^{Equity}_{j,e,t} \right] + \\ & + \gamma_{CoCo} \left[\Delta \ln \widehat{CDS}_{j,e,t} \times D^{CoCo}_{j,e,t} \right] + \boldsymbol{\phi} \boldsymbol{Z}_{j,t} + \epsilon_{j,e,t} \quad . \end{aligned} \tag{9}$$

and allows us to formulate the following hypothesis:

Hypothesis 1: Equivalence of Equity and CoCo Capital

Common equity and CoCo capital issuances are functionally equivalent in reducing credit default risk, if the their effect on the (log) CDS spread around issuance announcements is identical, hence in Eq. (11) we have $\widehat{\gamma}_{Equity} = \widehat{\gamma}_{CoCo}$.

Next, we consider differences in default risk reduction by CoCo bond type. First, we can distinguish CoCo bonds by their trigger level into high-trigger ($High$) or low-trigger (Low) bonds. A CoCo bond is labeled as high-trigger if the conversion level is at least 5.125% of the CET1 capital ratio or above. All bonds with a lower reference value are classified as low-trigger. Second, we can sort CoCo bonds by their conversion features, where we find three types: Equity conversion (EC) implies that debt is swapped into equity, whereas write-down features reduce the face value of the debt either permanently (PWD) or in a transitory manner

(TWD). Accordingly, we can disaggregate the CoCo bond dummy $D^{CoCo}_{j,e,t}$ into the five types of CoCo bonds by their trigger level and conversion features. Extending the specification of Eq. (11) to the different types of CoCo bonds, we formulate the following hypothesis about the irrelevance of the CoCo bond design:

Hypothesis 2a: CoCo Bond Design Irrelevance

All CoCo bonds designs provide the same reduction in the credit default risk. Hence the coefficients for the six types of CoCo bonds in a linear regression similar to Eq. (11) should be identical with $\widehat{\gamma}_{CoCo} = \widehat{\gamma}_{High} = \widehat{\gamma}_{Low} = \widehat{\gamma}_{EC} = \widehat{\gamma}_{PWD} = \widehat{\gamma}_{TWD}$.

An alternative prediction is that agency conflicts render capital conversion measures based on discretionary accounting triggers a very uncertain mechanism. Accounting data is only produced at a quarterly frequency and shareholders have a strong interest in delaying any conversion decision which implies a substantial dilution of their equity stake. This implies that CoCo bonds with an equity conversion feature should perform poorly as an equity substitutes in terms of CDS spread reduction:

Hypothesis 2b: Delayed Equity Conversion

All CoCo bonds which convert into equity (EC) invite delayed conversion and expose the bank to more default risk relative to common equity unlike CoCo bonds with a permanent write-down feature (PWD), hence $\widehat{\gamma}_{EC} < \widehat{\gamma}_{PWD} = \widehat{\gamma}_{Equity}$.

We also note that CoCo Bonds with equity conversion features differ in the degree to which they dilute equity owners. Most stipulate a lower bound on the equity price P^{Conv} at which conversion occurs. The ratio of this price relative to the equity price P^{Equity} at issuance implies a "worst case" conversion factor P^{Equity}/P^{Conv}. The higher this factor, the larger the potential equity dilution for shareholders in case conversion is triggered.

Finally, we conjecture two potential effects of capital structure choice on bank asset risk. First, debt write-down of CoCo bonds can represent an economically significant value transfer to bank equity owners. This has led to the suspicion that the existence of such CoCo bonds provides substantial risk shifting incentive. We can test this third hypothesis by examining the correlation between realized asset return volatility and the level and type of CoCo capital on the bank's balance sheet. To avoid spurious correlations between asset price volatility and capital structure measures driven by asset price shocks, we use only accounting measures to construct the explanatory variable. Let $Equity^{Book}$ denotes the book value of total equity at the beginning of each quarter, $CoCo^{Book}$ the book value of CoCo bonds, and TA^{Book} the book value of total assets. We then regress the annualized asset volatility $\sigma^A_{j,t}$ on a bank's share of book equity $[Equity^{Book}/TA^{Book}]_{jt}$ and CoCo bond capital $[CoCo^{Book}/TA^{Book}]_{jt}$ in the linear regression

$$\sigma^A_{j,t} = \lambda_{Equity}\left[\frac{Equity^{Book}}{TA^{Book}}\right]_{j,t-1} + \lambda_{CoCo}\left[\frac{CoCo^{Book}}{TA^{Book}}\right]_{j,t-1} + \mu_j + \epsilon_{jt}, \tag{10}$$

where μ_j denotes a bank fixed effect. Furthermore, we can look at any subsample of CoCo bonds of a particular type to see if the risk shifting effect is specific to the CoCo bond design.

Hypothesis 3a: Risk Shifting for CoCo bonds with Debt Write-Down

A bank's share of CoCo bond capital with (permanent) debt write-down features correlate positively with the riskiness of bank asset after the CoCo bond issuance, hence $\lambda_{PWD} > 0$.

A second potential endogenous response of bank asset risk to prior capital structure choices concerns the issuance of CoCo bonds with equity conversion features. The risk of equity dilution under conversion could incentivize management to make less risky asset choices after the respective CoCo bonds are issued:

Hypothesis 3b: Asset Risk Reduction under Equity Conversion Risk

Issuance of CoCo bonds converting into equity triggers a reduction of bank asset risk capital because of the increased risk of equity delusion for incumbent shareholders, hence $\lambda_{EC} < 0$.

2.3 Endogenity Issues

Our identification relies on the assumption that the announcements of bank capital measures convey *new information* about a bank's future capital structure and its default risk. Fully anticipated capital measures should not give rise to any CDS pricing effect. Such a surprise element does not preclude market expectations about the type of capital measure a bank is most likely to undertake. In the latter sense, the choice of the capital measure can be endogenous and dependent on bank characteristics even if the announcement of the measure is a surprise. We use two econometric strategies address this endogeneity concern:

In Section 4.3, we use bank type and bank fixed effects to control for heterogeneity across banks. In particular, regressions with bank fixed effects identify default risk reduction based strictly on the intertemporal surprise element of individual issuance events. In Section 4.4, we use an instrumental variable approach to predict the issuance choice of banks based on (pre-determined) bank characteristics. The second stage regression uses predicted rather then observed issuance choice dummies to distinguish the CDS spread reduction of each issuance choice. Yet for the validity of our inference on the default risk reduction, we need to assume that equity issuances carry the same "surprise element" as CoCo issuance announcements. If CoCo issuance are anticipated to a large degree than equity issuances, then the null hypothesis of similar CDS premium reduction should be rejected even though both capital measures are strictly equivalent in terms of their default risk reduction.

Another endogeneity issue concerns the relationship between of capital structure choice and bank policy: Capital market choices may provide market signals about future bank asset risk. For example, CoCo issuance with permanent write-down features could signal a more risky future investment strategy so that the default risk reduction is attenuated for such CoCo issuances. We verify directly if capital structure choices relate to systematic changes in asset volatility. We show in Section 4.5 that CoCo bonds with write-down features on bank balance sheets are not associated with higher bank asset risk. The exception are CoCo bonds converting to equity, which come with lower (rather than higher) bank asset risk.[5] But even if we account for this volatility effect, CoCo bonds with equity conversion features provide very little default risk relief compared to equity issuances as shown in Section 4.2.

[5] See Hori and Ceron (b, 2016) for similar finding.

3 Data

3.1 Issuance Choice by European Banks

CoCo bond issuances by banks started in the autumn of 2009. Accordingly, we collect bank data from August 2009 to March 2016. European bank are by far the most important issuers of CoCo bonds during this period followed by banks in China (Kartasheva, 2015). Yet, focusing on European banks represents a sensible sample choice for two reasons: First, many large European banks have single name CDS contracts traded on their debt, which is a prerequisite for measuring and comparing default risk changes under various capital measures. Second, European banks share similar relationships to their respective sovereigns, whereas partially state-owned banks in China may enjoy a very different level of implicit and explicit state guarantees. Such guarantees can be expected to attenuate any announcement effect on CDS premia and impair a meaningful inference.

The data on CoCo bond and equity issuances is sourced from Bloomberg. We find that 160 European banks are involved in at least one CoCo issuance or equity issuance during the sample period, of which 35 feature both types of capital increase. Figure 1 (Panel A) shows the value of CoCo bond and common equity issued by year. In total, 101 European banks issued CoCo bonds with an aggregate value of 177 billion Euros. Figure 2, shows the aggregate CoCo bond issuance value by country. At 50 billion Euros, the UK (GB) accounts for 28% of all CoCo bond value issued followed by Switzerland with 17%. By contrast, 94 European banks engaged in equity issuances with an aggregate value of 195 billion Euros. Figure 1 (Panel B) shows the aggregate common equity issuance value by country, where the UK (GB) is also the biggest issuer of equity and accounts for almost 47% of the volume of equity issued, followed by Spain with 15%.

The issuing banks are often large and fall into the G-SIB classification of the Bank for International Settlements. A total of 14 out of 15 European G-SIB banks issued CoCo bonds (the exception being Group BPCE) and 11 out of 15 also issued equity during our sample period. The G-SIB banks account for 61% of all CoCo issuances and 43% of the equity issuances by value.

