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Are Contingent Convertibles Going-Concern Capital?

by

Franco Fiordelisi[*]
University of Rome III and Middlesex Business School

George Pennacchi[†]
University of Illinois

Ornella Ricci[‡]
University of Rome III

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Abstract

Contingent convertibles (CoCos) are intended to either convert to new equity or be written down prior to failure while a bank is a going concern. Yet, in the first actual test case, CoCos never converted before its bank failed. We develop a model that predicts that CoCos lead to less (*more*) extreme stock returns and have yields greater than (*similar to*) standard subordinated debt yields if investors do (*do not*) expect them to convert or be written down prior to failure. These predictions are tested using data on CoCos issued by European banks during 2011 to 2017. We find evidence that equity conversion CoCos reduce stock return variance and several other measures of downside risk, consistent with the perception that they are going-concern capital. However, we also provide event study evidence that recent regulatory actions reduced the CoCo – subordinated debt yield spread, which indicates a diminished investor belief that CoCos are going-concern capital.

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[*] Via S. D'Amico 77, 00145 Rome, Italy; (39) 0657 335 672; franco.fiordelisi@uniroma3.it
[†] Department of Finance, 515 E. Gregory Drive, Champaign, IL U.S.A.;(1) 217 244 0952; gpennacc@illinois.edu
[‡] Via S. D'Amico 77, 00145 Rome, Italy; (39) 0657 335 708; ornella.ricci@uniroma3.it

For all the attention paid to CoCos in the last few years, it is even now not clear as a practical matter that an instrument can be developed which would be cheaper than common equity but still structured so as to convert in a timely, reliable fashion. Furthermore, as the history of Tier 1 capital under the original Basel Accord teaches, there is considerable risk that once some form of hybrid is permitted, a slippery slope effect ensues, whereby national regulators approve increasingly diluted forms of capital under political pressures.

*(*Regulating Systemically Important Financial Firms, *remarks by Daniel K. Tarullo, Member Board of Governors of the Federal Reserve System, at the Peter G. Peterson Institute for International Economics Washington, D.C. ,* June 3, 2011, *page 7).*

I. Introduction

Contingent convertibles (CoCos) are hybrid bank capital instruments that either convert from debt to new equity or have their principal written down following a triggering event. CoCos were conceived by Flannery (2005) to trigger at the onset of financial stress in order to automatically de-lever a bank while it is a "going concern"; that is, while the bank is still solvent. This property makes CoCos fundamentally different from other debt-like capital, such as standard subordinated debt, that absorbs losses only when a bank is a "gone concern"; that is, when the bank is insolvent (failed). Since debt overhang creates a disincentive to raise new equity capital after a bank suffers losses, CoCos can pre-commit a viable bank to recapitalize, thereby stabilizing it and avoiding direct costs of financial distress and failure.[1]

This paper provides evidence on whether investors believe CoCos are truly "going-concern" capital, meaning that CoCos will trigger while a bank is still solvent rather than insolvent. It begins by presenting a model with two main predictions. The first is that after a bank issues CoCos, its stock returns will become less (*more*) extreme if investors believe there is a high (*low*) probability that CoCos will trigger prior to the bank's insolvency. The second prediction is that a regulatory action that reduces the likelihood that CoCos are triggered will decrease the spread between the yield on CoCos and the yield on standard subordinated debt.

[1] Flannery (2014) provides a review of potential benefits of CoCos. The debt overhang problem is discussed by Myers (1977). Costs of financial distress and failure include not only direct costs incurred by the bank's creditors but also negative externalities arising from reduced lending to bank-dependent borrowers and bank asset fire sales. See Shleifer and Vishny (2011) for a review of fire sale costs.

The paper then presents empirical evidence on these two predictions using 2011 to 2017 data on European banks. It finds that over the entire sample period, investors viewed only equity conversion (EC) CoCos, but not principal write-down (WD) CoCos, as going-concern capital. This is because a bank's stock return volatility tended to decline after it issued EC CoCos but not WD CoCos. However, the paper also finds that regulatory actions taken in 2016 and 2017 reduced the yield spread between a bank's CoCo and its subordinated debt, consistent with a reduced the likelihood that even EC CoCos will convert while the bank is a going concern.

Capital standards under Basel III designate going-concern capital as Tier 1 and gone-concern capital as Tier 2.[2] The two components of Tier 1 capital are Common Equity Tier 1 (CET1) and Additional Tier 1 (AT1) while Tier 2 capital is primarily standard subordinated debt. A CoCo can qualify as AT1 capital if it triggers when its bank's ratio of CET1 to risk-weighted assets (RWA) declines to at least 5.125%. In addition, the CoCo must give bank regulators discretion to trigger a conversion or write down.[3] Thus, regulation favors AT1 CoCos relative to Tier 2 subordinated debt due to the presumption that CoCos will trigger and de-lever a bank while it is a going concern, thereby mitigating financial distress and failure costs.

Since 2009 there have been over 500 different CoCo issues that, in total, have raised over $600 billion.[4] Undoubtedly CoCos' popularity is at least partially due to their classification as higher-quality Tier 1 capital.[5] Moreover, all actual CoCos have followed the Basel guidelines and contain triggers tied to a regulatory capital ratio (CET1/RWA) and/or discretionary triggers. Importantly, these regulatory capital and discretionary triggers in the Basel standards differ from

[2] See Basel Committee on Banking Supervision (2011, page 12).
[3] There are other conditions to qualify for AT1, such as the requirement of a perpetual maturity.
[4] Moody's Global Credit Research 10 April 2018. These amounts are as of year-end 2017.
[5] Relative to CET1, AT1 CoCos can have tax advantages due to the deductibility of CoCos' interest expense. Further increasing banks' desire to issue CoCos is that Basel III increased the minimum ratio of Tier 1/RWA from 4% to 6% and implemented a new Tier 1 leverage minimum of 3%. Note that in countries where national regulators have superceded Basel standards and not permitted CoCos to be included in Tier 1 capital, CoCo issuance as been rare. This is the case for the United States where no U.S. banks have issued CoCos.

those envisioned by many of the original proposals for CoCos. Flannery (2005) recommended that CoCos be triggered when the bank's stock price (or its market value of equity) declined below a pre-specified threshold. Several other academic studies, including Bulow and Klemperer (2015), Calomiris and Herring (2013), McDonald (2013), and Pennacchi et al. (2014) have recommended various types of CoCos with market price triggers.

Because actual CoCos have triggers based on a regulatory (book value) capital ratio, rather than a market value ratio, a critical question is whether CoCos will actually convert or be written down while the bank is still solvent. Hart and Zingales (2010) note that the first CoCo issued by Lloyds in 2009 would not have triggered at the peak of the financial crisis. Similarly, Haldane (2011) and Pennacchi et al. (2014) argue that regulatory capital ratios are slower to adjust and easier to manipulate compared to market value ratios. In particular, Haldane (2011, Charts 5 and 6) shows that prior to the Lehman Brothers failure, large banks' market value capital ratios were far better predictors of their eventual failure or need for a government bailout than were their regulatory capital ratios.[6] In addition, Glasserman and Perotti (2017) argue that political pressures constrain bank regulators from using their discretion to force a conversion or write down. Consequently, regulatory forbearance can also lead to CoCos' failure to recapitalize a bank prior to its "point of non-viability," i.e., insolvency.

This is exactly what happened with the first "test case" of AT1 CoCos. Spain's Banco Popular had two issues of EC CoCos with triggers at the CET1/RWA ratios of 5.125% and 7.00%. When on 6 June 2017 the European Central Bank (ECB) declared the bank to be non-viable and the European Single Resolution Board sold the bank's assets, senior debt, and deposits to Santander, Banco Popular's last reported CET1/RWA ratio was above 7%. The

[6] Similarly, Duffie (2009) notes that Citigroup's Tier 1 capital ratio was 11.8% in December of 2008 and Kuritzkes and Scott (2009) note that the five large U.S. banks that failed or were distressed acquisitions reported Tier 1 capital ratios between 12.3% and 16.1% at the quarter-end before they closed.

resolution made Banco Popular's shareholders' equity, CoCos, and subordinated debt all worthless. Thus, its unconverted AT1 CoCos performed as gone-concern capital, effectively being no different from the bank's Tier 2 capital, which may have surprised investors.[7] [8]

Our paper addresses the broader issue of whether investors, in general, believe CoCos are likely to convert or be written down prior to insolvency. We first develop a simple model that shows if a bank issues a CoCo that investors expect will not convert or be written down before insolvency, then the CoCo acts similar to subordinated debt and makes the bank's stock returns more extreme. This is a pure "leverage" effect on stock returns due to more debt. Instead if investors believe the CoCo will absorb losses via a conversion or write down while the bank is solvent, then the CoCo cushions the downside risk of the bank's stock. This "insurance" effect can offset the "leverage" effect and make stock returns less extreme. Thus, both the distribution of a bank's stock returns and its CoCo yields relative to those of its subordinated debt shed light on whether CoCos are gone-concern or going-concern forms of capital.

These model predictions guide our empirical tests that use data from a sample of European banks during 2011 to 2017 when there was substantial CoCo issuance. Our first set of tests analyze how a bank's stock returns change before and after it issues a CoCo. We find that, in general, CoCos tend to reduce stock returns' variances and other measures of tail risks. Moreover, EC CoCos appear to have a greater effect relative to WD CoCos, consistent with investor beliefs that EC CoCos may tend to have more loss-absorption prior to insolvency. These

[7] See "Going going gone" by Reuters' Neil Unmack who on 7 June 2017 states "Popular's bonds fell short. The securities are supposed to provide extra capital before a bank fails, allowing it to absorb losses over time without failing or requiring a government bailout. But regulators deemed Popular non-viable before any of the triggers in its bonds could blow….Before the news of the resolution, Popular's CoCo bonds were trading at around 50 percent of face value….Higher-ranked Tier 2 bonds were trading around 80 percent of par…Both are now worthless."

[8] Investors may have been surprised in part because during the European sovereign debt crisis some solvent banks imposed losses on investors of other hybrid capital instruments. Vallée (2017) examines European banks' imposition of losses on callable subordinated debt investors by not following their previous practice of calling the debt and then offering a discounted tender offer to the investors. While the tender offers were voluntary, in many cases they were accepted, which had the effect of increasing the banks' Tier 1 capital.

results are robust to controlling for the potential endogeneity of CoCo issuance and for asset risk-shifting incentives.

Our second set of tests consider the model's prediction that if there is a decline in the likelihood that CoCos absorb losses while the bank is solvent, their yields should decrease relative to those of standard subordinated debt. We investigate two regulatory actions that may have influenced investors' perceptions regarding CoCos' going-concern loss absorption. The first was a 10 March 2016 announcement by the European Commission that made it less likely that capital regulations would force going-concern losses on CoCos. The second is the 7 June 2017 failure of Banco Popular. Indeed, we find evidence that these events reduced the difference between the credit spread on a bank's CoCos and the credit spread on its subordinated debt, consistent with a belief that CoCos are less like going-concern capital and more like gone-concern capital.

Our paper contributes to small empirical literature that examines the effect of CoCo issuance on market prices. Avdjiev et al. (2015) and Ammann et al. (2017) conduct event studies that examine a bank's stock price and credit default swap (CDS) spread reactions to its CoCo issuance. Both studies show that CoCo issuance significantly reduces the spreads of CDS contracts written on the bank's more senior debt. The former study finds mixed evidence of a significant stock price reaction, but the latter one finds a positive stock price reaction. Berg and Kaserer (2015) show that Lloyds Bank CoCo returns are more sensitive than standard debt to changes in the implied volatility of Lloyd Bank's stock, consistent with its CoCos absorbing losses at conversion. Hesse (2016) compares yields on subordinated debt, WD CoCos, and EC CoCos, and finds that WD CoCos tend to have the highest yields, followed by EC CoCos.

The recent distress of large European banks, such as Deutsche Bank's early 2016 announcement of a record €6.8 billion loss for 2015 and Banco Popular's failure in June 2017, have raised concerns as to whether CoCos reduce or exacerbate systemic risk. Gleason et al. (2017) find negative stock price reactions of large banks upon news events that created uncertainty over payments on Deutsche Bank's CoCos. Kiewiet et al. (2017) also show that the Deutsche Bank crisis in early 2016 created a significant market-wide downturn of CoCo prices, and the negative reaction was substantially unrelated to the issuing bank's likelihood of being capital-constrained. De Spiegeleer et al. (2017) confirm the Deutsche Bank crisis's negative effect on the CoCo market, while they find no significant impact for the Banco Popular resolution in June 2017, perhaps because the distress at Banco Popular had started in mid-2015.

As far as we are aware, our paper is unique in testing whether CoCos are perceived as going-concern capital by analyzing the annual volatility of a bank's stock returns before versus after its issuance of a CoCo. This contrasts with prior work that uses an event study framework to infer stock and senior debt price reactions to CoCo issuance. We do conduct an event study of CoCo and subordinated debt spreads, but to examine regulatory actions that are predicted to change the going-concern nature of CoCos.