3.2 Bank Sample with CDS Data

Our inference on bank default risk is based on CDS spreads for the individual bank. Data on single name CDS data is sourced from Thomson Reuters Datastream. For the years prior to 2013, we also dispose of CDS data from Markit and use it to cross-check the Thomson Reuters data. Both data sets report identical or very similar price observations. As our benchmark for bank default risk, we use the five-year subordinated CDS spreads as the most liquid CDS instrument. Subordinate debt is generally exposed to a higher probability of default than senior debt.

Unfortunately, CDS contracts are traded only for the larger banks. Only 29 of the 101 CoCo bond issuing banks and 28 of the 94 equity issuing banks feature a five-year subordinate CDS contract, which reduces our bank sample accordingly. The final sample comprises 35 banks with 105 CoCo bond and 68 common equity issuance events. Summary statistics for these 35 banks are provided in Table 1, Panel A.

Panel B and C report additional statistics on capital measures for the 68 common equity issuances and 105 CoCo issuances, respectively. The average capital amount issued is at 1.16 billion Euros slightly higher for common equity issuances than for CoCo bonds issuances at 1.07 billion. However, the median issuance volume of CoCo bonds is at 1 billion Euros twice the median value of common equity issuances. This difference can be traced to a few very large equity issuances by Banco Santander (7.5 billions Euro), HSBC (5 billion Euro) and Lloyds Banking Group (4 billion Euro). Scaling the issuance value by a bank's total asset (TA^{Book}) or total equity ($Equity^{Book}$), we find broad similar issuance sizes for both types of capital measures.

3.3 CoCo Bond Properties

Table 2 provides more comprehensive statistics on the properties of CoCo bonds. Panel A distinguished CoCo bonds by their conversion features, Panel B by their trigger level, Panel C by their currency of issuance, and Panel D by their maturity type. The 105 CoCo bonds issued have different conversion features in almost equal number: 41 CoCo bond issuances involve a temporary write-down (TWD), 35 have an equity conversion (EC), and 29 a permanent write-down (PWD) feature. The temporary write down (TWD) allows the bank to write down (fully or partially) the CoCo bond when the trigger is breached. However, as opposed to the permanent write down CoCo bonds (PWD), when the bank's capital moves back above the trigger level, the amount temporarily written down is recovered and remains due. The equity conversion feature (EC) concerns CoCo bonds which are converted to equity at a pre-defined price (and hence number of shares) when the trigger level is hit. CoCo bonds also differ by their trigger level as shown in Panel B. We define as low trigger CoCo bond (LT) those for which conversion occurs below the CET1 capital ratio of 5.125%. This condition is fulfilled for 17 of the 105 CoCo bond issuances. However, it is important to note, that CoCo bonds can also be triggered by the regulators before the accounting trigger is reached—a case referred to as "point of non-viability" or "discretionary" trigger. Most of the CoCo bonds in our sample also feature these additional regulatory trigger. Panel C shows that half of the CoCo bonds in our sample are issued in USD currency, event though the bank sample consists only of European banks. The Euro follows as the second most important currency of issuance with 39 events. Finally, Panel D distinguishes CoCo bonds by their maturity type.

In Table 3, we sort the CoCo bonds first by their trigger level and then provide the frequency of the conversion mechanisms. Roughly two thirds of the CoCo bonds with high trigger are with an equity conversion feature. By contrast, the majority (58.82%) of CoCo bonds with low trigger are CoCo bonds with an permanent write- down conversion feature. For the temporary write-down conversion, low and high trigger CoCo bonds are found in almost equal proportions.

4 Estimation Results

4.1 Predicted vs. Observed CDS Spreads

The relationship between bank capital and default risk is inherently non-linear. As outlined in Section 2.1, we apply an augmented Merton-type option pricing model to capture this non-linearity. As a first step, we seek to evaluate the empirical fit of such a model. Does it describe the cross-section properties of single name CDS spreads for our European bank sample?

As bank-specific solvency risk is unlikely to be the only factor influencing the single name CDS spread, we augment the Merton model by a linear combination of three additional pricing factors. These are the *VIX* (i.e., the CBOT option index), the *Market Yield* (i.e., the 5 year spot yield of government bond in bank domicile) and a proxy for *Bank Liquidity* (i.e., the ratio of cash and cash equivalent assets to total deposits). The *VIX* factor proxies for expectations about future market volatility and risk sentiment. This seems appropriate because the CDS premium of the Merton model is based on lagged volatility measures and does not incorporate expectations about future volatility. The *Market Yield* can influence bank solvency through various channels not captured by the Merton model. Finally, *Bank Liquidity* represents another key variable of potential bank distress (other than solvency) and is therefore included as a control variable.

First, we evaluate the overall model fit for the full sample of daily single name 5 year CDS spreads for 35 European banks from July 2009 until March 2016. We consider both the full sample and a more restricted sample which excludes the lowest 3% of (log) CDS spreads. Extremely low CDS spreads are unlikely to be well explained by a model of default risk — and particularly so after a log transformation of the CDS spread. We note that these excluded CDS spreads concern 24 highly capitalized banks mostly in the years 2013 and 2014. These outliers do not concern any issuance event: When defining a 40 day event sample around all equity and CoCo issuance announcements, none of the CDS spread observations falls into the lowest 3% of CDS spreads of the full sample.

In Table 4, Column (1)-(2), we regress the observed spread on the predicted spread in accordance with Eq. (2) without and with exclusion of the lowest 3% of CDS spreads, respectively. The estimated coefficient of $\beta = 1.009$ in Column (2) suggests that our augmented Merton model predicts the observed CDS spread without bias in the panel of $30,307$ spread observations. The empirical model fit is high with an adjusted R^2 of 0.956. We conclude that our (augmented) Merton-type model provides a very good and parsimonious framework for explaining CDS spread. The estimated coefficient is slightly lower at $\beta = 0.893$ if we keep the 3% of extremely low CDS spreads in the sample.

As much of our empirical analysis focuses on 40-day event windows around issuance events, we also verify if the model works for this event subsample of roughly only $6,920$ $(= 40 \times 173)$ daily observations. The estimated coefficient in Table 4, Column (2) drops to $\beta = 0.680$, which implies a weaker relationship between observed and predicted CDS spread. One explanation for this attenuation of the predictive framework for event window observations could be that capital measures are sometimes anticipated prior to their announcement thus already incorporated into the CDS spreads.[6]

Figure 3 illustrates the relationship between observed and predicted spread both for the full sample and the event subsample. While announcement of bank capital measures may not always come as a perfect surprise to the capital market, we adopt the working assumption that the "surprise effect" is not biased towards particular capital measures. All subsequent hypothesis tests are predicated on the independence between the event surprise component and the type of issuance event.

4.2 CDS Spread Dynamics around the Issuance Announcement

As a test of Hypotheses 1, 2a and 2b, we report in Table 4, Columns (3)-(6), linear regression of Eq. (9). The observed (log) CDS spread $\ln CDS_{j,e,t}$ in each event window is decomposed onto a prior predicted (log) spread $\ln \widehat{CDS}^{pre}_{j,e,t}$ and the spread change $\Delta \ln \widehat{CDS}_{j,e,t}$ interacted with the dummy $D^{Cap}_{j,e,t}$ marking the event-specific capital increase. Under the null the hypothesis that common equity and CoCo bonds are functionally equivalent in their credit risk reduction (Hypothesis 1), the Merton model predicts *ceteris paribus* the same CDS spread decline for both types of capital directly after the announcement date. This implies qualitatively similar regression coefficients ($\gamma_{Equity} \approx \gamma_{CoCo}$) in Column (3) of Table 4.

The estimated coefficient for equity issuances at $\gamma_{Equity} = 0.901$ is relatively close to one, which reveals that equity issuances feature a CDS spread reduction of about 90% of the predicted decline. By contrast, CoCo issuances show on average a CDS spread increase given the negative point estimate $\gamma_{CoCo} = -0.293$. We conclude that common equity issuance largely achieve the model predicted CDS spread reduction, whereas CoCo bond issuances to not or even have the reverse effect.

In Table 4, Columns (5)-(6) decompose CoCo issuances further by high and low trigger CoCo bonds and by their conversion or design features. The interesting result here is the heterogeneity of the announcement effect by CoCo bond design in Column (6). CoCo bonds converting into equity feature a particularly large divergence between the model implied CDS spread change and the observed change with a regression coefficient $\widehat{\gamma}_{EC} = -1.141$. By contrast, CoCo bonds with permanent write-down features the predicted positive coefficient near one,

[6] We find indeed that the attenuation effect disappears as we enlarge length of the event window. We then converge to the coefficient $\beta = 1$ obtained for the full sample.

that is $\widehat{\gamma}_{PWD} = 1.060$.

The significant negative coefficient for equity issuance suggests a specification issue for our model. While a coefficient near zero is plausible if a certain type of capital increase is ineffective in reducing credit risk, any systematic default risk increase is more difficult to rationalize. The specification problem could be related to the assumption of persistent bank asset risk in our predictive model, which is not valid for banks issuing CoCo bonds. As we show in Section 4.5, equity convertible CoCo bonds come with an average decrease in the volatility of bank asset values. If the market anticipates this reduction in bank asset risk, we also need to calculate the predicted CDS spread change $\Delta \ln \widehat{CDS}_{j,e,t}$ based on a lower future bank asset volatility σ_j^A for CoCo bonds with equity conversion features. In Column (6) of Table 4 we re-estimates the regression with the volatility adjustment and obtain a small positive coefficient $\widehat{\gamma}_{EC} = 0.117$. This suggests that CoCo bonds with equity conversion features are merely ineffective in reducing bank default risk compared to common equity.

It is also interesting to examine the coefficients for our three control variables. The *VIX* enters with a negative sign, which is surprising at first thought. However, we note that bank asset volatility is mean reverting, whereas our Merton-type model assumes persistent asset volatility. Hence a high contemporaneous level of volatility implies overestimation of the CDS premium and the negative *VIX* coefficient can compensate the prediction bias for long-run volatility. A higher *Market Yield* correlate with a higher credit default risk for banks. Higher market-wide interest rates presumably undermine the quality of the bank loan book on the asset side and increase refinancing costs on the liability side of the bank balance sheet. Finally, *Bank Liquidity* correlates negatively with a banks' CDS spread, which is expected if liquidity risk is a component of bank credit risk. As we cannot hope to find an exhaustive list of control variables characterizing bank heterogeneity with respect to default risk, we turn to fixed effect regressions in the next section.

4.3 Controlling for Bank Type and Bank Fixed Effects

A specification concern for the regression in Eq. (9) are omitted bank characteristics which influence the observed CDS spread as well as the issuance choice. The standard econometric response is to include bank type of bank fixed effects μ_j which control for bank heterogeneity with respect to credit default risk. But in Eq. (9) these same omitted bank characteristics could also influence the level of the predicted CDS spread $\ln \widehat{CDS}^{pre}_{j,e,t}$, which represents an important component of the observed spread similar to a lagged dependent variable in a dynamic panel.[7] To avoid a panel estimation bias, we impose the restriction $\beta = 1$ in Eq. (9) and run the following modified regression specification

$$\ln CDS_{j,e,t} - \ln \widehat{CDS}^{pre}_{j,e,t} = \gamma_{Equity} \left[\Delta \ln \widehat{CDS}_{j,e,t} \times D^{Equity}_{j,e,t} \right] + \\ + \gamma_{CoCo} \left[\Delta \ln \widehat{CDS}_{j,e,t} \times D^{CoCo}_{j,e,t} \right] + \boldsymbol{\phi Z}_{j,t} + \mu_j + \epsilon_{j,e,t} \ . \tag{11}$$

The regression results are reported in Table 5. Columns (1)-(3) include bank type fixed effects, where we introduce a dummy marking all banks which issue (at least once) equity and a second dummy marking all banks which issue (at least once) CoCo bonds. Columns (4)-(6) feature individual dummies for each bank. We highlight that both bank type fixed effects are significantly negative in Columns (1)-(3). This means that 22 banks (out of 35) engaged in *both* common equity (*Dummy equity issuing bank* = 1) and CoCo bond (*Dummy CoCo issuing bank* = 1) issuances feature a particularly low CDS premium. These are mostly the larger banks which could also benefit from implicit state guarantees for their debt.

The baseline regression in Columns (1) and (4) now show larger CDS spread reductions for CoCo bond issues CoCo bonds at $\widehat{\gamma}_{CoCo} = 0.459$ and $\widehat{\gamma}_{CoCo} = 0.700$, respectively. But the estimate announcement effects for common equity issuances is again considerably larger at $\widehat{\gamma}_{Equity} = 1.201$ and $\widehat{\gamma}_{Equity} = 1.281$, respectively. These somewhat larger equity coefficients are expected because we imposed the constraint $\beta = 1$ relative to an (unconstrained) estimate $\widehat{\beta} = 0.781$ in Table 4, Column (3). This should imply a large coefficient estimate because the component $-\ln \widehat{CDS}^{pre}_{j,e,t}$ (instead of $-\beta \ln \widehat{CDS}^{pre}_{j,e,t}$) of the dependent variable now covaries more strongly and positively with the independent variable.[8]

A comparison of high and low trigger CoCo bonds in Table 5, Column (5), reveals relatively similar CDS spread reductions for both types of bonds at $\widehat{\gamma}_{HT} = 0.685$ and $\widehat{\gamma}_{LT} = 0.533$, respectively. Both types of CoCo bonds are associated with average announcement effects

[7] The fact that $\ln \widehat{CDS}^{pre}_{j,e,t}$ is deterministic non-linear function of a restrained number of endogenous variables does not preclude its potential correlation with the bank fixed effects.

[8] As a robustness check, we run the alternative regression where the dependent variable is defined as $y = \ln CDS_{j,e,t} - \widehat{\beta} \ln \widehat{CDS}^{pre}_{j,e,t}$ with $\widehat{\beta} = 0.781$. The corresponding results are reported in the Appendix as Table A1. The difference between the coefficient $\widehat{\gamma}_{Equity}$and $\widehat{\gamma}_{CoCo}$ remains qualitatively similar.

which amount to only half of the CDS spread reduction of common equity. This also suggests that the level of the conversion trigger is not a critical design feature with respect to the effectiveness of a CoCo bond.

Similar to Table 4, we find again heterogeneity across the CoCo bond design: CoCo bonds with permanent write-down features (PWD) yield a coefficient $\widehat{\gamma}_{PWD} = 1.285$ of the same magnitude as for common equity issuances (Table 5, Column 6). For CoCo bonds converting into equity (EC) or with a temporary write-down feature (TWD), the CDS spread reduction falls short of the predicted level as indicated by the low coefficient estimates $\widehat{\gamma}_{EC} = 0.659$ and $\widehat{\gamma}_{TWD} = 0.662$, respectively. The superior CDS spread reduction induced by CoCo bonds with a permanent write-down feature could reside in their incentive compatibility: Unlike for CoCo bonds with equity conversion, incumbent shareholders benefit from the write-down of bank debt so that delayed conversion is not an issue. Moreover, debt relief is permanent unlike for CoCo bonds with a temporary write-down feature, which should facilitate future bank refinancing operations.

4.4 CDS Spread Dynamics for Predicted Capital Measures

The fixed effect regressions in the previous section infer default risk reduction only from the intertemporal pattern of the CDS spread dynamics of each bank. Bank fixed effect eliminate any correlation between a *permanent bank specific component* of the CDS spread and the endogenous issuance choice. However, the endogeneity problem could be more subtle in the sense that issuance choices signals *changes in future* bank policy. The "surprise element" of a particular issuance choice could correlate with a change in future bank asset volatility, which in turn implies a correlated change of the *future bank specific component* of the CDS spread. Bank fixed effects do not control for this second type of endogeneity.

However, we can eliminate any potential correlation between surprise in the issuance choice and the CDS spread reaction by replacing observed issuance choice $D^{Cap}_{j,e,t}$ (with $Cap \in \{Equity$, $CoCo$, HT, LT, EC, PWD, $TWD\}$) with predicted one denoted by $\widehat{D}^{Cap}_{j,e,t}$. In Table 6, we report probit and multinomial probit regressions which predict a CoCo issuance choice $D^{CoCo}_{j,e,t}$ in Column (1), a choice for high or low trigger CoCo bonds $D^{HT}_{j,e,t}$ and $D^{LT}_{j,e,t}$ in Columns (2a)-(2b), and choices about the CoCo bond conversion features, $D^{EC}_{j,e,t}$, $D^{PWD}_{j,e,t}$, $D^{TWD}_{j,e,t}$ in Columns

(3a)-(3c), respectively. The default choice is a common equity issuance with $D_{j,e,t}^{Equity} = 1$ if the dummies for the CoCo bond choices are all zero. As explanatory variables in this first stage we use the *Total Capital Shortfall* defined as the capital needed to fulfil the regulatory requirements for total capital ratio in % (with regard to national requirements and distinguishing between G-SIBs, SIFIs requirements), if the requirements are fulfilled, it is equal to zero. Another control is a bank's *Leverage*, and its *Log Total Assets*. Generally, larger banks are more likely to prefer CoCo bond over equity issuances and in particular CoCo bond with permanent write-down features. Banks with a high *Leverage* also tend to opt more often for CoCo bonds with permanent write-down CoCo feature. A high *Total Capital Shortfall* tends to predict CoCo issuances with a high trigger. These results mirror similar findings by Avdjiev *et al.* (2017) and Roman Goncharenko *et al.* (2018). Although we do not report the coefficients, the first stage regressions also include the three previous control variables (*VIX*, *Market Yield*, *Bank Liquidity*) as well as bank fixed effects. At values between 70 and 91, the F-statistics for the first stage regressions in Columns (1) - (3c) show that we have strong instruments.

Table 6, Columns (4)-(6), report the second stage regressions with the estimated issuance choice dummies replacing observed choices in the interaction terms with $\Delta \ln \widehat{CDS}_{j,e,t}$. Similar to Table 5, Columns (4)-(6), all regressions include bank fixed effects. The presence of estimated regressors in the second stage requires us to bootstrap the standard errors (jointly with the first stage) which is done at the issuance event level with 500 replications. CoCo bond issuances show again a significantly lower coefficient (in economic and statistical terms) at $\widehat{\gamma}_{CoCo} = 0.729$ compared to $\widehat{\gamma}_{Equity} = 1.186$ for common equity issuances. When we compare CoCos with various conversion features in Column (6), CoCo bonds with permanent write-down (PWD) again stand out as much more effective in reducing CDS spreads (with $\widehat{\gamma}_{PWD} = 1.142$) relative to other CoCo bond designs. Overall, replacing observed issuance choices with predicted ones yields qualitatively similar results as in those obtained in Section 4.3.