The remainder of the paper is structured as follows. Section II presents a model that predicts how stock return volatility and the difference between CoCo and subordinated debt yields are affected by a CoCo's likelihood of absorbing losses while its bank is a going concern. Section III provides empirical evidence on the relationship between CoCo issuance and changes in stock return volatility while Section IV contains event study evidence of recent regulatory actions' effects on CoCos' going concern loss absorption. Section V draws conclusions.

II. A Model of Bank Stock Returns

Consider a two-period model with dates 0, 1, and 2 that uses the binomial framework of Cox, Ross, and Rubinstein (1979). Initially, we analyze a bank that is financed by two-period deposits and shareholders' equity. Then, we examine how the distribution of shareholders' equity changes after the bank also issues CoCos that may be written down or may convert to equity at the end of the first period. Technical details and proofs of results are given in the Appendix.

II.1 A Bank without CoCos

At date 0 a bank issues deposits and shareholders' equity whose initial values are denoted as D_0 and S_0, respectively. As a result, the bank's initial assets equal their sum, denoted as $A_0 = D_0 + S_0$. Let R_F be the constant per-period default-free return, equal to 1 plus the default-free interest rate. The bank's assets are risky and have a binomial distribution each period. With probability p the bank's assets experience a proportional return of u, and with probability 1-p they have a proportional return d, where $d < R_F < u$. Returns d and u can be interpreted occurring in states of the world when the bank's loans have default rates that are high and low, respectively.

Assuming complete markets, assets equal the risk-neutral expectation of their discounted end-of-period value, $A_t = \hat{E}_t\left[A_{t+1}\right]/R_F$. An implication is that the risk-neutral probabilities of the high asset return and low asset return are $\hat{p} \equiv \left(R_F - d\right)/\left(u-d\right)$ and $1-\hat{p} = \left(u - R_F\right)/\left(u-d\right)$, respectively. Thus, the risk-neutral distribution of the bank's asset values at date 2 is

$$A_2 = \begin{cases} u^2 A_0 & \text{with risk-neutral probability } \hat{p}^2 \\ udA_0 & \text{with risk-neutral probability } 2\hat{p}\left(1-\hat{p}\right) \\ d^2 A_0 & \text{with risk-neutral probability } \left(1-\hat{p}\right)^2 \end{cases} \tag{1}$$

To make the problem interesting, we assume that the amount of initial shareholders' equity (bank capital) is large enough to avoid default on the bank's deposits if the assets have a low return in no more than one of the two periods. However, equity capital is inadequate to avoid default if low returns occur in both periods, making deposits default-risky.[9] Let R_D equal one plus the promised deposit interest rate so that that bank's date 2 promised payment is $D_0 R_D^2$. R_D is set fairly such that the initial value of deposits equals the amount contributed, D_0.

The following lemma gives the distributions of the bank's stock return over the first period and over the first and second periods.

Lemma 1: Consider a bank financed with only deposits and shareholders' equity and having an initial deposit to stock ratio of $l_0 \equiv D_0/S_0$. Then its stock return distributions over the first period and over the first and second periods are given by

$$\frac{S_1}{S_0} = \begin{cases} \frac{1}{R_F}\left[u\left(1+l_0\right)\left(\hat{p}u+\left(1-\hat{p}\right)d\right)-l_0 R_D^2\right] & \text{with risk-neutral probability } \hat{p} \\ \hat{p}\,\frac{ud\left(1+l_0\right)-l_0 R_D^2}{R_F} & \text{with risk-neutral probability } 1\text{-}\hat{p} \end{cases} \tag{2}$$

and

$$\frac{S_2}{S_0} = \begin{cases} u^2\left(1+l_0\right)-l_0 R_D^2 & \text{with risk-neutral probability } \hat{p}^2 \\ ud\left(1+l_0\right)-l_0 R_D^2 & \text{with risk-neutral probability } 2\hat{p}\left(1-\hat{p}\right) \\ 0 & \text{with risk-neutral probability } \left(1-\hat{p}\right)^2 \end{cases} \tag{3}$$

where

$$R_D^2 = \frac{R_F^2 - \left(1-\hat{p}\right)^2 d^2 \left(1+\frac{1}{l_0}\right)}{\hat{p}^2 + 2\hat{p}\left(1-\hat{p}\right)}. \tag{4}$$

Proof: See the Appendix.

[9] Appendix A gives the parametric conditions on the asset to deposit ratio, $(S_0 + D_0)/D_0$, whereby deposits default when asset returns are low in both periods but do not default when asset returns are low in only one or zero periods.

Lemma 1 shows that the bank's stock return distribution depends on the promised deposit interest rate, R_D, which in turn is an increasing function of the bank's initial "leverage ratio," l_0. The next section derives the stock return distribution for a similar bank that also issues CoCos.

II.2 A Bank with CoCos

Now consider a bank that issues the same amounts of deposits, D_0, and shareholders' equity, S_0, as the previously-analyzed bank that issued no CoCos. In addition, the current bank issues CoCos with initial principal of C_0 so that its initial assets equal $A_0^* \equiv A_0+C_0 = D_0+S_0+C_0$.

For simplicity, we assume that the bank's initial assets are just large enough to avoid default on its deposits if the low return, d, is realized in both periods, making the promised return on deposits equals the default-free return of R_F. Specifically, let $d^2 A_0^* = D_0 R_F^2$ or $A_0^* = D_0(R_F/d)^2$, so that $C_0 = D_0(R_F/d)^2 - D_0 - S_0$. This assumption is in the spirit of recent bank regulations that require banks to have total loss-absorbing capacity (TLAC) such that depositors, or deposit insurers, sustain no loss if a bank fails. An implication is that if the bank's assets return d in each period, both shareholders' equity and contingent capital have a date 2 payoff equal to zero.

Two types of CoCos are considered: CoCos that may be written down and CoCos that may convert to new shareholders' equity. We assume that if the bank experiences the low return of d over the first period, then there is a risk-neutral probability π that the CoCo is written down or converted. With risk-neutral probability $1-\pi$, it is not written down or converted and promises to pay $C_0 R_C^2$ at the end of the second period, where R_C is the CoCo's fair promised return.

CoCo write downs or conversions are modeled as being uncertain for at least two reasons. First, in practice CoCo triggers are based on accounting value regulatory capital ratios, rather than market value capital ratios. Since banks can, and do, attempt to manipulate accounting values, writing down or converting a CoCo depends on a bank's likely uncertain ability to alter its regulatory capital.[10] Second, CoCo contracts also give regulators discretion to force a write down or conversion. Given that CoCos are relatively new instruments, it is unclear how strict regulators may be when employing this discretion.[11]

If principal write-down CoCos are written down at date 1, their new principal equals wC_0 where $0 \leq w < 1$. If equity conversion CoCos are converted at date 1, they become new equity shares equal to a proportion ρ of the bank's total shares following the conversion. For brevity, we present the case of principal write down CoCos, which are the most popular type of CoCo.[12] However, the Appendix shows that the distribution of stock returns for equity conversion CoCos equal those for write down CoCos when

$$\rho = \frac{wdC_0 / D_0}{(u-d)\left[\hat{p}^2 + \hat{p}(1-\hat{p})\left(2-\pi(1-w)\right)\right]} \tag{5}$$

When condition (5) holds, equity conversion and write down CoCos have the same loss when converted or written down and have the same promised return, R_C. Hence, for a given write-down rate, w, and CoCo to deposit ratio, C_0/D_0, we can translate results for principal write-down CoCos to equity conversion CoCos. While, in principle, equity conversion CoCos could convert to sufficiently many new shares such that CoCo investors obtain a gain relative to their unconverted bond's value, Berg and Kaserer (2015) show that in practice CoCo investors are highly likely to suffer a loss at conversion relative to the CoCo's par value. This is because CoCo contracts convert to too few shares given the estimated stock price when a bank's regulatory capital ratio hits its trigger. Thus we assume values for ρ in condition (5) consistent with $w < 1$.

[10] There is extensive empirical evidence that banks manipulate accounting values to maintain a high regulatory capital ratio in the face of market value losses. See Haldane (2011), Mariathasan and Merrouche (2014), Begley, Purnanandam, and Zheng (2015), and Plosser and Santos (2015).
[11] Uncertainty over regulatory discretion in early 2016 is cited as a factor for the volatility in Deutsche Bank's CoCos. See Gleason et al. (2017).
[12] Write down CoCos are 53% of our sample and 55% of the sample in Avdjiev et al. (2015).

The Appendix gives the model's parametric conditions such that if the bank's assets have a low return during no more than one period, then assets are sufficient to pay the date 2 promised payments on unconverted CoCos and deposits. Given these conditions, the next lemma derives the CoCo-issuing bank's stock return distribution over the first period and over both periods.

Lemma 2: Consider a bank financed with deposits, shareholders' equity, and CoCos that with probability π are written down to a proportion w of their initial principal if the bank's assets earn the low return of d over the first period. Let $l_0 \equiv D_0/S_0$ and $c_0 \equiv C_0/S_0$ be the ratios of initial deposits to initial stock and of initial CoCos to initial stock, respectively. Then the bank's stock return distributions over the first period and over both periods are

$$\frac{S_1}{S_0} = \begin{cases} \dfrac{(1+l_0+c_0)u\left(\hat{p}u+(1-\hat{p})d\right)-\left(c_0R_C^2+l_0R_F^2\right)}{R_F} & \text{with risk-neutral probability } \hat{p} \\ \hat{p}\dfrac{ud(1+l_0+c_0)-\left(c_0R_C^2+l_0R_F^2\right)}{R_F} & \text{with risk-neutral probability } (1-\pi)(1-\hat{p}) \\ \hat{p}\dfrac{ud(1+l_0+c_0)-\left(wc_0R_C^2+l_0R_F^2\right)}{R_F} & \text{with risk-neutral probability } \pi(1-\hat{p}) \end{cases} \tag{6}$$

and

$$\frac{S_2}{S_0} = \begin{cases} u^2(1+l_0+c_0)-\left(c_0R_C^2+l_0R_F^2\right) & \text{with risk-neutral probability } \hat{p}^2 \\ ud(1+l_0+c_0)-\left(c_0R_C^2+l_0R_F^2\right) & \text{with risk-neutral probability } (2-\pi)\hat{p}(1-\hat{p}) \\ ud(1+l_0+c_0)-\left(wc_0R_C^2+l_0R_F^2\right) & \text{with risk-neutral probability } \pi\hat{p}(1-\hat{p}) \\ 0 & \text{with risk-neutral probability } (1-\hat{p})^2 \end{cases} \tag{7}$$

where

$$R_C^2 = \frac{R_F^2}{\hat{p}^2+\hat{p}(1-\hat{p})\left(2-\pi(1-w)\right)}. \tag{8}$$

Proof: See the Appendix.

II.3 Model Predictions on Stock Volatility and CoCo Yields

An analysis of the stock return distributions given in Lemmas 1 and 2 leads to the following proposition.

Proposition 1: Consider a bank that issues only deposits and shareholders' equity versus a bank with the same deposits and equity that also issues CoCos. The CoCo-issuing bank's stock return variance is decreasing in both the probability that CoCos are written down, π, and the CoCos' loss given a write down, (1-w). For sufficiently low values of $\pi(1-w)$, the CoCo-issuing bank's stock return variance is higher than that of the bank that does not issue CoCos. However, when $\pi(1-w)$ is sufficiently large, the CoCo-issuing bank has a relatively lower stock return variance. These qualitative results hold for stock returns computed over the first period or over both the first and second periods.

Proof: See the Appendix.

Note that while Proposition 1 is stated in terms a CoCo that has its principal written down, the same results hold for an equity conversion CoCo: the greater the likelihood of conversion, π, and the smaller is the value of shares granted to CoCo investors, ρ, the lower is the stock return variance of the CoCo-issuing bank.[13]

The intuition for Proposition 1 is straightforward. Consider the polar case of CoCos that have a zero probability of being written down, $\pi=0$ or experience no reduction of principal upon being written down, $w = 1$. Such CoCos are equivalent to standard, 2-period subordinated debt, and the CoCo-issuing bank is equivalent to a more highly-levered version of the bank that does not issue CoCos. This "pure leverage" effect makes the CoCo-issuing bank's stock returns more

[13] For write down and equity conversion CoCos that give rise to identical CoCo and stock return distributions satisfying equation (5), straightforward algebra shows that $\partial\rho/\partial w > 0$. In other words, a larger write down (lower w) translates to a smaller value of equity at conversion (lower ρ).

extreme.[14] With more leverage, the fair total promised return per unit debt, or equivalently the debt's fair credit spread, is higher. An implication is that depositors and CoCo investors receive more interest when the bank does not default, which includes the scenario when there is only one low bank asset return over the two periods. Since shareholders must receive a lower return in this same scenario when there is only one low asset return over both periods, equilibrium requires that they receive a higher return when the bank's assets earn high returns over both periods. Consequently, stock returns become more extreme for the CoCo-issuing bank.

However, this leverage effect can be offset by an "insurance effect" when there is a sufficiently high probability that CoCos are written down at a loss; that is, when $\pi(1\text{-}w)$ is sufficiently large. Compared to the depositors of the bank without CoCos, the CoCo-issuing bank's total debtholders may be paid a lower total amount per unit debt in the scenario where the bank experiences a low asset return in only one of the periods. That is because this scenario includes the event where CoCo investors experience a write-down loss. In turn, the CoCo-issuing bank's shareholders experience a relative gain in this asset return scenario compared to the shareholders of the bank with only deposits. Therefore, when assets have a high return over both periods, equilibrium requires relatively higher compensation to CoCo investors and a relatively lower return to shareholders. Consequently, stock returns across the two scenarios are less extreme for the CoCo-issuing bank relative to those of the bank without CoCos.