4.5 Capital Structure Choice and Asset Volatility

Lastly, we study the relationship between bank asset volatility as a proxy of risk taking and issuance choices directly. The analysis so far assumed that bank asset risk does not change after the issuance and we need to check the validity of this assumption. The literature has highlighted that CoCo bonds with permanent write-down features could present an incentive for risk shifting as triggering permanent write-down implies a wealth transfer from CoCo owners to shareholders. This issue might be particularly pertinent for CoCo bonds with a high trigger level. Similarly, the presence of CoCo bonds converting into equity could alter the risk taking incentives for bank executives and shareholders.

We calculate (annualized) daily realized bank asset volatility over the 60 trading days of a quarter as a proxy of bank risk and relate it to the components of a banks capital structure. To avoid any spurious correlation with the volatility measure, we express the components of the capital structure as book values ratios relative to total asset. All regressions include bank and time (quarter) fixed effects. Hence, we control for any permanent bank-specific volatility effect and only identify idiosyncratic volatility changes related to changes of the capital structure of any given bank.

Table 7, Columns (1)-(2), provide results for the full sample of all banks. The level of a bank's capital in the form of either equity or CoCo capital shows no statistically significant relationship with bank asset volatility as shown in Column (1). Decomposing overall bank capital into a common equity component $Equity^{Book}/TA^{Book}$ and a CoCo capital component $CoCo^{Book}/TA^{Book}$ shows the latter to be negatively related to bank asset risk with a coefficient of $\widehat{\lambda}_{CoCo} = -37.423$. Changes in common equity still show no statistically significant relationship with bank asset volatility.

Columns (3)-(7) of Table 7 provide estimates for subsamples of bank issuing particular types of CoCo bonds: Columns (3)-(4) focus on high and low trigger CoCo bonds, and Columns (5)-(7) on banks issuing CoCo bonds with specific conversion features. The most important result to highlight is the strong negative relationship between increases in CoCo capital with equity conversion features (EC) and subsequent levels of realized bank asset volatility. Column (6) reports a point estimate of $\widehat{\lambda}_{EC} = -75.178$. The median CoCo issuance amounts to 0.1% of total book assets, which for this type of bond translates into a decrease in realized volatility by -0.0752 of the median level of asset volatility. By contrast, CoCo bonds with a permanent write-down feature show no evidence for any risk shifting.

We retain that only CoCo bonds converting into equity show any systematic relationship with realized bank asset volatility. This result justifies our working assumption that capital issuances and issuance choice do not alter bank policy with respect to bank asset risk — except for CoCo bonds converting into equity. For the latter type of bond, we incorporate the average expected volatility decrease into the predicted CDS spread decrease in Table 4, Column (6). But this does not overturn a negative assessment of this type of bond with respect to the reduction of credit default risk.

5 Conclusion

The aim of this paper is to shed more light on the quality of CoCo bonds as regulatory capital. We analyze the announcement effect of new CoCo bond issuance on CDS spreads and benchmark it against the corresponding effect for common equity issuances. To do so, we first estimate a simple enhanced Merton model as a theoretical benchmark for credit default risk. We add three linear pricing factors to improve the empirical fit of the model. Such a model provides reasonably good predictions for the average CDS spread reduction of common equity issuances.

Under the null hypothesis that CoCo capital is functionally equivalent to common equity and their issuance announcements have the same surprise effect, we predict and test for a quantitatively similar CDS spread reduction around the issuance announcement. We find that this is generally not the case: CoCo bonds as a class to not achieve the same reduction in bank default risk as the equivalent notional amount of common equity. However, much of the observed risk reduction depends on the design features of the CoCo bonds. CoCo bonds converting into a full and permanent debt relief (permanent write-down) achieve the same bank default risk reduction as common equity, whereas other CoCo bond types are inferior in their default risk relief. These results are robust to bank fixed effects and an instrumental variable strategy which bases the inference on predicted rather than observed issuance choices.

The most plausible interpretation of these results is that timely conversion represents a major incentive problem for CoCo bond issuing banks. Unlike CoCo bonds converting into equity, those with permanent write-down features are not subject to such incentive problems. By contrast, we find no evidence that such bonds give rise to risk shifting incentives as was conjectured in the theoretical literature. The incentive compatibility of CoCo bonds with write-down features presupposes that their owners are different from the common equity owners of a bank. Unfortunately, very little is known about the ownership distribution of CoCo bonds.

Such information would allow for a more refined hypotheses — something left to future research.

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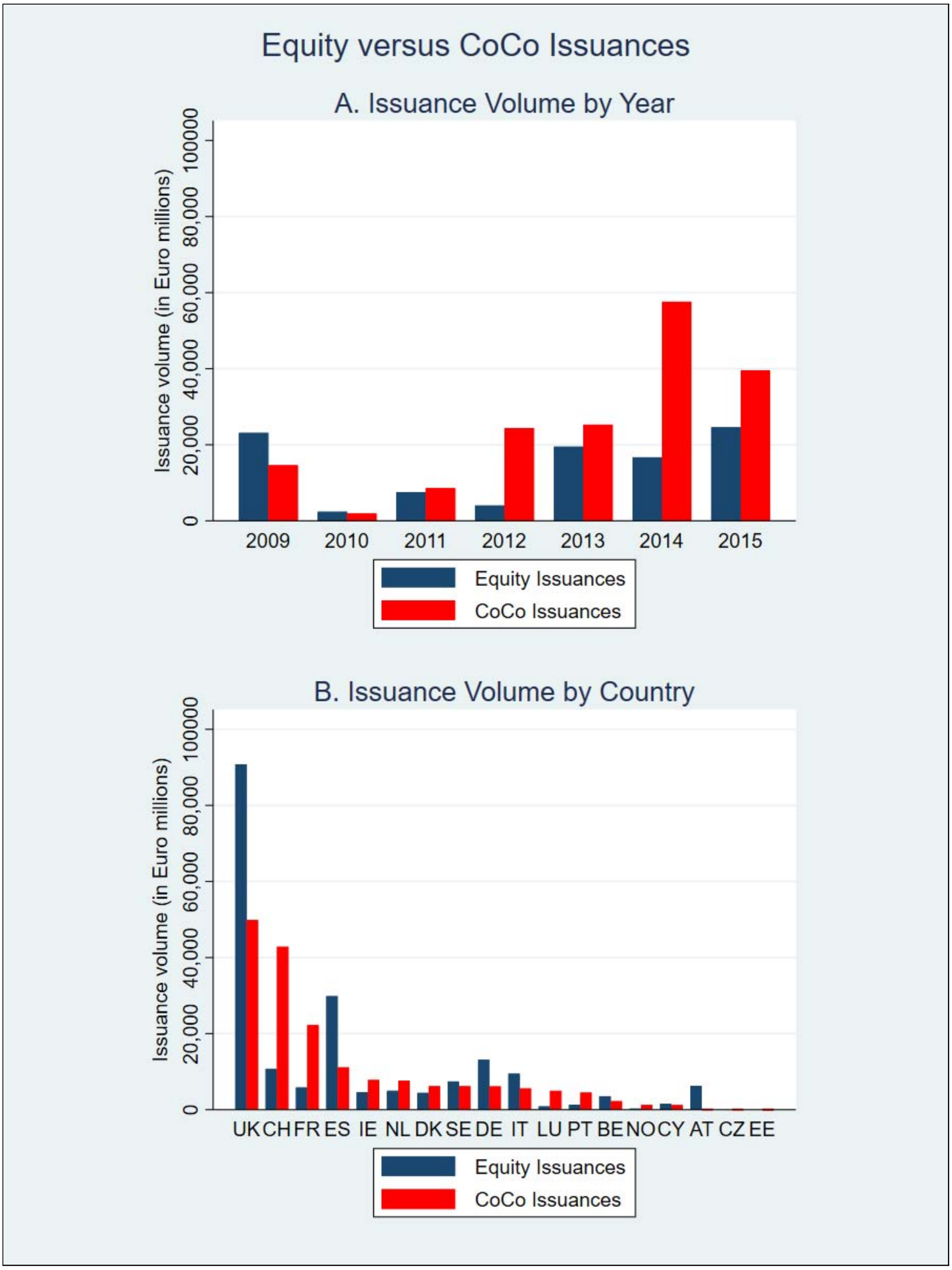

Figure 1: Plotted are observe (daily) CDS premia against model predicted CDS premia for the single name CDS contracts of 35 European banks involved in equity or CoCo bond issuance for the period 2009-2016. Small (grey) dots correspond to all observations and purple crosses to a subample of 40 trading days around each issuance event.