The intuition for Proposition 1's results carries over to other tail risk statistics for the stock return distribution. When CoCos are subject to a high probability of write down or loss in the low asset return state, they absorb more asset losses in this bad state so that shareholders will absorb less due to the insurance effect. Hence, a high probability of CoCo loss absorption will

[14] This result is consistent with the continuous-time structural model of Merton (1974).

reduce the stock's crash risk, Value at Risk (VaR), and Expected Shortfall (ES) relative to these downside measures for stock returns of a bank without CoCos.

Figures 1 and 2 illustrate the results of Proposition 1 by graphing a CoCo-issuing bank's annualized (per-period) standard deviation of stock returns implied by the model. The figures assume $u = 1/d = e^{0.04}$ which is consistent with empirical estimates of an approximately 4% bank asset return volatility (Pennacchi, Vermaelen, and Wolff (2014)). It is also assumed that the default-free interest rate is zero, so that $R_F = 1$, and the initial deposit-to-equity ratio equals $l_0 = D_0/S_0 = 20$. These parameters imply that the ratio of initial CoCos-to-equity required to make deposits default-free equals $c_0 = l_0\left[\left(R_F / d\right)^2 - 1\right] - 1 = 0.666$. Thus, the bank issues an initial amount of CoCos equal to two-thirds the amount of initial shareholders' equity.

Figure 1 gives the standard deviation (volatility) of S_1/S_0 as a function of π, the probability that the CoCo is written down or converted if returns are low over the first period. The blue dotted line is the volatility of the bank that does not issue CoCos, which is a constant 63%. The red dashed line is the stock volatility of a CoCo-issuing bank where the loss given a write down or conversion is (1-w) = 50%. The solid green line is the stock volatility of a CoCo-issuing bank where the write down or conversion loss is greater at (1-w) = 75%. One can see that for very low π, the pure leverage effect leads to slightly higher one-period stock volatility for the CoCo-issuing banks compared to the bank without CoCos. Yet when π is sufficiently large, the CoCo-issuing banks' stock volatilities are significantly below that of the bank without CoCos, and the reduction in stock return volatility is greater when the CoCo loss is greater.

The qualitative results are the same when comparing stock return volatilities over two periods. Figure 2 shows the per-period (annualized) standard deviation of S_2/S_1, which for the bank without CoCos is equal to 65%. Here there is a greater range of low π values where the leverage effect dominates the insurance effect. Yet when π exceeds around 35%-40%, the CoCo-issuing bank's stock volatility becomes lower than that of the bank without CoCos, and as Proposition 1 predicts, the effect is larger when the loss at write-down or conversion is greater.

Proposition 1 allows for the possibility that different types of CoCos may have different effects on stock return volatility. For example, if investors perceive that there is a greater possibility that equity conversion CoCos will be converted at a loss compared to the possibility that principal write down CoCos will be written down at a loss, then the reduction in stock volatility could be greater for the former type of CoCo than the latter type.

We close this section by stating an additional model implication.

Proposition 2: When $w < 1$ or ρ in equation (5) is consistent with $w < 1$, then a decline in the probability of a write down or conversion, π, reduces the fair yield on a CoCo so that it is closer to the yield on standard subordinated debt.

Proof: See the Appendix.

Proposition 2 guides our second set of empirical tests. Its simple intuition is that a lower probability of CoCo losses due to a write down or conversion will reduce CoCo credit spreads, making them more like those of standard subordinated debt.

III. Empirical Analysis of CoCo Issuance and Stock Return Volatility

This section examines whether CoCos are going concern capital based on the insights from Proposition 1. It first discusses the data and variables used in our tests. Next, it considers identification issues related to our test methodology. Our empirical test results then follow.

III.1 Data and Variable Construction

We collected data during the period 2011 to 2017 for all European listed banks from several sources.[15] Information on CoCo issuances were obtained from Bloomberg, and daily bank stock returns taken from Datastream. Each bank's annual accounting information was obtained from Orbis Bank. Descriptions of all variables calculated from this data are given in Table 1 while summary statistics are reported in Table 2.

Table 2 shows our sample's data on CoCo issuance by country (Panel A) and by year (Panel B). The first column of each panel indicates the number of banks issuing CoCos, while the second and the third columns show, respectively, the number of banks issuing equity conversion (EC) and write down (WD) CoCos. These two columns do not always sum up to the first, since banks sometimes issued both EC and WD CoCos in the same year. Overall, we have 91 bank-year observations when CoCos were issued, corresponding to 41 different banks.

Our tests use several stock return risk variables that we now discuss. One is the annualized standard deviation of weekly bank stock returns (VOL), which is the most common measure of return volatility. The others are measures of bank-specific "crash" or downside" risk that adjust for market-wide movements. Following Hutton et al. (2009) and Dewally and Shao (2013), we run a stock return regression that includes lag and lead terms for market returns:

$$r_{i,t} = \alpha_i + \beta_1 r_{m,t-2} + \beta_2 r_{m,t-1} + \beta_3 r_{m,t} + \beta_4 r_{m,t+1} + \beta_5 r_{m,t+2} + \varepsilon_{i,t} \tag{9}$$

where $r_{i,t}$ is the date t return for bank i in week t and $r_{m,t}$ is the market index return over the same week. The market return is the MSCI Europe All Cap, a broad European stock index.

From this augmented market model, we calculate several crash risk measures from bank-specific returns, defined as the residual rate of return, $\varepsilon_{i,t}$, from regression (9). Following prior research, e.g., Hutton et al. (2009), the threshold to identify a crash event is defined as 3.09

[15] CoCo issuance was rare before the end of 2010 when the Basel Committee made public a new set of capital requirements for banks.

standard deviations below the mean of the bank's residual returns.[16] An upward "jump" occurs when the bank-specific return is higher than its mean plus 3.09 standard deviations. Our first measure of crash risk is *N_CRASH*, which is the number of crashes registered in a given year. We also consider the number of jumps (*N_JUMP*) and the number of crashes minus the number of jumps in a given year (*CRASH_JUMP*). Another measure of crash risk is *NCSKEW*, given by the negative of the third moment of bank-specific weekly returns, divided by the cube standard deviation, e.g., Callen and Fang (2015):

$$NCSKEW_{i,t} = -\frac{n(n-1)^{3/2}\sum_{i=1}^{n}\varepsilon_{i,t}^{3}}{(n-1)(n-2)\left(\sum_{i=1}^{n}\varepsilon_{i,t}^{2}\right)^{3/2}} \tag{10}$$

We also calculate down-to-up volatility (*DUVOL*), which is the log of the ratio of the standard deviation in the crash weeks to the standard deviation in the jump weeks:

$$DUVOL_{i,t} = \ln\left(\frac{(n_j-1)\sum_{crash}\varepsilon_{i,t}^{2}}{(n_c-1)\sum_{jump}\varepsilon_{i,t}^{2}}\right) \tag{11}$$

Perhaps the most common measure of downside risk is Value at Risk (*VaR*), which we calculate from historical simulation with a confidence level of 97.5%, a one-day holding period, and using one year of daily stock returns. We also calculate Expected Shortfall (*ES*) over the same time horizon.

III.2 Identification and Test Methodology

Our model assumes the bank asset volatility, as modelled by the returns *u* and *d*, is the same for a bank that issues CoCos and one that does not. Yet theory on the risk-taking incentives of CoCos predicts that a bank's shareholders prefer greater asset risk when a CoCo's contractual

[16] If the distribution of bank-specific returns were normal, the frequency of a crash or jump would be 0.1% each week or about 5% in a year. As shown in Table 2 Panel C, our sample's frequency of crashes is much higher than would be consistent with a normal distribution.

terms impose losses on their investors when written down or converted into equity (Calomiris and Herring (2013), Chan and van Wijnbergen (2016), Berg and Kaserer (2014), Hilscher and Raviv (2014), Koziol and Lawrenz (2012), Pennacchi, Vermaelen, and Wolff (2014)). Hence, Proposition 1's prediction that stock return volatility declines when a bank issues going concern CoCos could possibly be offset if the bank's choice of asset return volatility is endogenous.

The relative importance of this asset "risk-shifting" incentive for stock volatility is an empirical question that we consider in a preliminary diagnostic test. Moreover, our main empirical test based on Proposition 1 also accounts more generally for whether the issuance of a CoCo is endogenous to bank managers' beliefs that future asset volatility will change.

Specifically, our diagnostic test of asset risk-shifting considers the panel data regression

$$Y_{i,t} = \alpha + \beta_1 Post\_CoCo_{i,t} + \gamma' Controls_{i,t-1} + A_i + B_{j,t} + \eta_{i,t} \tag{12}$$

where $Y_{i,t}$ is an asset risk measure of bank i in year t and $Post\_CoCo_{i,t}$ is an indicator that bank i had issued a CoCo prior to year t. The coefficient of this indicator variable shows whether asset risk changed any time after the bank issued a CoCo. $Controls_{i,t}$ are a vector of control variables that include bank size (log of total assets), profitability (Return on Assets), specialization (loans-to-total assets), efficiency (cost-to-income ratio), and capital (total capital-to-assets). We also control for bank fixed effects, A_i, and country×year fixed effects, $B_{j,t}$. These fixed effects should account for bank-specific and annual country-level differences in risks.

Our risk measures, $Y_{i,t}$, include the bank's risk-weighted asset-to-total asset ratio (RWA ratio) and its ratio of non-performing loans-to-total loans (NPL ratio). This latter measure is especially relevant in Europe where most banks are highly lending-oriented (Fiordelisi et al. (2017)). We also consider several measures of asset composition: loans-to-total assets, securities-to-total assets; derivatives-to-total assets; and off-balance sheet items-to-total assets.

After investigating whether CoCo issuance is directly associated with a change in asset risk, we further examine whether there is a causal link between CoCo issuance and a subsequent change in the volatility of a bank's stock returns. There are two challenges to establishing causality. First, CoCo issuance could be endogenous to managers' expectations of future stock return volatility, leading to a reverse causality problem. Second, there may be omitted variables that bias our inference that CoCos are associated with changes in stock return volatility. Our main test based on Proposition 1 must address these potential problems.

To account for the possibility of endogeneity of CoCo issuance, we use a dynamic panel data model similar to Fresard (2010), Dal Bó et al. (2017), Dessaint, Golubov, and Volpin (2017), and Gopalan, Mukherjee, and Singh (2017). CoCo issuance, our "treatment" variable, is considered at the time of issuance (date *t*), one year prior to issuance (date *t*-1), and one year after issuance (date *t*+1). This is done by creating the following indicator variables. $CoCo_{i,t}$ equals 1 if the bank issues a CoCo in the current year *t*. $Post\_CoCo_{i,t}$ equals 1 if year *t* is one year after the bank issued a CoCo. Finally, $Pre\_CoCo_{i,t}$ equals 1 if year *t* is one year before a bank issues a CoCo. Specifically, we run the regression

$$Y_{i,t} = \alpha + \beta_1 Pre\_CoCo_{i,t} + \beta_2 CoCo_{i,t} + \beta_3 Post\_CoCo_{i,t} + \gamma' Controls_{i,t-1} + A_i + B_{j,t} + \eta_{i,t} \quad (13)$$

where the dependent variable, $Y_{i,t}$, is a measure of bank *i*'s stock return volatility in year *t*. A significant β_2 coefficient on $CoCo_{i,t}$ would indicate a contemporaneous relationship between CoCo issuance and stock return volatility. A significant coefficient β_3 on $Post\_CoCo_{i,t}$ would indicate a causal relationship between CoCo issuance and stock volatility. Finally, a significant β_1 coefficient on $Pre\_CoCo_{i,t}$ would indicate a (reverse-) causal relationship between stock volatility and CoCo issuance. An insignificant β_1 coefficient on $Pre\_CoCo_{i,t}$ would be consistent with meeting the randomization condition for the treatment; that is, banks that do and do not issue CoCos behave similarly before a CoCo is issued, alleviating concerns of reverse causality. We also control for the possibility that a bank does not issue CoCos in a given period but has issued CoCos in the past by defining an indicator variable ($CoCo\_Out_{i,t}$) taking the value of 1 if the bank has an outstanding CoCo. As a robustness check, we also run our dynamic panel data model taking into account only CoCos outstanding, rather than CoCos issuance.

The regression equation (13) also addresses potential omitted variable bias by including bank fixed effects, A_i, and country×year fixed effects, $B_{j,t}$. These fixed effects control for any omitted bank-specific or country-year variables. Additional controls include bank size, profitability, specialization, efficiency, capital, and capital quality (ratio of Tier 1 capital to total capital). This last control accounts for the bank's use of subordinated debt and other hybrid instruments.

III.3 Empirical Results

III.3A CoCo Issuance and Bank Asset Risk

We begin by examining the empirical validity of a main assumption of our model, namely, that banks do not change their asset risk after issuing CoCos. The results of running regression (12) where the dependent variables are measures of asset risk are reported in Table 3. The key explanatory variable in Panel A is $Post\_CoCo_{i,t}$ that indicates whether the bank had issued a CoCo in a prior year. As shown its estimated coefficient in each of the regressions, there is no significant evidence that issuing a CoCo is associated with higher asset risk. In particular, while the sign of the coefficients on $Post\_CoCo_{i,t}$ is positive for the RWA ratio regression and negative for the NPL ratio regression, they are not close to being statistically significant at conventional confidence levels. There also is little evidence that banks shift their portfolio's proportion of loans, securities, derivatives, and off-balance sheet items.

To see whether the results hold if we consider EC CoCos separately, Panel B of Table 3 reports similar regression as those in Panel A but replaces $Post\_CoCo_{i,t}$ with $Post\_CoCo\_EC_{i,t}$ that indicates whether the bank had issued an EC CoCo in a prior year. The results show no significant relationship between EC CoCo issuance and any of the six measures of asset risk. Panel C reaches the same conclusion when WD CoCos are considered separately. Issuing a WD CoCo does not predict a significant change in any of the measures of asset risk.

Note that if we had found a positive relationship between CoCo issuance and asset risk, as previous theoretical research suggests, it would have biased our tests against finding that CoCos are going concern capital. This is because a going-concern CoCos' insurance effect on stock return downside risk could be neutralized by higher bank asset risk. However, it is also comforting that the regressions in Table 3 do not indicate that CoCo issuance leads to *lower* asset risk. Such a finding would confound our inference that it is CoCos' loss absorption prior to insolvency, not a decline in asset risk, that leads to lower stock return volatility.

III.3B CoCo Issuance and Bank Stock Return Volatility

We now examine the model's implication stated in Proposition 1. If investors believe that CoCos are likely to absorb losses prior to insolvency, a bank that issues them should find that its stock volatility declines. If, instead, CoCos are unlikely to experience losses due to a write down or conversion, the issuing bank should see a rise in its stock volatility. This insight is examined by running the regression in equation (13) using as dependent variables several different measures of volatility and tail risks. Recall that this specification is also designed to examine the possibility of reverse causality.

Prior research has uncovered some differences between EC and WD CoCos. Avdjiev et al. (2015) find that the reduction of senior bond CDS spreads at the time of CoCo issuance tends to be greater for EC CoCos compared to WD CoCos. Comparing CoCos during the period 2013 to 2016, Hesse (2016) shows that WD CoCos tend to have higher yields than EC CoCos. Consistent with past literature, we run the model shown in equation (13) differentiating between EC and WD CoCos by replacing the indicator variable *CoCo* with two different ones: *CoCo_EC* equals 1 if the bank issues an EC CoCo; and *CoCo_WD* equals 1 if the bank issues a WD CoCo.

Table 4 reports the results of running the regression model for EC CoCos. First note that there is little evidence of a reverse causality problem: the coefficients on *Pre_CoCo_EC* are statistically insignificant for all risk measures, thereby enabling us to interpret the *CoCo_EC* and the *Post_CoCo_EC* coefficients in a causal way. The results in Table 4 also show that for several different measures of stock return volatility, the *Post_CoCo_EC* coefficients are negative and statistically significant at the 5% (*VOL*, *DUVOL*, *VaR*, *ES*). The contemporaneous effect is negative and statistically significant at the 5% confidence level or less for two indicators of crash risk (*N_CRASH* and *NCSKEW*) and also for the number of jumps (*N_JUMP*).

As shown in the Internet Appendix Table IA1, these findings are substantially confirmed if we run the model considering the outstanding, rather than the issuance, of EC CoCos. There is no evidence of reverse causality and, when statistically significant at the 10% confidence level or less, the coefficients for the outstanding indicator variables at time *t* and time *t*-1 imply a negative impact on stock return risk.

Overall, these results suggest that the issuance of EC CoCos causes a decline in stock return volatility, tail, and downside risks. This evidence is consistent with investors assigning a non-negligible probability of CoCos being converted to equity prior to the issuing bank's insolvency, even though such events have not occurred as of this writing.

Next, we turn to examining whether these results are also valid for WD CoCos.

As can be seen in Table 5, WD CoCos appear to have no effect on reducing stock return volatility. The coefficient for both the contemporaneous and the post-issuance effect are never statistically significant at the 10% confidence level or less, irrespective of the risk measure considered. Moreover, Internet Appendix Table IA2 shows that the same results hold if for a regression where the treatment is the outstanding of WD CoCos, rather than their issuance.

Overall, there appears to be differences in investors' perceptions regarding EC CoCos versus WD CoCos. They seem to believe that EC CoCos are effective in reducing the issuing bank's stock return volatility and tail risks, consistent with them being going concern capital. In contrast, WD CoCos have no significant effects on stock return volatility and tail risks, implying less likelihood that they absorb losses when the bank is still solvent. What might explain these differences?

One possibility is that investors expect that a write down is less likely than a conversion. A write down may be viewed as imposing more explicit losses on CoCo investors than a conversion to equity. Thus, both banks (for reputational reasons) and regulators (for investor protection reasons) maybe more hesitant to trigger or force write down losses. This may render the probability of conversion, and hence the effect on reducing bank risk prior to insolvency, higher for EC rather than for WD CoCos. Second, even if the probabilities of conversion and write down are similar, there could be a difference in the losses imposed on CoCo investors due to conversion (ρ in the model) and the losses imposed on CoCo investors due to a write down (w in the model).[17]

As a final step of our empirical strategy, we check that our results hold for a regression

[17] It is non-trivial to estimate EC CoCo investor losses at the time of conversion. Although the CoCo contract typically specifies the number of new shares that CoCo investors would receive, one must make an assumption regarding the per-share market price of the bank's stock when the bank's CET1/RWA ratio hits the trigger (e.g., 5.125%) or regulators force a conversion. See Berg and Kaserer (2015).

that includes both EC and WD CoCos simultaneously. This is an important robustness check, since some banks issue both types of CoCos. As can be seen from the results reported in Table 6, our conclusions are confirmed and the risk reduction effect is found only for EC CoCos. Internet Appendix Table IA3 shows that the results are qualitatively the same if we consider CoCos outstanding, rather than CoCo issuance, as the treatment.

IV. The Impact of Regulatory Actions on CoCo – Subordinated Debt Spreads

This section analyzes whether recent regulatory decisions changed investors' perceptions of whether CoCos are going-concern or gone-concern capital. It first discusses these regulatory changes and how they may affect CoCo and subordinated debt credit spreads based on our model's implication in Proposition 2. It then describes the data and empirical methodology, followed by a presentation of the test results.

IV.1 Recent Regulatory Developments Affecting CoCos

As mentioned earlier, an AT1 CoCo must have a conversion or write-down trigger tied to its bank's CET1 to RWA regulatory capital ratio, with a minimum trigger ratio of 5.125%. However, there are other minimum CET1capital requirements that can lead to going-concern losses by AT1 CoCo investors. As discussed in Mesnard and Magnus (2016) and Glasserman and Perotti (2017), if a European bank's CET1 capital falls below another constraint, it faces a "maximum distributable amount" (MDA) restriction on payment of its stock dividends and AT1 CoCo coupons.[18] Thus, failing to meet its MDA standard could cancel a bank's CoCo coupons, which has the same effect as a partial write down.[19] The MDA constraint is tied to the bank's minimum "Pillar 1" requirement of 4.5% and additional required capital buffers, including "capital conservation" and "countercyclical" buffers. On 16 December 2015, the European

[18] Payment of bonuses and pension rights are also restricted.
[19] Our model assumes that a bank issues a zero-coupon CoCo. However, a coupon-paying CoCo might be interpreted as a portfolio of zero-coupon CoCos corresponding to each coupon and principal payment.

Banking Authority (EBA) announced that the MDA constraint should also include a "Pillar 2" capital requirement incorporating a bank's "capital guidance" which becomes a requirement if the bank "consistently fails to comply."[20] Until that time, it was unclear whether this Pillar 2 requirement would be included in the MDA standard.

Together with poor earnings reports by banks such as Deutsche Bank, this Pillar 2 requirement was blamed for a widespread decline in European bank stock and CoCo prices during January and February of 2016. Apparently in response to these price declines, on 10 March 2016 the European Commission issued a clarification stating that the "guidance" portion of Pillar 2 capital would not be included in the capital requirement threshold for MDA, thereby making it less likely that CoCos would absorb losses.[21] Glasserman and Perotti (2017) interpret this action as a "retreat" by regulators; that is, regulatory forbearance. Such behavior is consistent with Walther and White (2018) who predict that regulators will fail to effectively use their discretion in order to avoid signaling negative private information to bank creditors.

Another regulatory action, or perhaps the lack of one, relates to Banco Popular which was Spain's sixth largest bank. Banco Popular had two equity conversion AT1 CoCos, one with a "high" 7.0% CET1 ratio trigger and another with a "low" 5.125% CET1 ratio trigger. Both CoCos failed to be triggered prior to 7 June 2017 when the ECB declared the bank "failing or likely to fail" and Europe's Single Resolution Board arranged its acquisition by Santander. The terms of the resolution completely wiped out Banco Popular's common shareholders' equity, its CoCos, and its Tier 2 subordinated bonds.[22] The CoCos failed to convert while Banco Popular was a going concern because its last reported CET1 ratio in the first quarter of 2017 was over

[20] On 19 February 2016, the European Central Bank (ECB) confirmed the EBA's opinion.
[21] The EU's statement calls for using a "margin of flexibility in order to avoid solutions with are too rigid and might negatively affect the AT1 bond market." At a press conference on the same day, the ECB President Mario Draghi called the EU communication "quite important" by clarifying the nature of Pillar 2 requirements that determine the MDA.
[22] The bank's senior bondholders suffered no loss as Santander took over these liabilities.

10%. Banco's Popular's closure may not have been a surprise since its stock price was trading below €1 for almost all of 2017 and much of 2016, whereas it traded over €3 at the end of 2015 and over €4 at the end of 2014. Banco Popular's failure may illustrate both the inadequacy regulatory capital ratios to signal distress and regulatory forbearance. Regulators could have forced the bank to recognize more losses and/or require conversion prior to its insolvency.

The effects of the March 2016 EU MDA announcement and the June 2017 Banco Popular failure could be interpreted by investors as reducing the likelihood that CoCos would absorb losses while a bank was a going concern. In other words, they both would have the effect of making CoCos more similar to gone-concern Tier 2 subordinated debt. Thus, our model's Proposition 2 predicts that these events should reduce the spread between a bank's CoCo yields and its subordinated debt yields. The remainder of this section will test this hypothesis.

IV.2 Data and Test Methodology

To analyze the effects of these two regulatory actions, we adopt an event study approach that compares individual banks' CoCo and subordinated debt values before versus after these events. If these events reduced the likelihood of a CoCo write down or conversion while a bank is a going concern, Proposition 2 predicts that the difference in the yields on CoCos and standard subordinated debt should narrow.[23]

In principle, we could directly compare yields on a bank's CoCos and its subordinated debt. However, a bank may have various issues of subordinated debt with different contractual

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[23] Another possible test is to compare individual banks' stock return volatilities before and after these regulatory events since Proposition 1 predicts that a decline in the likelihood of a write down or conversion, π, should raise the stock return volatilities of banks with outstanding CoCos. However, stock return volatility estimates are likely to be sensitive to confounding events that are unrelated to these regulatory actions. In contrast, the difference between observed CoCo and subordinated debt spreads is a more direct measure of investors' beliefs of whether CoCos are going concern capital and are likely to be less affected by confounding events. Note that this type of event study test using the difference between CoCo and subordinated debt spreads is not applicable to our earlier analysis that used changes in stock return volatility before and after CoCo issuance. Obviously credit spreads on a bank's CoCo are not observed prior to its issuance, and our test was to compare a bank without CoCos versus one with CoCos.

terms that could affect their yields. Instead we use a more uniform measure of subordinated debt risk, namely, the credit default swap (CDS) spread on the bank's subordinated debt. In theory, this subordinated CDS spread should equal the credit spread on a bank's subordinated floating-rate bonds.[24] We select the 5-year maturity subordinated spread, which is typically the most liquid and widely available CDS contract. As a counter-part credit spread on CoCos, we use the Z-spread on each CoCo issue. The Z-spread is a credit spread derived from discounting each promised CoCo cashflow by the zero-coupon bond yield that derives from the interest rate swap yield curve.[25]

We searched Bloomberg for pairs of these CoCo and the CDS credit spreads for individual banks during the 120 trading days surrounding each regulatory action event date. For each event date, the number of CoCo and CDS pairs used in our analysis depends on the availability of complete and liquid time series for these credit spreads. Specifically, we consider only series for which there is, on average, at least one change every 5 trading days (week). Based on each pair, we then carried out a test of whether the difference between CoCo and CDS spreads changed after the event. A decline in the difference would be evidence that the event led investors to believe that the bank's CoCo had become more like its subordinated debt.