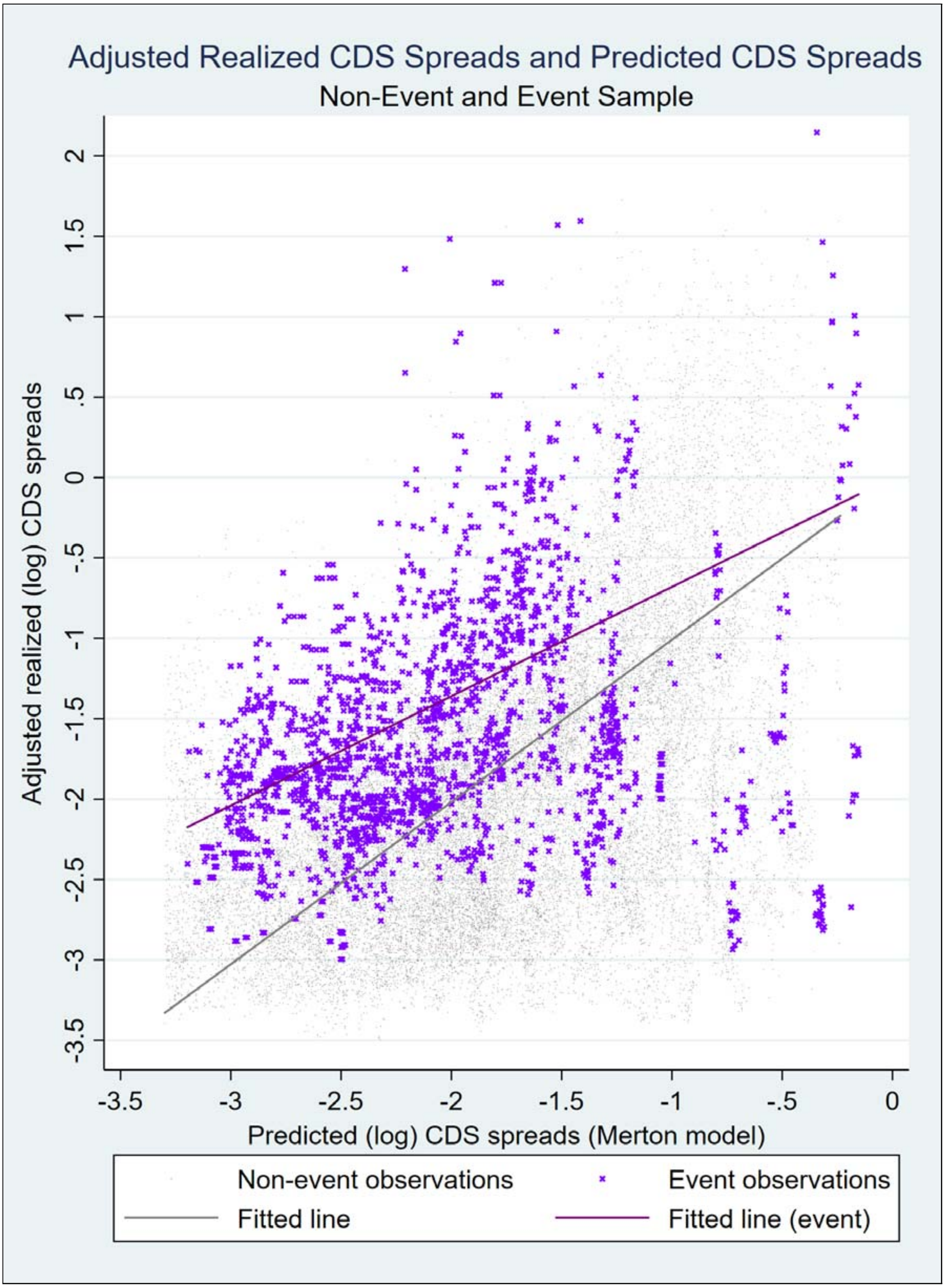

Figure 2: Plotted are observe (daily) CDS premia against model predicted (model-based) CDS premia for the single name CDS contracts of 35 European banks involved in equity or CoCo bond issuance for the period 2009-2016. Small (grey) dots correspond to all observations and purple crosses to a subample of 40 trading days around each issuance event.

Table 1: Summary Statistics

Panel A reports summary statistics of balance sheet information at quarterly frequency on all 35 banks which had a traded single name 5 year subordinate CDS and issued CoCo bonds or common equity in the period July 2009 to March 2016. Total assets (TA), total liabilities (TL), total equity (TE) and net profits are expressed in book value and in Euro billions. The summary statistics on the 5 year subordinated CDS spread are in basis points (bps) and sampled at the end of each trading day. NP Loans is an abbreviation of non-performing loans. The (CBOE) *VIX* is the measure of market expectations of near-term volatility conveyed by S&P 500 stock index option prices, the *Market Yield* is the euro area spot yield curve of the euro area central government bonds (methodology of computation by the ECB). The *Bank Liquidity* is computed as the ratio of cash and cash equivalents to total deposits. RWA is the abbreviation for risk-weighted assets, CET1 ratio and the total capital ratio are regulatory capital ratios. The *Total Capital Shortfall* is the capital (in percentages) needed to fullfil the capital requirements for total regulatory capital required in each country under consideration of the bank type (G-SIB, SIFI). If the requirements are met, it takes on the value of zero. *Leverage* is defined as the ratio of total debt to total assets using book values. Panels B and C show the summary statistics of for common equity and CoCo bond issuances, respectively. The AI is the abbreviation for amount issued and the ratios AI/TA and AI/TE are in percent.

	Obs. (1)	Mean (2)	Median (3)	Min. (4)	Max. (5)	STD (6)	P25 (7)	P75 (8)	Skew. (9)	Kurt. (10)
Panel A: Bank characteristics										
Total assets (TA)	745	320.18	270.69	58.02	734.20	201.22	154.09	468.23	0.48	1.95
Total liabilities (TL)	756	295.04	253.52	54.71	678.76	182.07	144.14	429.28	0.52	2.07
Total book equity (TE)	732	36.22	30.95	3.28	124.59	27.11	12.34	53.77	0.75	2.74
Net profit	847	1.28	1.13	−8.05	10.74	2.70	0.18	2.55	0.12	4.82
NP loans / total loans	598	0.05	0.04	0.01	0.24	0.05	0.02	0.07	1.49	4.59
RWA / total assets	701	0.41	0.42	0.17	0.92	0.16	0.27	0.49	0.66	3.15
CET1 ratio	345	0.13	0.12	0.08	0.21	0.03	0.11	0.14	0.99	3.81
Total capital ratio	358	0.16	0.15	0.10	0.25	0.03	0.13	0.17	0.70	2.88
Sub 5y CDS spread	42700	248.03	182.84	76.03	1090.61	184.90	117.56	301.49	1.79	6.14
VIX	51980	18.85	17.24	10.32	48.00	6.03	14.30	21.88	1.39	5.15
Market Yield	49178	1.19	0.96	−0.36	3.18	0.94	0.42	1.95	0.28	1.85
Bank Liquidity	613	104.14	84.30	25.28	303.24	60.68	59.74	146.84	1.01	3.39
Total Capital Shortfall	358	−0.42	0	−4.90	0	0.90	0.20	0	−2.32	8.09
Leverage	643	0.51	0.42	0.08	0.94	0.28	0.26	0.85	0.32	1.47
Panel B: Common equity issuances										
Amount issued (AI)	68	1157.96	500.00	0.02	7500.00	1519.06	172.89	1314.12	2.10	7.42
AI/TA	67	0.21	0.18	$1.74e^{-5}$	1.06	0.20	0.03	0.34	1.40	6.17
AI/TE	67	3.73	3.41	$3.82e^{-4}$	13.99	3.26	0.73	5.92	0.78	3.09
Panel C: CoCo bond issuances										
Amount issued (AI)	105	1069.56	1000.00	74.00	3000	520.71	750	1398.12	0.56	4.05
AI/TA ratio	101	0.17	0.10	0.02	3.41	0.36	0.06	0.17	8.01	72.81
AI/TE ratio	103	3.14	1.78	0.39	75.00	7.62	1.24	2.91	8.80	83.34
Coupon on CoCo bonds	105	6.70	6.50	2.63	11.5	1.41	5.75	7.63	0.37	3.88

Table 2: CoCo Bonds Characteristics

We summaries various features of CoCo issuances in Columns (1)-(4) and the bank characteristics of the issuing banks in Columns (5)-(6). Panel A reports the sample distribution of CoCo bonds by their conversion features, Panel B by trigger level, Panel C by currency of issuance, and Panel D by maturity features. Column (1) provides the number of observatons and Columns (2) the type frequency (in percent). Column (3) provides the average amount issued (AI) and Column (4) the ratio of average amount issued and total assets (AI/TA). Columns (5)-(7) report on the average bank characteristics of the issuing banks, namely their total assets (TA) in Euro billions, their tier 1 capital ratio and and the ratio of total capital ratio.

	CoCo Issuances				Bank Characteristics		
	Obs.	Frequency (%)	Average Issued (AI)	AI/TA in %	Total Assets (TA)	Capital Tier 1 Ratio %	Total Captial Ratio %
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: CoCo bonds by conversion features							
Equity conversion (EC)	35	33.33	1.279	0.299	1053.004	13.472	16.800
Permanent write-down (PWD)	29	27.62	1.045	0.123	932.648	14.291	18.530
Temporary write-down (TWD)	41	39.05	0.907	0.143	993.238	14.307	17.221
Panel B: CoCo bonds by conversion trigger level							
Low trigger	17	16.19	1.031	0.151	931.097	14.467	17.500
High trigger	87	82.86	1.092	0.156	1137.202	13.602	17.662
NA	1	0.95	1.45	1.432	132.057	10.733	11.587
Panel C: CoCo bonds by currency of issuance							
USD	52	49.52	1.150	0.131	1092.611	14.531	18.074
EUR	39	37.14	1.022	0.306	808.713	13.145	15.986
GBP	9	8.57	1.221	0.089	1545.900	12.578	17.200
NOK	2	1.90	0.198	0.0531	468.571	16.900	19.700
SEK	1	0.95	0.246	0.038	644.868	18.500	21.600
CHF	1	0.95	0.234	0.033	708.330	16.800	20.600
NA	1	0.95	0.743	0.310	239.825	15.800	19.000
Panel D: CoCo bonds by maturity type							
Perp-Call	88	83.81	1.027	0.134	1052.695	14.168	17.162
Call	8	7.62	1.017	0.144	966.490	13.138	17.163
At Maturity	7	6.67	1.380	0.399	615.994	13.936	16.590
Conv-Call	1	0.95	1.109	0.720	154.091	10.250	11.030
Perpetual	1	0.95	3.000	3.41	997.151	13.999	17.381

Table 3: Frequency and Average Default Spread by CoCo Bond Design

Table 3 shows the frequency of issuance of different CoCo types and their respective average default spread (in basis points) over government bonds in the bank domicile. We distinguish the CoCo bonds in our sample by trigger level with a distinction between low and high trigger CoCos, and by conversion features with a distinction between equity conversion (EC), permanent write down (PWD) or temporary write down (TWD).