Specifically, define bank *i*'s CoCo Z-spread on trading day *t* as $s_{i,t}^{CoCo}$ and its corresponding subordinated CDS spread as $s_{i,t}^{CDS}$. We calculated the average difference over *n* trading days before the event and the average difference over the *n* trading days after the event:

$$AVG_i^k = \tfrac{1}{n}\sum_{t=1}^{n}\left(s_{i,t}^{CoCo} - s_{i,t}^{CDS}\right) \text{ where } k = \text{ before, after} \tag{14}$$

The one-tailed test of a decline in this difference based on a 5% confidence level is

[24] Bomfin (2016) page 73 uses a no-arbitrage argument to derive this result.
[25] The Z-spread can be considered as the spread that would need to be added to the zero-coupon swap yield curve that would make these discounted cashflows equal to the market price of the CoCo.

$$AVG_i^{before} - AVG_i^{after} > 1.65\sqrt{\tfrac{1}{n}\left(Var_i^{before} + Var_i^{after}\right)} \tag{15}$$

where $Var_i^k = \frac{1}{n-1}\sum_{t=1}^{n}\left(s_{i,t}^{CoCo} - s_{i,t}^{CDS} - AVG_i^k\right)^2$. We repeated this test for two different windows: 20 trading days before and after (approximately 1 month) or 60 trading days before and after (approximately 3 months).

IV.3 Empirical Results

We first present the results for the 10 March 2016 EU MDA announcement, followed by the 7 June 2017 failure of Banco Popular. Table 7 Panel A reports the results for the EU MDA announcement of 10 March 2016. When tests use the shorter event window (-20; +20 trading days), there is strong evidence of a decline in the difference between a bank's CoCo Z-spread and its subordinated CDS spread. This difference's pre-event average across banks is 502 basis points while its corresponding post-event average is 444 basis points. Our tests using individual banks find a statistically significant decrease in the difference for 43 out of 54 CoCo-CDS pairs, while there are only 5 cases of increases in the difference. The tests are also repeated by distinguishing between the two types of CoCos: we find a reduction for 19 out of 22 equity conversion CoCos and 5 out of 32 write-down CoCos.

Tests using the longer event window (-60; + 60 trading days) find opposite evidence, with most CoCo-CDS pairs showing an increase in the difference of their spreads. However, the longer window includes the pre-event period starting in mid-December 2015, and the worst of the European bank CoCo crisis is generally considered to be 8 February 2016 when Deutsche Bank confirmed the payments of its CoCo coupons due at the end of April 2016 but also raised doubts of its ability to pay later coupons.[26] Hence, this longer event window contains a pre-event period during which CoCo spreads were initially low but rose due to other “contaminating” crisis events. Since the longer event window contains confounding events, we omit these results from Table 7 Panel A but make them available upon request.

The results for the Banco Popular failure of 7 June 2017 are shown in Table 7 Panel B. As with the previous EU MDA event, our tests using different length event windows produce conflicting evidence. Here the shorter (-20; +20 trading day) window indicates a slight increase in the difference between banks’ CoCo Z-spread and their subordinated CDS spread, with the average across banks increasing by a relatively small 12 basis points.

When the longer (-60;+60 trading day) event window is used, there is stronger evidence of convergence between spreads on CoCos and subordinated CDS, with an average decline in the difference across banks of 28 basis points. Tests using individual bank CoCo-CDS spreads find a statistically significant reduction for 27 out of 39 cases. The tests that distinguish between the two types of CoCos find a decline in the difference between equity conversion CoCo spreads and CDS spreads for 11 out of 18 cases. Even stronger evidence exists for write down CoCos where the write-down CoCo spread minus the CDS spread declines for 16 out of 21 cases.

We believe that for Banco Popular, the longer event window is more relevant. During the month prior to its 7 June 2017 resolution, investors may have believed that failure was imminent. On 5 May 2017, Banco Popular reported a €137 million first quarter loss and a decline in its deposits of 5% during the quarter.[27] This announcement likely accelerated a run on deposits

[26] Deutsche Bank’s stock fell 40% and its CoCos fell 24% from the start of 2016 to 8 February 2016. Gleason et al. (2017) Figure 2 shows that prices of other banks’ CoCos declined in tandem to those of Deutsche Bank.
[27] See “Spain’s Banco Popular reports €137m first-quarter loss: Troubled lender faces capital increase after another hit from toxic real-estate portfolio,” *Financial Times* 5 May 2017. This followed a €3.5 billion loss for all of 2016.

which declined by almost 25% during its last few weeks.[28] Banco Popular's stock price averaged €0.64 during its last 20 trading days, so even if its CoCos converted during this time, investors would have lost between 66% and 68% of their CoCo's par value.[29] Thus, investors may have been resigned to the fact that Banco Popular was already a gone concern.

Three months before its failure, there was an awareness that Banco Popular was in distress. However, investors may have believed that it was more likely than not that Banco Popular would remain a going concern.[30] Consequently, relative to the longer 60 trading day pre-event period, the fact that regulators never forced the bank's CoCos to convert should have been more of a surprise.

Overall when we condition on the most reasonable length of event window, our results suggest that the EU's MDA announcement and Banco Popular's failure reduced investors' belief that CoCo's are going concern capital. Regulators missed opportunities to strengthen investors' expectation that CoCos would recapitalize banks at an early stage of financial stress, thereby making them more resilient. Instead, it appears that political pressures led to regulatory forbearance that makes it harder to justify CoCos' status as higher-quality AT1 capital.

V. Conclusions

This paper combines theory and empirical analysis to shed light on whether investors believe that CoCos are going-concern or gone-concern capital. Our model shows that if CoCos are not expected to be written down or converted prior to a bank's insolvency, then a pure 'leverage' effect makes the bank's stock returns more extreme after CoCo issuance. Instead, if when a bank's assets suffer losses, investors expect CoCos to be written down or converted at a

[28] See "ECB triggers overnight Santander rescue of Spain's Banco Popular," Reuters 7 June 2017.
[29] The bank's "high trigger" and "low trigger" CoCos had conversion prices of €1.889 and €2.015, respectively.
[30] Hope may have risen when in February 2017 Emilio Saracho, previously of JPMorgan, took over as chairman of the bank.

loss, then an ‘insurance’ effect makes stock returns less extreme with CoCos. An implication is that by comparing a bank’s stock returns before and after CoCo issuance, we can infer whether investors believe CoCos are gone-concern or going-concern capital.

Using data on listed European banks from 2011 to 2017, several measures of bank stock return volatility were analyzed. In general, CoCo issuance leads to a reduction in stock return variance and several other measures of downside risk. Yet upon closer examination, the decline in stock return volatility appears mainly for banks that issue equity conversion (EC), rather than principal write down (WD), CoCos. This is consistent with an investor belief that conversion to equity at a loss is more likely than a write down of principal prior to a bank’s insolvency.

If the “market” views EC, but not WD, CoCos as going concern capital, then regulation might classify only EC CoCos as AT1 capital, relegating WD CoCos to Tier 2 status. But recent regulatory events suggest that even EC CoCos’ standing as going concern capital may now be in doubt. We presented event study evidence of a diminished investor perception that CoCos absorb losses prior to a bank’s failure. The change was a result of two instances of regulatory forbearance: one was the EU’s relaxation of banks’ MDA constraint, and the other was the failure to force conversion of Banco Popular’s CoCos. By showing that the difference between a bank’s CoCo credit spread and its subordinated CDS spread declined after these events, investors believed CoCos became more like gone-concern, rather than going-concern capital.

Policymakers may want to re-valuate the manner in which CoCos are triggered in order to make a bank recapitalization more likely prior to insolvency. Several academic proposals, including Haldane (2011), Calomiris and Herring (2013), Flannery (2014), and Pennacchi and Tchistyi (2015), believe that CoCo triggers must be are based on market values, rather than regulatory accounting values, in order to achieve timely write-downs or conversions.

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Table 1 - Variable Description

This table presents the definition and the source of data for all variables used in our empirical work. We collected data from the following sources: (+) Bloomberg; (#) Orbis bank; and (§) authors' calculation using Datastream data.

Variable	Definition
VOL(§)	Annualized standard deviation of the bank's stock return
N_CRASH(§)	Number of crashes in a given year
N_JUMP(§)	Number of jumps in a given year
CRASH_JUMP(§)	Number of crashes minus number of jumps in a given year
NCSKEW(§)	The negative of the third moment of bank-specific weekly returns, divided by the standard deviation cubed
DUVOL(§)	Down-to-up volatility, which is the log of the ratio of the standard deviation in the crash weeks to the standard deviation in the jump weeks
VaR(§)	Value at Risk, one-day, 97.5%
ES(§)	Expected shortfall, one-day, 97.5%
Pre_CoCo(+)	Indicator equal to 1 in a year preceding the issue of a CoCo
Pre_CoCo _EC(+)	Indicator equal to 1 in a year preceding the issue of an equity conversion CoCo
Pre_CoCo _WD(+)	Indicator equal to 1 in a year preceding the issue of a write-down CoCo
CoCo(+)	Indicator equal to 1 in a year when a CoCo is issued
CoCo__EC(+)	Indicator equal to 1 in a year when an equity conversion CoCo is issued
CoCo__WD(+)	Indicator equal to 1 in a year when a write down CoCo is issued
Post_CoCo(+)	Indicator equal to 1 in a year after the issue of a CoCo
Post_CoCo _EC(+)	Indicator equal to 1 in a year after the issue of an equity conversion CoCo
Post_CoCo__WD(+)	Indicator equal to 1 in a year after the issue of a write-down CoCo
Pre_CoCo_Out(+)	Indicator equal to 1 if the bank has an outstanding CoCo next year
Pre_CoCo_ Out_EC(+)	Indicator equal to 1 if the bank has an outstanding equity conversion CoCo next year
Pre_CoCo_ Out_WD(+)	Indicator equal to 1 if the bank has an outstanding write- down CoCo next year
CoCo(+)	Indicator equal to 1 if the bank has an outstanding CoCo
CoCo_EC_Out(+)	Indicator equal to 1 if the bank has an outstanding equity conversion CoCo
CoCo_WD_Out(+)	Indicator equal to 1 if the bank has an outstanding write-down CoCo
Post_CoCo_Out(+)	Indicator equal to 1 if the bank had an outstanding CoCo in the previous year
Post_CoCo__Out _EC(+)	Indicator equal to 1 if the bank had an outstanding equity conversion CoCo in the previous year
Post_CoCo__Out _WD(+)	Indicator equal to 1 if the bank had an outstanding write-down CoCo in the previous year
RWA ratio(#)	Ratio of risk weighted assets to total assets
NPL ratio(#)	Ratio of non-performing loans to total loans
Loans/TA(#)	Ratio of total loans to total assets
Securities/TA(#)	Ratio of total securities to total earning assets
Derivatives/TA(#)	Ratio of total derivatives to total earning assets
Off-balance sheet items/TA(#)	Ratio of total off balance-sheet items to total assets
Size(#)	Natural log of total assets
ROA(#)	Return on total earning assets
Cost-income ratio(#)	Ratio of total overheads to total operating income
Total capital ratio(#)	Ratio of total regulatory capital to risk weighted assets
Capital quality(#)	Ratio of Tier 1 capital to Total Regulatory Capital

Table 2 – **Summary Statistics**

This table shows the number of European banks issuing CoCos, categorized by whether they convert to equity or have their principal written down. Panel A gives banks issuing CoCos by country and Panel B gives banks issuing CoCos by year. Panel C shows summary statistics for all risk measures and control variables.

Panel A	All	Equity conversion	Principal write-down
Austria	6	0	6
Belgium	2	0	2
Croatia	0	0	0
Cyprus	1	1	0
Czech Republic	0	0	0
Denmark	8	1	7
Finland	0	0	0
France	11	0	11
Germany	3	0	3
Greece	0	0	0
Hungary	0	0	0
Ireland	5	4	1
Italy	7	0	7
Malta	0	0	0
Netherlands	2	2	0
Poland	0	0	0
Portugal	2	2	0
Romania	0	0	0
Slovakia	0	0	0
Spain	18	18	1
Sweden	8	3	5
United Kingdom	18	15	6
Total	**91**	**46**	**49**

Source: Bloomberg

Panel B	All	Equity conversion	Principal write-down
2011	3	3	0
2012	6	5	1
2013	10	6	5
2014	16	5	12
2015	22	9	14
2016	16	8	8
2017	18	10	9
Total	**91**	**46**	**49**

Source: Bloomberg

Panel C	Obs	Mean	Std. Dev.	Min	Max
VOL	400	0.406	0.333	0.13	1.813
N_CRASH	400	0.225	0.418	0.000	1.000
N_JUMP	400	0.253	0.456	0.000	2.000
CRASH_JUMP	400	-0.028	0.650	-2.000	1.000
NCSKEW	400	-0.024	0.705	-1.805	2.136
DUVOL	400	-0.023	0.489	-1.263	1.287
VaR	400	0.048	0.031	0.012	0.193
ES	400	0.064	0.042	0.016	0.268
RWA ratio	400	0.470	0.172	0.044	0.960
NPL ratio	384	0.114	0.136	0.003	0.724
Loans/TA	400	0.560	0.178	0.016	0.844
Securities/TA	388	0.233	0.123	0.025	0.814
Deriv/TA	388	0.055	0.077	0.000	0.374
OBS/TA	387	0.156	0.120	0.005	0.833
Size	400	17.911	1.838	14.391	21.437
ROA	400	0.005	0.021	-0.207	0.149
Cost-income ratio	400	0.632	0.174	0.273	1.293
Total capital ratio(%)	400	16.429	4.340	2.070	40.100
Capital quality (%)	400	40.584	33.296	13.000	181.300

Source: Bloomberg, Datasream, Orbis Bank

Table 3 – CoCo Issuance and Changes in Bank Asset Risk

This table reports results from regressions in the form of equation (12). The dependent variable is a measure of asset risk or asset composition. The main explanatory variable of interest is *Post_CoCo*, an indicator identifying a bank that has issued a CoCo in any prior year. The dependent variables are the ratio of risk weighted assets to total assets (Column 1), the ratio of non-performing loans to total loans (Column 2), the ratio of loans to total assets (Column 3), the ratio of total securities to total assets (Column 4), the ratio of derivatives to total assets (Column 5), and the ratio of total off-balance sheet items to total assets (Column 6). Table 1 gives detailed descriptions of variables. All continuous regressors are standardized and winsorized at the 1 and 99 percentiles. Control variables that are lagged one year are Size, ROA, Cost-income ratio, Total capital ratio and Capital quality as defined in Table 1. In Panels B and C, results are reported, respectively, for Equity Conversion (EC) and Write-Down (WD) CoCos. All models include bank and country×year fixed effects. Robust t-statistics are clustered at the bank level and reported in parentheses. ***, **, * denotes that estimates are statistically significant at the 1, 5 and 10% levels.

Panel A – All CoCos

	(1) RWA ratio	(2) NPL ratio	(3) Loans/TA	(4) Securities/TA	(5) Deriv/TA	(6) OBS/TA
Post_CoCo	0.005	-0.001	-0.002	0.002	-0.002	0.011
	(0.443)	(-0.126)	(-0.314)	(0.289)	(-0.681)	(0.839)
Size	-0.318***	-0.084	-0.006	0.037	0.011	0.006
	(-2.694)	(-1.193)	(-0.076)	(0.441)	(0.636)	(0.086)
ROA	-0.007	-0.048**	0.010	0.012	-0.001	0.036*
	(-0.378)	(-2.365)	(0.955)	(0.657)	(-0.402)	(1.880)
Cost-income ratio	-0.009	-0.007	-0.005	0.001	0.001	0.006
	(-1.282)	(-0.726)	(-0.944)	(0.217)	(0.467)	(0.531)
Total capital ratio	0.007	-0.001	-0.003	0.009	-0.002	0.009
	(0.584)	(-0.143)	(-0.414)	(1.216)	(-0.729)	(0.596)
Capital quality	-0.007	-0.002	0.002	0.001	-0.002	-0.007
	(-0.898)	(-0.366)	(0.482)	(0.169)	(-1.613)	(-0.478)
Bank FE	YES	YES	YES	YES	YES	YES
Country×Year FE	YES	YES	YES	YES	YES	YES
Observations	400	379	400	388	388	375
R-squared	0.507	0.771	0.494	0.451	0.477	0.320
Number of banks	98	92	98	93	93	92

Panel B –EC CoCos

	(1)	(2)	(3)	(4)	(5)	(6)
	RWA ratio	NPL ratio	Loans/TA	Securities/TA	Deriv/TA	OBS/TA
Post_CoCo_EC	0.008	0.016	0.011	-0.002	-0.001	0.007
	(0.458)	(1.629)	(1.418)	(-0.204)	(-0.171)	(0.549)
Size	-0.319***	-0.080	-0.002	0.035	0.012	0.002
	(-2.692)	(-1.150)	(-0.025)	(0.418)	(0.681)	(0.024)
ROA	-0.006	-0.046**	0.012	0.011	-0.001	0.036*
	(-0.333)	(-2.294)	(1.063)	(0.625)	(-0.394)	(1.882)
Cost-income ratio	-0.009	-0.008	-0.005	0.001	0.001	0.006
	(-1.294)	(-0.771)	(-1.014)	(0.227)	(0.477)	(0.520)
Total capital ratio	0.007	-0.003	-0.005	0.009	-0.002	0.010
	(0.550)	(-0.308)	(-0.568)	(1.244)	(-0.779)	(0.632)
Capital quality	-0.007	-0.001	0.003	0.001	-0.002	-0.007
	(-0.896)	(-0.294)	(0.530)	(0.136)	(-1.571)	(-0.502)
Bank FE	YES	YES	YES	YES	YES	YES
Country×Year FE	YES	YES	YES	YES	YES	YES
Observations	400	379	400	388	388	375
R-squared	0.507	0.773	0.496	0.451	0.476	0.319
Number of banks	98	92	98	93	93	92

Panel C – WD CoCos

	(1)	(2)	(3)	(4)	(5)	(6)
	RWA ratio	NPL ratio	Loans/TA	Securities/TA	Deriv/TA	OBS/TA
Post_CoCo_WD	0.006	-0.009	-0.009	0.007	-0.001	0.014
	(0.509)	(-1.442)	(-1.312)	(0.790)	(-0.325)	(0.931)
Size	-0.319***	-0.086	-0.009	0.038	0.012	0.005
	(-2.708)	(-1.249)	(-0.112)	(0.462)	(0.679)	(0.068)
ROA	-0.008	-0.047**	0.011	0.011	-0.001	0.034*
	(-0.416)	(-2.351)	(1.030)	(0.624)	(-0.355)	(1.725)
Cost-income ratio	-0.009	-0.008	-0.005	0.001	0.000	0.007
	(-1.270)	(-0.748)	(-0.994)	(0.245)	(0.423)	(0.558)
Total capital ratio	0.008	-0.001	-0.004	0.009	-0.002	0.011
	(0.647)	(-0.152)	(-0.452)	(1.278)	(-0.811)	(0.684)
Capital quality	-0.007	-0.001	0.003	0.001	-0.002	-0.007
	(-0.906)	(-0.339)	(0.501)	(0.138)	(-1.567)	(-0.517)
Bank FE	YES	YES	YES	YES	YES	YES
Country×Year FE	YES	YES	YES	YES	YES	YES
Observations	400	379	400	388	388	375
R-squared	0.507	0.772	0.496	0.452	0.477	0.320
Number of banks	98	92	98	93	93	92

Table 4 – Equity Conversion (EC) Cocos and Stock Return Volatility

This table reports results from regression equation (13) where the dependent variable is a measure of stock return volatility. Specifically, the dependent variable is stock return standard deviation in Column 1, the number of crashes in Column 2, the number of jumps in Column 3, the number of crashes minus the number of jumps in Column 4, negative conditional skewness in Column 5, down-to-up volatility in Column 6, Value at Risk, one-day, 97.5% in Column 7, and Expected Shortfall in Column 8. The main variables of interest are the indicator variables identifying the issue of equity conversion CoCo bonds. All variables are defined in Table 1. Control variables that are lagged one year are Size, ROA, Loans/TA, Cost-income ratio, Total capital ratio and Capital quality as defined in Table 1.All continuous regressors are standardized and winsorized at the 1 and 99 percentiles. All models include bank and country×year fixed effects. Robust standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. ***, **, * denote that estimates are statistically significant at the 1, 5 and 10% levels.

VARIABLES	(1) VOL	(2) N_CRASH	(3) N_JUMP	(4) CRASH_JUMP	(5) NCSKEW	(6) DUVOL	(7) VaR	(8) ES
Pre_CoCo_EC	0.056	0.032	0.000	0.026	-0.149	-0.081	0.001	-0.004
	(0.982)	(0.195)	(0.004)	(0.112)	(-0.532)	(-0.421)	(0.307)	(-1.090)
CoCo_EC	-0.118	-0.323**	-0.242**	-0.110	-0.604***	-0.321	0.003	-0.007
	(-1.187)	(-2.218)	(-2.532)	(-0.944)	(-2.656)	(-1.505)	(0.988)	(-1.325)
Post_CoCo_ EC	-0.128**	-0.189	-0.023	-0.166	-0.361	-0.375**	-0.006**	-0.011**
	(-2.117)	(-1.025)	(-0.145)	(-0.550)	(-1.471)	(-2.265)	(-2.373)	(-2.291)
CoCo_Out_EC	0.174	-0.286	0.142	-0.419*	0.376	0.326*	-0.004	0.000
	(1.317)	(-1.416)	(1.193)	(-1.898)	(1.216)	(1.706)	(-0.882)	(0.076)
Size	-0.527**	-0.404	-0.568	0.129	0.154	-0.011	-0.009	-0.023
	(-2.339)	(-0.785)	(-1.482)	(0.174)	(0.203)	(-0.021)	(-0.628)	(-1.388)
ROA	-0.312***	-0.082	-0.077	0.003	0.068	-0.012	-0.017**	-0.015**
	(-3.503)	(-0.714)	(-0.378)	(0.010)	(0.289)	(-0.071)	(-2.322)	(-2.347)
Loans/TA	0.357**	0.117	-0.140	0.261	0.385*	0.377**	0.009***	0.008*
	(2.584)	(0.988)	(-0.963)	(1.352)	(1.800)	(2.442)	(2.700)	(1.974)
Cost-income ratio	-0.026	0.014	0.009	0.017	-0.021	0.006	-0.001	0.001
	(-1.137)	(0.342)	(0.229)	(0.276)	(-0.281)	(0.109)	(-0.309)	(0.442)
Total capital ratio	-0.016	0.007	0.125*	-0.123	-0.048	0.017	0.004*	0.004
	(-0.391)	(0.105)	(1.939)	(-1.393)	(-0.487)	(0.232)	(1.740)	(1.588)
Capital quality	-0.015	-0.084	-0.001	-0.087	-0.002	0.018	0.000	-0.000
	(-0.455)	(-1.479)	(-0.010)	(-0.987)	(-0.023)	(0.300)	(0.378)	(-0.225)
Constant	0.546***	0.456***	0.286***	0.152	0.125	0.128	0.054***	0.085***
	(7.469)	(3.324)	(2.655)	(0.775)	(0.546)	(0.819)	(11.429)	(15.513)
Observations	400	400	400	400	400	400	400	400
R-squared	0.699	0.410	0.407	0.424	0.376	0.398	0.816	0.802
Number of banks	98	98	98	98	98	98	98	98

Table 5 – Write-down (WD) Cocos and Stock Return Volatility

This table reports results from regression equation (13) where the dependent variable is a measure of stock return volatility. Specifically, the dependent variable is stock return standard deviation in Column 1, the number of crashes in Column 2, the number of jumps in Column 3, the number of crashes minus the number of jumps in Column 4, negative conditional skewness in Column 5, down-to-up volatility in Column 6, Value at Risk, one-day, 97.5% in Column 7, and Expected Shortfall in Column 8. The main variables of interest are the indicator variables identifying the issue of write-down CoCo bonds. All variables are defined in Table 1. Control variables that are lagged one year are Size, ROA, Loans/TA, Cost-income ratio, Total capital ratio and Capital quality as defined in Table 1.All continuous regressors are standardized and winsorized at the 1 and 99 percentiles. All models include bank and country×year fixed effects. Robust standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. ***, **, * denote that estimates are statistically significant at the 1, 5 and 10% levels.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	VOL	N_CRASH	N_JUMP	CRASH_JUMP	NCSKEW	DUVOL	VaR	ES
Pre_CoCo_WD	-0.030	-0.091	-0.047	-0.047	-0.072	-0.053	-0.002	-0.003
	(-0.871)	(-0.995)	(-0.543)	(-0.420)	(-0.507)	(-0.624)	(-1.293)	(-1.395)
CoCo _ WD	0.015	-0.075	0.051	-0.123	0.021	-0.082	-0.003	0.000
	(0.264)	(-0.647)	(0.380)	(-0.728)	(0.092)	(-0.573)	(-1.324)	(0.021)
Post_ CoCo _ WD	-0.037	-0.058	-0.071	0.015	-0.091	-0.107	-0.003	-0.005
	(-0.704)	(-0.406)	(-0.644)	(0.084)	(-0.565)	(-0.920)	(-1.612)	(-1.409)
CoCo _Out_ WD	0.029	0.082	0.232	-0.150	-0.158	0.122	0.007**	0.006
	(0.383)	(0.393)	(1.547)	(-0.574)	(-0.528)	(0.593)	(2.261)	(0.994)
Size	-0.493**	-0.274	-0.512	0.215	0.312	0.155	-0.007	-0.017
	(-2.206)	(-0.534)	(-1.329)	(0.289)	(0.401)	(0.300)	(-0.476)	(-1.081)
ROA	-0.305***	-0.034	-0.092	0.068	0.099	0.010	-0.016**	-0.014**
	(-3.310)	(-0.267)	(-0.440)	(0.229)	(0.409)	(0.054)	(-2.050)	(-2.011)
Loans/TA	0.342**	0.152	-0.139	0.304	0.412*	0.358**	0.009**	0.008**
	(2.519)	(1.180)	(-0.963)	(1.560)	(1.704)	(2.208)	(2.481)	(1.993)
Cost-income ratio	-0.037	0.010	0.005	0.016	-0.045	-0.011	-0.000	0.001
	(-1.494)	(0.238)	(0.117)	(0.266)	(-0.607)	(-0.193)	(-0.249)	(0.346)
Total capital ratio	-0.022	-0.037	0.137**	-0.178*	-0.056	0.008	0.003	0.003
	(-0.537)	(-0.524)	(2.118)	(-1.956)	(-0.582)	(0.116)	(1.410)	(1.395)
Capital quality	-0.012	-0.084	0.000	-0.087	0.005	0.027	0.001	-0.000
	(-0.350)	(-1.489)	(0.004)	(-0.993)	(0.060)	(0.475)	(0.543)	(-0.030)
Constant	0.559***	0.335**	0.224**	0.091	0.124	0.083	0.052***	0.082***
	(7.869)	(2.569)	(2.081)	(0.484)	(0.590)	(0.534)	(11.231)	(14.430)
Observations	400	400	400	400	400	400	400	400
R-squared	0.691	0.374	0.414	0.417	0.364	0.385	0.815	0.798
Number of banks	98	98	98	98	98	98	98	98

Table 6 – Equity Conversion (EC) CoCos, Write-down (WD) CoCos, and Stock Return Volatility

This table reports results from regression equation (13) where the dependent variable is a measure of stock return volatility. Specifically, the dependent variable is stock return standard deviation in Column 1, the number of crashes in Column 2, the number of jumps in Column 3, the number of crashes minus the number of jumps in Column 4, negative conditional skewness in Column 5, down-to-up volatility in Column 6, Value at Risk, one-day, 97.5% in Column 7, and Expected Shortfall in Column 8. The main variables of interest are the indicator variables identifying the issue of both equity conversion and write-down CoCos. All variables are defined in Table 1. Control variables that are lagged one year are Size, ROA, Loans/TA, Cost-income ratio, Total capital ratio and Capital quality as defined in Table 1.All continuous regressors are standardized and winsorized at the 1 and 99 percentiles. All models include bank and country×year fixed effects. Robust standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. ***, **, * denote that estimates are statistically significant at the 1, 5 and 10% levels.