	Frequency of Issuance (%)			Average Default Spread (bp)		
	EC	PWD	TWD	EC	PWD	TWD
	(1)	(2)	(3)	(4)	(5)	(6)
Low trigger	23.53	58.82	17.65	45.68	75.78	51.40
High trigger	56.81	32.95	10.24	45.89	74.82	29.07
NA	100	0.00	0.00	103.11	–	–

Table 4: CDS Spreads and Capital Measure in the Event Sample

We estimate the effect of 173 capital measures in 35 European banks over the period July 2009 to March 2016 on a bank's CDS spread around the announcement. Compared are common equity issuances and CoCo bond issuances. Based on the Merton model, we calculate the predicted (log) CDS spread $\ln \widehat{CDS}_{j,t}$ under the assumption that equity and CoCo capital provide the same capital buffer against default. Column (1) regresses the observed (log) CDS spread $\ln CDS_{j,t}$ for every trading day (Full Sample) on the predicted (log) CDS spread and a set of control variables $Z_{j,t}$ consisting of the *VIX* as a measure of market uncertainty, the *Market Yield* on a five-year Bund contract, a proxy of *Bank Liquidity* given by the ratio of cash and cash equivalents to total deposits. Column (2) shows the same regression, but we include also the daily data of the lowest 10 % of CDS spreads. For a second sample (Event Sample), we compute for each bank j in issuing event e the predicted (log) CDS spread reduction $\Delta \ln \widehat{CDS}_{j,e}$ under the null hypothesis that contingent CoCo bond capital is of the same quality as common equity in terms of its default risk relief. In Column (2), the observed CDS spread $\ln CDS_{j,e,t}$ for a symmetric 40 day window around each issuance announcement event is then regressed on the initial predicted CDS spread $\ln \widehat{CDS}^{Prior}_{j,e}$ and the predicted incremental change from either common equity issuance or CoCo bond issuance. Identical default risk relief implies a similar spread reduction for both types of capital increase in Column (3), namely $\gamma_{Equity} = \gamma_{CoCo}$ for the linear regression

$$\ln CDS_{j,e,t} = \beta \ln \widehat{CDS}^{Prior}_{j,e} + \gamma_{Equity} \left[\Delta \ln \widehat{CDS}_{j,e} \times D^{Equity}_{j,e,t} \right] + \gamma_{CoCo} \left[\Delta \ln \widehat{CDS}_{j,e} \times D^{CoCo}_{j,e,t} \right] + \phi Z_{j,t} + \epsilon_{j,e,t},$$

where $D^{Equity}_{j,e,t}$ and $D^{CoCo}_{j,e,t}$ represent dummies equal to one for event dates after the equity or CoCo bond issuance announcement, respectively. Column (4) splits the dummy $D^{CoCo}_{j,e,t}$ further into $D^{HT}_{j,e,t}$ and $D^{LT}_{j,e,t}$ into issuance events with a high or low trigger CoCo, respectively. Column (5) creates three different event dummies $D^{EC}_{j,e,t}$, $D^{PWD}_{j,e,t}$ and $D^{TWD}_{j,e,t}$ depending on the conversion features of the CoCo, namely equity conversion (EC), permanent write-down (PWD) and temporary write-down (TWD), respectively. In Column (6), we adjusted predicted change in $\Delta \ln \widehat{CDS}_{j,e}$ for the average change in asset volatility of CoCo bonds with an equity conversion mechanism. The asset volatility change is inferred from Table 7. Reported are robust standard errors adjusted for clustering at the bank level. We use ***, **, and * to denote statistical significance at the 1%, 5%, and 10% level respectively.

	Full Sample		Event Sample				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\ln \widehat{CDS}_{j,t}$	0.893***	1.009***	0.680***				
	(0.009)	(0.005)	(0.015)				
$\ln \widehat{CDS}^{Prior}_{j,e}$				0.781***	0.775***	0.742***	0.773***
				(0.019)	(0.019)	(0.019)	(0.019)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{Equity}_{j,e,t}$				0.901***	0.879***	0.825***	0.843***
				(0.097)	(0.097)	(0.096)	(0.096)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{CoCo}_{j,e,t}$				−0.293***			
				(0.077)			
$\Delta \ln \widehat{CDS}_{j,e} \times D^{HT}_{j,e,t}$					−0.512***		
					(0.130)		
$\Delta \ln \widehat{CDS}_{j,e} \times D^{LT}_{j,e,t}$					−0.192**		
					(0.091)		
$\Delta \ln \widehat{CDS}_{j,e} \times D^{EC}_{j,e,t}$						−1.141***	0.117***
						(0.132)	(0.020)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{PWD}_{j,e,t}$						1.060***	1.156***
						(0.288)	(0.286)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{TWD}_{j,e,t}$						−0.091	−0.111***
						(0.097)	(0.097)
Controls							
VIX	−0.098***	−0.080***	−0.119***	−0.099***	−0.099***	−0.101***	−0.097***
	(0.002)	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Market Yield	0.152***	0.123***	0.389***	0.307***	0.303***	0.311***	0.281***
	(0.007)	(0.006)	(0.024)	(0.023)	(0.023)	(0.022)	(0.023)
Bank Liquidity	−0.005***	−0.004***	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***
	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)
Exclude 10% lowest spreads	No	Yes	No	No	No	No	No
Adjustment for volaility change	No	No	No	No	No	No	Yes
Observations	32307	30307	6754	6754	6713	6754	6754
Issuance Events	–	–	173	173	172	173	173
Adjusted R^2	0.953	0.956	0.969	0.965	0.965	0.966	0.966
Residual SD Error	0.792	0.803	0.737	0.792	0.791	0.781	0.778
F-statistics	162395***	164425***	17877***	11574***	9934***	8943***	8904
$H_0 : Equity = CoCo/HT/EC$				9.641***	8.576***	12.045***	7.404***
$H_0 : Equity = LT/PWD$					8.052***	0.774	1.038
$H_0 : Equity = TWD$						6.719***	6.990***

Table 5: Alternative Specification with Bank Type and Bank Fixed Effects

We estimate the effect of 173 capital measures in 35 European banks over the period July 2009 to March 2016 on a bank's CDS spread around the announcement. Compared are common equity issuances events and CoCo bond issuances using bank type fixed effects in Columns (1)-(3) and bank fixed effects in Colmuns (4)-(6). Based on the Merton model, we calculate the predicted (log) CDS spread $\ln \widehat{CDS}_{j,t}$ under the assumption that equity and CoCo capital provide the same capital buffer against default. For a symmetric 40 day window around each issuance announcement event, we calculate the difference between the observed (log) CDS spread $\ln CDS_{j,e,t}$ and the predicted (log) spread under the pior capital structure $\ln \widehat{CDS}^{Prior}_{j,e}$ as the dependent variable. The latter is regressed on the predicted (log) change of the CDS spread for equity issuance events $\Delta \ln \widehat{CDS}_{j,e} \times D^{Equity}_{j,e,t}$ and CoCo issuance events $\Delta \ln \widehat{CDS}_{j,e} \times D^{CoCo}_{j,e,t}$. The dummy variable $D^{X}_{j,e,t}$ takes on the value of 1 if and only if the issuance event e is of type X and the event date t is after the announcement date. A set of control variables $Z_{j,t}$ consists of the *VIX* as a measure of market uncertainty, the *Market Yield* on a five-year Bund contract, a proxy of *Bank Liquidity* given by the ratio of cash and cash equivalents to total deposits. Identical default risk relief implies a similar spread reduction for both types of capital increase in Column (3), namely $\gamma_{Equity} = \gamma_{CoCo}$ for the linear regression

$$\ln CDS_{j,e,t} - \ln \widehat{CDS}^{Prior}_{j,e} = \gamma_{Equity} \left[\Delta \ln \widehat{CDS}_{j,e} \times D^{Equity}_{j,e,t}\right] + \gamma_{CoCo} \left[\Delta \ln \widehat{CDS}_{j,e} \times D^{CoCo}_{j,e,t}\right] + \phi Z_{j,t} + \mu_j + \epsilon_{j,e,t} \ ,$$

where μ_j is either a bank type fixed effect or a bank fixed effect. We define a *Dummy equity issuing banks* and a *Dummy CoCo issuing banks* as equal to one if a bank undertook at least one equity or CoCo issuance in 2009–2016, respectively. Column (4) splits the dummy $D^{CoCo}_{j,e,t}$ further into $D^{HT}_{j,e,t}$ and $D^{LT}_{j,e,t}$ into issuance events with a high or low trigger CoCo, respectively. Column (5) creates three different event dummies $D^{Equity}_{j,e,t}$, $D^{PWD}_{j,e,t}$ and $D^{TWD}_{j,e,t}$ depending on the conversion features of the CoCo, namely equity conversion (EC), permanent write-down (PWD), and temporary write-down (TWD), respectively. Reported are robust standard errors adjusted for clustering at the bank level. We use ***, **, and * to denote statistical significance at the 1%, 5%, and 10% level respectively.