VARIABLES	(1) VOL	(2) N_CRASH	(3) N_JUMP	(4) CRASH_JUMP	(5) NCSKEW	(6) DUVOL	(7) VaR	(8) ES
Pre_CoCo_EC	0.053	0.018	0.000	0.011	-0.159	-0.104	0.000	-0.005
	(0.921)	(0.110)	(0.001)	(0.054)	(-0.556)	(-0.524)	(0.113)	(-1.205)
CoCo_EC	-0.117	-0.327**	-0.260**	-0.097	-0.586**	-0.328	0.003	-0.007
	(-1.186)	(-2.139)	(-2.573)	(-0.829)	(-2.550)	(-1.549)	(0.870)	(-1.409)
Post_CoCo_EC	-0.133**	-0.215	-0.027	-0.186	-0.376	-0.402**	-0.007**	-0.012**
	(-2.090)	(-1.149)	(-0.166)	(-0.611)	(-1.510)	(-2.384)	(-2.568)	(-2.367)
Pre_CoCo_WD	-0.036	-0.108	-0.046	-0.065	-0.092	-0.075	-0.002*	-0.004*
	(-1.051)	(-1.226)	(-0.536)	(-0.584)	(-0.672)	(-0.898)	(-1.672)	(-1.744)
CoCo_WD	0.008	-0.052	0.046	-0.092	-0.014	-0.119	-0.003	-0.000
	(0.145)	(-0.458)	(0.324)	(-0.544)	(-0.060)	(-0.856)	(-1.285)	(-0.086)
Post_CoCo_WD	-0.035	-0.032	-0.065	0.036	-0.084	-0.110	-0.003	-0.005
	(-0.664)	(-0.245)	(-0.575)	(0.208)	(-0.558)	(-1.001)	(-1.476)	(-1.326)
CoCo_Out_EC	0.175	-0.274	0.163	-0.427*	0.363	0.354*	-0.003	0.001
	(1.317)	(-1.306)	(1.241)	(-1.900)	(1.220)	(1.891)	(-0.674)	(0.174)
CoCo_Out_WD	0.038	0.051	0.245	-0.191	-0.113	0.164	0.007**	0.006
	(0.486)	(0.238)	(1.609)	(-0.692)	(-0.350)	(0.759)	(2.164)	(1.101)
Size	-0.517**	-0.345	-0.543	0.163	0.149	0.022	-0.008	-0.021
	(-2.304)	(-0.673)	(-1.377)	(0.215)	(0.188)	(0.043)	(-0.526)	(-1.338)
ROA	-0.311***	-0.078	-0.084	0.015	0.086	-0.006	-0.017**	-0.015**
	(-3.437)	(-0.675)	(-0.409)	(0.054)	(0.349)	(-0.036)	(-2.273)	(-2.243)
Loans/TA	0.358**	0.125	-0.145	0.276	0.391	0.363**	0.009***	0.008*
	(2.581)	(1.057)	(-0.971)	(1.447)	(1.653)	(2.186)	(2.671)	(1.868)
Cost-income ratio	-0.024	0.023	0.015	0.021	-0.019	0.013	-0.000	0.001
	(-1.004)	(0.533)	(0.408)	(0.337)	(-0.247)	(0.226)	(-0.171)	(0.575)
Total capital ratio	-0.015	0.008	0.132**	-0.129	-0.050	0.019	0.004*	0.004*
	(-0.354)	(0.123)	(2.027)	(-1.452)	(-0.500)	(0.249)	(1.793)	(1.664)

Capital quality	-0.013	-0.080	0.001	-0.085	0.002	0.021	0.000	-0.000
	(-0.409)	(-1.429)	(0.023)	(-0.967)	(0.021)	(0.354)	(0.457)	(-0.113)
Constant	0.543***	0.449***	0.219*	0.209	0.186	0.115	0.053***	0.085***
	(7.167)	(3.427)	(1.938)	(1.103)	(0.854)	(0.741)	(10.919)	(14.799)
Observations	400	400	400	400	400	400	400	400
R-squared	0.701	0.414	0.419	0.430	0.378	0.402	0.820	0.806
Number of banks	98	98	98	98	98	98	98	98

Table 7 – Recent Regulatory Developments Affecting CoCos

This table reports the descriptive statistics of the difference between a bank's CoCo Z-spread (credit spread) and its subordinated CDS spread around the 10 March 2016 EU MDA announcement (Panel A) and the 7 June 2017 Banco Popular failure (Panel B). The table reports the average value of this difference across banks before and after the events, together with the minimum and the maximum values registered in each period. We also count the number of individual bank observations for which there is a difference in means before and after the event date using a one-tailed test: H_0: no significant change in the difference between the bank's CoCo Z-spread and its subordinated CDS spread; H_1: a significant decline/increase in the difference between the bank's CoCo Z-spread and its subordinated CDS spread. Values are in basis points. Source of financial data: Bloomberg

Panel A – EU MDA Announcement (10 March 2016)

Short event window (-20; + 20) around the announcement			
	All CoCos (54 obs)		
	Average Difference	Minimum	Maximum
Before	502.16	-115.56	849.70
After	443.68	-150.27	736.69
No. of obs. for which the difference decreases: 43			
No. of obs. for which the difference increases: 5			
	Equity conversion CoCos (22 obs)		
	Average Difference	Minimum	Maximum
Before	602.35	0.00	849.70
After	535.59	0.00	739.69
No. of obs. for which the difference decreases: 19			
No. of obs. for which the difference increases: 0			
	Write-down CoCos (32 obs)		
Media	Average Difference	Min	Max
Before	433.28	-115.56	762.21
After	380.49	-150.27	689.29
No. of obs. for which the difference decreases: 24			
No. of obs. for which the difference increases: 5			

Panel B – Banco Popular Failure

Short event window (-20; + 20) around the announcement				Long event window (-60; + 60) around the announcement			
All CoCos (39 obs)				*All CoCos (39 obs)*			
	Average Difference	Minimum	Maximum		Average Difference	Minimum	Maximum
Before	263.96	-240.95	415.07	Before	271.73	-247.35	425.08
After	276.38	-213.19	427.26	After	243.93	-194.31	401.49
No. of obs. for which the difference decreases: 4				No. of obs. for which the difference decreases: 27			
No. of obs. for which the difference increases: 25				No. of obs. for which the difference increases: 8			
Equity conversion CoCos (19 obs)				*Equity conversion CoCos (18 obs)*			
	Average Difference	Minimum	Maximum		Average Difference	Minimum	Maximum
Before	304.46	-5.17	415.07	Before	323.61	-12.74	425.08
After	320.74	0.00	427.26	After	296.59	0.00	401.49
No. of obs. for which the difference decreases: 3				No. of obs. for which the difference decreases: 11			
No. of obs. for which the difference increases: 13				No. of obs. for which the difference increases: 4			
Write-down CoCos (27 obs)				*Write-down CoCos (21 obs)*			
Media	Average Difference	Min	Max	Media	Average Difference	Min	Max
Before	225.49	-240.95	358.92	Before	227.26	-247.35	377.98
After	234.23	-213.19	382.08	After	198.80	-194.31	344.78
No. of obs. for which the difference decreases: 1				No. of obs. for which the difference decreases: 16			
No. of obs. for which the difference increases: 12				No. of obs. for which the difference increases: 4			

Figure 1 One Period Stock Return Volatility

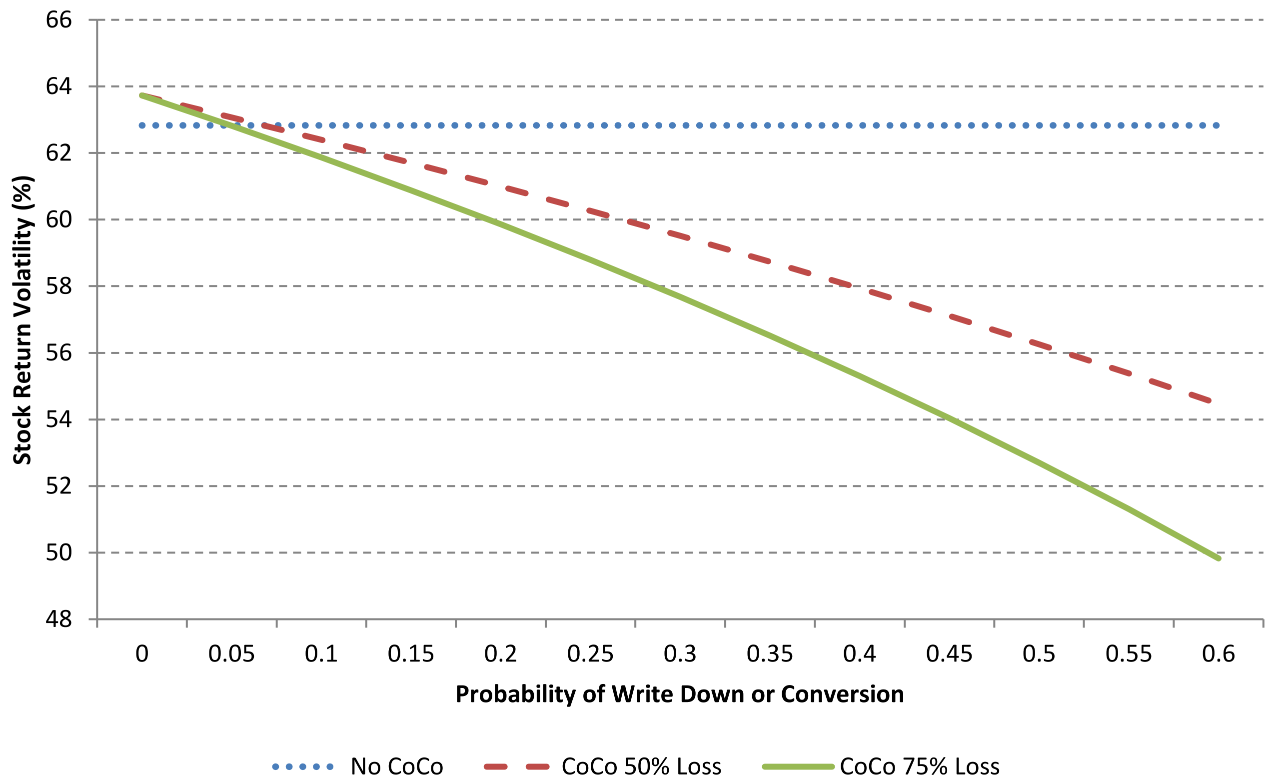
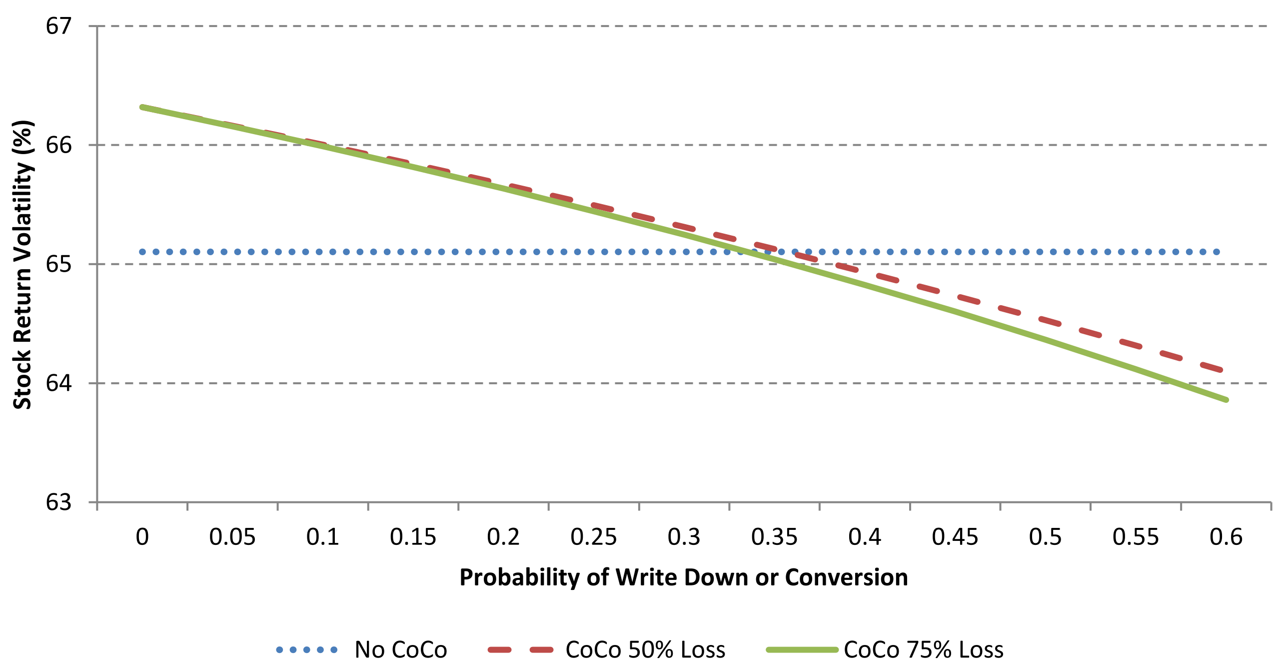