	Bank Type Fixed Effects			Bank Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{Equity}_{j,e,t}$	1.210***	1.207***	1.197***	1.281***	1.274***	1.252***
	(0.083)	(0.083)	(0.083)	(0.085)	(0.084)	(0.086)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{CoCo}_{j,e,t}$	0.459***			0.700***		
	(0.063)			(0.064)		
$\Delta \ln \widehat{CDS}_{j,e} \times D^{HT}_{j,e,t}$		0.672***			0.685***	
		(0.108)			(0.116)	
$\Delta \ln \widehat{CDS}_{j,e} \times D^{LT}_{j,e,t}$		0.353***			0.533***	
		(0.077)			(0.083)	
$\Delta \ln \widehat{CDS}_{j,e} \times D^{EC}_{j,e,t}$			0.680***			0.659***
			(0.110)			(0.124)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{PWD}_{j,e,t}$			1.174***			1.245***
			(0.249)			(0.307)
$\Delta \ln \widehat{CDS}_{j,e} \times D^{TWD}_{j,e,t}$			0.227***			0.662***
			(0.084)			(0.082)
Controls						
VIX	0.0001	−0.0004	−0.001	0.002	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Bank Liquidity	−0.002***	−0.002***	−0.001***	−0.002***	−0.001***	−0.001***
	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
Market Yield	0.244***	0.248***	0.249***	0.148***	0.147***	0.150***
	(0.020)	(0.020)	(0.020)	(0.021)	(0.021)	(0.021)
Dummy equity issuing banks	−2.103***	−2.111***	−2.119***			
	(0.071)	(0.071)	(0.072)			
Dummy CoCo issuing bank	−1.860***	−1.874***	−1.889***			
	(0.059)	(0.059)	(0.061)			
Observations	6754	6713	6754	6754	6713	6754
Issuance events	173	172	173	173	172	173
Adjusted R^2	0.831	0.831	0.833	0.927	0.927	0.927
Residual Std. Error	0.812	0.812	0.807	0.535	0.534	0.535
F-statistic	2516***	2097***	1826***	103327***	103453***	102756***
$H_0 : Eq. = CoCo/HT/EC$	7.207***	3.928***	3.752***	5.461***	4.113***	3.930***
$H_0 : Eq. = LT/PWD$		7.543***	0.088		6.275***	0.022
$H_0 : Eq. = TWD$			8.214***			4.965***

Table 6: Modelling Capital Issuance Choice

We model in a first stage the capital issuance choice of banks and use the predicted probabilities for each capital measure to estimate its effect on CDS spread reduction. Reported are the first stage regressions for the capital structure choice of equity versus CoCo issuance in Column (1) using the maximum likelihood method for consistency, the tripple choice between equity and high and low trigger CoCos in Columns (2a)-(2b), and the choice between equity and CoCos with different conversion features in Columns (3a)-(3c), respectively. We estimate probit and multinomial probit models for the first stage issuance choice. The explanatory variables are *Total Capital Shortfall* defined as the (strictly positive) difference between a bank's total regulatory capital ratio (measured one quarter before issuance) and its required capital ratio specific to the country of bank domicile as per January 2019; *Leverage* as the ratio of total bank debt to total assets; and the log of total bank assets (*Log Total Assets*). The predicted categorical variables from the multinomial probit regressions are then used in the second stage OLS regressions as an independent variable for regressing the observed categories on them including the same exogenous variables as in the final regression (but not the instruments). The predicted categorical variables from this second stage are then used in the third stage OLS regressions corresponding to columns (5) and (6) here. For this methodology see Adams et al. (2009). Columns (4)-(6) reports the second stage regressions where the capital choice dummy $D^{X}_{j,e,t}$ is replaced by the predicted likelihood of the respective choice based on the first-stage estimate $\widehat{D}^{X}_{j,e,t}$. For the second stage regressions, we report unadjusted standard errors in parentheses and in brackets the bootstrapped standard errors which account for the first-stage estimation of the regressors. We use ***, **, and * to denote statistical significance at the 1%, 5%, and 10% level respectively.

	Probit	Multinomial Probit		Multinomial Probit			Second Stage		
Dependent Variable:	$D^{CoCo}_{j,e,t}$	$D^{LT}_{j,e,t}$	$D^{HT}_{j,e,t}$	$D^{EC}_{j,e,t}$	$D^{PWD}_{j,e,t}$	$D^{TWD}_{j,e,t}$	$\ln CDS_{j,e,t} - \ln \widehat{CDS}^{Prior}_{j,e}$		
	(1)	(2a)	(2b)	(3a)	(3b)	(3c)	(4)	(5)	(6)
$\Delta \ln \widehat{CDS}_{j,e} \times \widehat{D}^{Equity}_{j,e,t}$							1.186***	0.709***	0.656***
							(0.079)	(0.98)	(0.107)
							[0.084]	[0.101]	[0.111]
$\Delta \ln \widehat{CDS}_{j,e} \times \widehat{D}^{CoCo}_{j,e,t}$							0.727***		
							(0.057)		
							[0.062]		
$\Delta \ln \widehat{CDS}_{j,e} \times \widehat{D}^{HT}_{j,e,t}$								0.306***	
								(0.106)	
								[0.112]	
$\Delta \ln \widehat{CDS}_{j,e} \times \widehat{D}^{LT}_{j,e,t}$								0.284***	
								(0.072)	
								[0.078]	
$\Delta \ln \widehat{CDS}_{j,e} \times \widehat{D}^{EC}_{j,e,t}$									0.269***
									(0.105)
									[0.113]
$\Delta \ln \widehat{CDS}_{j,e} \times \widehat{D}^{PWD}_{j,e,t}$									1.144***
									(0.295)
									[0.301]
$\Delta \ln \widehat{CDS}_{j,e} \times \widehat{D}^{TWD}_{j,e,t}$									0.204***
									(0.071)
									[0.076]
Total Capital Shortfall	−0.016	−0.705***	18.230***	0.339***	−1.025	0.085			
	(0.047)	(0.227)	(0.836)	(0.125)	(1.196)	(0.169)			
Leverage	−0.033**	−8.375***	−12.852***	−0.477***	18.852***	0.562***			
	(0.015)	(0.857)	(0.873)	(0.062)	(3.275)	(0.086)			
Log Total Assets	0.639***	9.945***	23.723***	1.033***	9.988***	5.128***			
	(0.073)	(0.315)	(0.148)	(0.219)	(0.169)	(0.571)			
Other control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	173	172	172	173	173	173	6754	6713	6754
Issuance events	173	172	172	173	173	173	173	172	173
Log likelihood	−898.321								
Akaike inf. criterium		1,101	1,105	1,322	1,343	1,352			
Adjusted R^2							0.933	0.919	0.921
F-statistics	71.57***	82.19***	81.92***	90.45***	90.98***	90.13***	97.12***	98.19***	96.78***
$H_0: Eq. = CoCo/HT/EC$							4.40***	2.67***	2.44***
$H_0: Eq. = LT/PWD$								3.33***	1.52
$H_0: Eq. = TWD$									3.36***

Table 7: Asset Volatility and Capital Structure

We measure asset volatility for 35 European banks during the period July 2009 to March 2016 as the annualized daily realized volatility over the last 60 trading days. In Column (1), we regress asset volatility (measued at market values of assets) on the capital ratio, where $Equity^{Book}$ denotes the book value of common equity, $CoCo^{Book}$ the book value of CoCo bonds, and TA^{Book} book values of total assets. In Column (2) we regress asset volatility separately onto the common capital equity share and CoCo capital share in the linear regression

$$Asset\ Volatility_{j,t} = \lambda_{Equity} \left[\frac{Equity^{Book}}{TA^{Bool}}\right]_{j,t-1} + \lambda_{CoCo} \left[\frac{CoCo^{Book}}{TA^{Book}}\right]_{j,t-1} + \mu_j + \epsilon_{j,t} \quad ,$$

where μ_j denotes a bank fixed effect. Columns (3)-(7) use subsamples of bank which have $CoCo^{Type}$ issuances sorted by trigger level and conversion features. Reported are robust standard errors adjusted for clustering at the bank level. We use ***, **, and * to denote statistical significance at the 1%, 5%, and 10% level respectively.

	Full Sample		CoCo Subsamples				
			Trigger Level		Conversion Feature		
			High	Low	*EC*	*PWD*	*TWD*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$[Equity^{Book} + CoCo^{Book}]/TA^{Book}$	0.699						
	(0.678)						
$Equity^{Book}/TA^{Book}$		4.556	3.866	4.370	2.900	5.316***	1.664
		(5.128)	(3.260)	(2.808)	(8.600)	(1.750)	(2.640)
$CoCo^{Book}/TA^{Book}$		−37.423***					
		(11.921)					
$CoCo^{Type}/TA^{Book}$			−10.964	2.231	−75.178***	0.750	2.345
			(19.350)	(6.368)	(23.841)	(4.791)	(10.647)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	731	195	106	106	91	56	81
Adjusted R^2	0.683	0.573	0.848	0.891	0.537	0.937	0.924
Residual SD Error	0.140	0.217	0.099	0.065	0.303	0.042	0.053
F-statistics	55.256***	11.073***	43.140***	46.823***	9.127***	104.518***	71.226***
$H_0 : \lambda_{Equity} = \lambda_{CoCo}$		3.235**	0.756	0.307	3.081***	0.895	0.062

Internet Appendix

Are CoCo Bonds a Good Substitute for Equity? Evidence from European Banks

Not for Journal Publication

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Appendix A: Robustness

Table A1: Alternative Specification with Bank Type and Bank Fixed Effects

We replicate the results in Table 5 for an alternative dependent variable. We replace $\ln CDS_{j,e,t} - \ln \widehat{CDS}_{j,e}^{Prior}$ by $\ln CDS_{j,e,t} - \beta \times \ln \widehat{CDS}_{j,e}^{Prior}$ based on the fitted value $\beta = 0.781$ in Table 4, Column (4). As before, the dummy variable $D_{j,e,t}^{X}$ takes on the value of 1 if and only if the issuance event e is of type X and the event date t is after the announcement date. A set of control variables $Z_{j,t}$ consists of the VIX as a measure of market uncertainty, the *Market Yield* on a five-year Bund contract, a proxy of *Bank Liquidity* given by the ratio of cash and cash equivalents to total deposits. Identical default risk relief implies a similar spread reduction for both types of capital increase in Column (3), namely $\gamma_{Equity} = \gamma_{CoCo}$ for the linear regression

$$\ln CDS_{j,e,t} - 0.781 \times \ln \widehat{CDS}_{j,e}^{Prior} = \gamma_{Equity} \left[\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{Equity}\right] + \gamma_{CoCo} \left[\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{CoCo}\right] + \phi Z_{j,t} + \mu_j + \epsilon_{j,e,t} \quad ,$$

where μ_j is either a bank type fixed effect or a bank fixed effect. We define a *Dummy equity issuing banks* and a *Dummy CoCo issuing banks* as equal to one if a bank undertook at least one equity or CoCo issuance in 2009–2016, respectively. Column (4) splits the dummy $D_{j,e,t}^{CoCo}$ further into $D_{j,e,t}^{HT}$ and $D_{j,e,t}^{LT}$ into issuance events with a high or low trigger CoCo, respectively. Column (5) creates three different event dummies $D_{j,e,t}^{Equity}$, $D_{j,e,t}^{PWD}$and $D_{j,e,t}^{TWD}$ depending on the conversion features of the CoCo, namely equity conversion (EC), permanent write-down (PWD), and temporary write-down (TWD), respectively. Reported are robust standard errors adjusted for clustering at the bank level. We use ***, **, and * to denote statistical significance at the 1%, 5%, and 10% level respectively.

	Bank Type Fixed Effects			Bank Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{Equity}$	1.000***	0.998***	0.989***	1.059***	1.051***	1.021***
	(0.070)	(0.070)	(0.070)	(0.071)	(0.070)	(0.072)
$\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{CoCo}$	0.256***			0.430***		
	(0.053)			(0.054)		
$\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{LT}$		0.204***			0.253***	
		(0.065)			(0.069)	
$\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{HT}$		0.361***			0.757***	
		(0.091)			(0.097)	
$\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{EC}$			0.311***			0.298***
			(0.093)			(0.104)
$\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{PWD}$			0.810***			1.108***
			(0.210)			(0.256)
$\Delta \ln \widehat{CDS}_{j,e} \times D_{j,e,t}^{TWD}$			0.138*			0.412***
			(0.071)			(0.068)
Controls						
VIX	−0.002	−0.003	−0.003	0.003	0.003	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Bank Liquidity	−0.002***	−0.002***	−0.002***	−0.002***	−0.001***	−0.002***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Market Yield	0.271***	0.273***	0.274***	0.184***	0.182***	0.185***
	(0.016)	(0.016)	(0.016)	(0.018)	(0.018)	(0.018)
Dummy equity issuing banks	−2.525***	−2.530***	−2.525***			
	(0.060)	(0.060)	(0.061)			
Dummy CoCo issuing bank	−2.327***	−2.334***	−2.330***			
	(0.050)	(0.050)	(0.051)			
Observations	6754	6713	6754	6754	6713	6754
Issuance events	173	172	173	173	172	173
Adjusted R^2	0.944	0.944	0.945	0.966	0.966	0.966
Residual Std. Error	0.573	0.573	0.572	0.446	0.445	0.446
F-Statistic	6,197.945***	5,425.630***	4,835.025***	232.202***	233.123***	231.573***
$H_0: Eq. = CoCo/HT/EC$	8.474***	8.312***	5.825***	7.051***	8.119***	5.716***
$H_0: Eq. = LT/PWD$		5.548***	0.809		2.458***	0.327
$H_0: Eq. = TWD$			8.535***			6.149***

Appendix B: Bank Asset Volatility

This section outlines how we compute bank asset volatility $\sigma_{A,t}$. Balance sheet information on bank liabilities is available only quarterly, where $N_{E,q}$ denote the end of the quarter number of shares outstanding, $N_{CoCo,q}$ the number of CoCo bonds outstanding, and $N_{D,q}$ the units of bank debt at a unit face value. The corresponding daily prices for equity shares, CoCo bonds, and bank debt are $P_{E,t}$, $P_{CoCo,t}$, and $P_{D,t}$, respectively. In the absence of daily market prices for bank debt, we set $P_{D,t} = 1 - CDS_t$, where the CDS_t stands for the 5-year single name (bank) CDS spread level. The balance sheet also provides quarterly information on bank deposits ($Deposits_q$), which are always valued at their nominal value. Total asset value at day t at market prices follows as

$$V(A)_t = \underbrace{N_{E,t} \times P_{E,t}}_{Equity_t} + \underbrace{N_{CoCo,t} \times P_{CoCo,t}}_{CoCo_t} + \underbrace{N_{D,t} \times P_{D,t}}_{Debt_t} + Deposits_q$$

and daily (log) asset returns as

$$R_t = \ln V(A)_t - \ln V(A)_{t-1}.$$

We define asset volatility as realized daily volatility measured over previous 60 days ($n = 60$). Note that we adjust the realized volatility measure $\sigma_{A,t}$ to correspond to the 5 year maturity of the single name CDS spreads. Hence, we have

$$\sigma_{A,t,real} = \sqrt{\frac{252 \times 5}{60} \sum_{s=1}^{n} R_{t-s}^2}.$$

The economic literature on asset price volatility has often used simpler measures for non-banks where CoCo capital did not exist. For example Schaefer and Strebulaev (2008) us an approach based on equity and debt only. Asset volatility is measured as

$$\sigma_{A,t} = \sqrt{(1-L)^2 \sigma_{E,t}^2 + L^2 \sigma_{D,t}^2 + 2L(1-L)\sigma_{ED,t}}.$$

where $\sigma_{E,t}$ and $\sigma_{D,t}$ denote the volatility of equity and debt, respectively, $\sigma_{ED,t}$ represents the covariance between the returns on equity and debt, L is the financial leverage ratio defined as

$$L = \frac{\text{Book Value of Debt}}{\text{Market Value of Equity} + \text{Book Value of Debt}}.$$

A still simpler approach is adopted by Feldhütter and Schaefer (2016). They determine asset volatility as

$$\sigma_{A,t} = \delta(L)(1-L)\sigma_{E,t} \ ,$$

where $\delta(L)$is a step function of the financial leverage L. Feldhütter and Schaefer calibrate

$$\delta(L) = \begin{cases} 1.00 & \text{if} \quad 0.00 \leq L \leq 0.25 \\ 1.05 & \text{if} \quad 0.25 < L \leq 0.35 \\ 1.10 & \text{if} \quad 0.35 < L \leq 0.45 \\ 1.20 & \text{if} \quad 0.45 < L \leq 0.55 \\ 1.40 & \text{if} \quad 0.55 < L \leq 0.75 \\ 1.80 & \text{if} \quad 0.75 < L. \end{cases}$$

Schaefer and Strebulaev (2008), Feldhütter and Schaefer (2016), and Hau and Hrasko (2018) compute asset volatility for a 60 window prior to day t. Using the European bank sample, Table A2 reports in Panel A the correlation of bank asset volatility measures across the three methods, in Panel B the pairwise correlation of the different volatility components, and in Panel C their covariance. We note that the covariance between the market value of equity and CoCo liabilities take on the largest value of the three covariance elements in Panel C. This covariance is ignored in the methods proposed by Schaefer and Strebulaev (2008) and Feldhütter and Schaefer (2016).

Table A2: Different Bank Asset Volatility Measurements

	FS 2016	SS 2008	HH 2018
Panel A: Correlations Across Methods			
Feldhütter and Schaefer (= FS) 2016	1.00	0.88	0.89
Schaefer and Strebulaev (= SS) 2008	0.88	1.00	0.86
Hau and Hrasko (= HH) 2018	0.89	0.86	1.00
Panel B: Correlations Across Components			
Equity-Debt (log) returns	–	0.18	0.18
CoCo-Debt (log) returns	–	–	0.12
CoCo-Equity (log) returns	–	–	0.26
Panel C: Covariances Across Components			
Equity-Debt (log) returns	–	$5.95e^{-6}$	$5.95e^{-6}$
CoCo-Debt (log) returns	–	–	$9.36e^{-7}$
CoCo-Equity (log) returns	–	–	$2.01e^{-5}$