Figure 2: Two-Period Stock Return Volatility



Appendix A: Proofs

Proof of Lemma 1

The fair promised return on deposits, R_D, must satisfy the risk-neutral value condition $D_0 = \hat{E}_0\left[D_2\right] / R_F^2$ which equals

$$D_0 = \frac{1}{R_F^2}\left(\hat{p}^2 \min\left[D_0 R_D^2, u^2 A_0\right] + 2\hat{p}\left(1-\hat{p}\right)\min\left[D_0 R_D^2, udA_0\right] + \left(1-\hat{p}\right)^2 \min\left[D_0 R_D^2, d^2 A_0\right]\right). \quad \text{(A.1)}$$

The assumption that deposits default only in the state where assets have losses in both periods implies that $d^2\left(D_0 + S_0\right) = d^2 A_0 < D_0 R_F^2$ but $D_0 R_D^2 < udA_0$. Using this assumption in (A.1):

$$D_0 = \frac{1}{R_F^2}\left(D_0 R_D^2\left[\hat{p}^2 + 2\hat{p}\left(1-\hat{p}\right)\right] + \left(1-\hat{p}\right)^2 d^2 A_0\right). \quad \text{(A.2)}$$

Rearranging (A.2) gives equation (4) in Lemma 1. Thus, the restriction $D_0 R_D^2 < du\left(D_0 + S_0\right)$ is

$$\frac{D_0 R_F^2 - \left(1-\hat{p}\right)^2 d^2\left(D_0 + S_0\right)}{\hat{p}^2 + 2\hat{p}\left(1-\hat{p}\right)} < du\left(D_0 + S_0\right). \quad \text{(A.3)}$$

Dividing inequalities (A.3) and $d^2\left(D_0 + S_0\right) < D_0 R_F^2$ by D_0/d^2 and simplifying gives the model's parametric restriction on the initial asset-to-deposit ratio $A_0/D_0=(S_0+D_0)/D_0$:

$$\frac{R_F^2}{d\left[u\left(\hat{p}^2 + 2\hat{p}\left(1-\hat{p}\right)\right) + d\left(1-\hat{p}\right)^2\right]} = \frac{R_F^2\left(u-d\right)}{d\left[u\left(R_F - d\right) + R_F\left(u - R_F\right)\right]} < \frac{S_0 + D_0}{D_0} < \frac{R_F^2}{d^2}. \quad \text{(A.4)}$$

The risk-neutral value condition for shareholders' equity implies $S_0 = \hat{E}_0\left[S_2\right] / R_F^2$ where

$$S_2 = \begin{cases} u^2\left(D_0 + S_0\right) - D_0 R_D^2 & \text{with risk-neutral probability } \hat{p}^2 \\ ud\left(D_0 + S_0\right) - D_0 R_D^2 & \text{with risk-neutral probability } 2\hat{p}\left(1-\hat{p}\right) \\ 0 & \text{with risk-neutral probability } \left(1-\hat{p}\right)^2. \end{cases} \quad \text{(A.5)}$$

Dividing by S_0, equation (A.5) can be re-written as equation (3) in Lemma 1.

As of date 1, the stock can take two values. Let S_u be the date 1 stock value conditional on the bank's assets experiencing the high return over the first period. Then

$$S_u = \frac{1}{R_F}\hat{E}_1\left[S_2 \mid u_{0,1}\right] = \frac{1}{R_F}\left[A_0 u\left(\hat{p}u + \left(1-\hat{p}\right)d\right) - D_0 R_D^2\right]. \quad \text{(A.6)}$$

Similarly, let S_d be its value conditional on a low first period return on the bank's assets:

$$S_d = \frac{1}{R_F}\hat{E}_1\left[S_2 \mid d_{0,1}\right] = \hat{p}\frac{udA_0 - D_0R_D^2}{R_F}. \tag{A.7}$$

Dividing (A.6) and (A.7) by S_0 and combining them leads to equation (2) in Lemma 1.

Proof of Lemma 2

We first analyze a CoCo whose principal is written down and then consider a CoCo that converts to new equity shares. Conditional on experiencing a low first-period asset return and being written down at date 1, the principal write-down CoCo's value at date 1 equals[34]

$$C_d^W = \frac{\hat{p}}{R_F}\min\left[wC_0R_C^2, \left(duA_0^* - D_0R_F^2\right)\right]. \tag{A.8}$$

Given a first period low asset return but not being written down, the date 1 CoCo value is

$$C_d^N = \frac{\hat{p}}{R_F}\min\left[C_0R_C^2, \left(duA_0^* - D_0R_F^2\right)\right]. \tag{A.9}$$

Conditional on a high first period asset return, the date 1 CoCo value equals

$$C_u = \frac{1}{R_F}\left[\hat{p}\min\left[C_0R_C^2, \left(u^2A_0^* - D_0R_F^2\right)\right] + \left(1-\hat{p}\right)\min\left[C_0R_C^2, \left(udA_0^* - D_0R_F^2\right)\right]\right]. \tag{A.10}$$

Based on these date 1 values, we can solve for the CoCo's promised return, R_C, such that the CoCo's initial value equals the principal amount initially contributed by CoCo investors:

$$\begin{aligned} C_0 &= \frac{1}{R_F}\left[\hat{p}C_u + \left(1-\hat{p}\right)\left(\pi C_d^W + \left(1-\pi\right)C_d^N\right)\right] \\ &= \frac{1}{R_F^2}\left\{\hat{p}^2\min\left[C_0R_C^2, u^2A_0^* - D_0R_F^2\right] + \hat{p}\left(1-\hat{p}\right)\min\left[C_0R_C^2, udA_0^* - D_0R_F^2\right]\right. \\ &\quad \left. + \left(1-\hat{p}\right)\hat{p}\left(\pi\min\left[wC_0R_C^2, duA_0^* - D_0R_F^2\right] + \left(1-\pi\right)\min\left[C_0R_C^2, duA_0^* - D_0R_F^2\right]\right)\right\}. \end{aligned} \tag{A.11}$$

When $C_0R_C^2 < \left(udA_0^* - D_0R_F^2\right)$ so that asset returns are sufficiently large such that unwritten-down CoCos do not default if there is a positive return over one of the periods, then (A.11) equals

$$C_0 = \frac{1}{R_F^2}\left\{C_0R_C^2\left[\hat{p}^2 + \hat{p}\left(1-\hat{p}\right)\left(1 + \left(1-\pi\right) + \pi w\right)\right]\right\}. \tag{A.12}$$

Re-arranging (A.12) leads to the value of R_C given by equation (8) in Lemma 2. Also, substituting this value for R_C into the inequality $C_0R_C^2 < \left(udA_0^* - D_0R_F^2\right)$ provides the parametric

[34] Recall the assumption that CoCo investors (and shareholders) receive zero at date 2 if there is a low return on assets during both periods.

restriction that must be satisfied for there to be no default on CoCos when bank assets experience a single low return over the two periods.

Since CoCos and default-free deposits are fairly priced at date 0, the conservation of value relationship implies that equity is as well. Therefore, $S_0 = \hat{E}_0\left[S_2\right]/R_F^2$ where

$$S_2 = \begin{cases} u^2 A_0^* - \left(C_0 R_C^2 + D_0 R_F^2\right) & \text{with risk-neutral probability } \hat{p}^2 \\ udA_0^* - \left(C_0 R_C^2 + D_0 R_F^2\right) & \text{with risk-neutral probability } \left(2-\pi\right)\hat{p}\left(1-\hat{p}\right) \\ udA_0^* - \left(wC_0 R_C^2 + D_0 R_F^2\right) & \text{with risk-neutral probability } \pi\hat{p}\left(1-\hat{p}\right) \\ 0 & \text{with risk-neutral probability } \left(1-\hat{p}\right)^2 \ . \end{cases} \tag{A.13}$$

Dividing both sides of (A.13) by S_0 leads to equation (7) of Lemma 2.

As of date 1, there are three possible values for the stock. Let S_u be the date 1 stock value conditional on the bank's assets experiencing the high return over the first period. Then

$$S_u = \frac{1}{R_F}\hat{E}_1\left[S_2 \mid u_{0,1}\right] = \frac{1}{R_F}\left[A_0^* u\left(\hat{p}u + \left(1-\hat{p}\right)d\right) - \left(C_0 R_C^2 + D_0 R_F^2\right)\right]. \tag{A.14}$$

Next, let S_d^N be the stock's date 1 value conditional on a low first-period asset return and the CoCo not being written down. Its value equals

$$S_d^N = \frac{1}{R_F}\hat{E}_1\left[S_2 \mid d_{0,1}, N\right] = \hat{p}\,\frac{udA_0^* - \left(C_0 R_i^2 + D_0 R_F^2\right)}{R_F}. \tag{A.15}$$

Last, the stock's date 1 value following a low first-period asset return and a CoCo write down is

$$S_d^W = \frac{1}{R_F}\hat{E}_1\left[S_2 \mid d_{0,1}, W\right] = \hat{p}\,\frac{udA_0^* - \left(wC_0 R_C^2 + D_0 R_F^2\right)}{R_F}. \tag{A.16}$$

In summary, the date 1 stock payoff is

$$S_1 = \begin{cases} \dfrac{A_0^* u\left(\hat{p}u + \left(1-\hat{p}\right)d\right) - \left(C_0 R_C^2 + D_0 R_F^2\right)}{R_F} & \text{with risk-neutral probability } \hat{p} \\ \hat{p}\,\dfrac{udA_0^* - \left(C_0 R_C^2 + D_0 R_F^2\right)}{R_F} & \text{with risk-neutral probability } \left(1-\pi\right)\left(1-\hat{p}\right) \\ \hat{p}\,\dfrac{udA_0^* - \left(wC_0 R_C^2 + D_0 R_F^2\right)}{R_F} & \text{with risk-neutral probability } \pi\left(1-\hat{p}\right) \ . \end{cases} \tag{A.17}$$

Dividing both sides of (A.17) by S_0 leads to equation (6) in Lemma 2.

Following the same logical steps as above, the stock return distributions over the first period and over the first and second periods for a bank that issues equity conversion CoCos are:

$$\frac{S_1^E}{S_0} = \begin{cases} \dfrac{(1+l_0+c_0)u\left(\hat{p}u+(1-\hat{p})d\right)-\left(c_0R_{CE}^2+l_0R_F^2\right)}{R_F} & \text{with risk-neutral probability } \hat{p} \\ \hat{p}\,\dfrac{ud\,(1+l_0+c_0)-\left(c_0R_{CE}^2+l_0R_F^2\right)}{R_F} & \text{with risk-neutral probability } (1-\pi)(1-\hat{p}) \\ \hat{p}(1-\rho)\dfrac{ud\,(1+l_0+c_0)-l_0R_F^2}{R_F} & \text{with risk-neutral probability } \pi(1-\hat{p}) \end{cases} \quad \text{(A.18)}$$

and

$$\frac{S_2^E}{S_0} = \begin{cases} u^2\,(1+l_0+c_0)-\left(c_0R_{CE}^2+l_0R_F^2\right) & \text{with risk-neutral probability } \hat{p}^2 \\ ud\,(1+l_0+c_0)-\left(c_0R_{CE}^2+l_0R_F^2\right) & \text{with risk-neutral probability } (2-\pi)\,\hat{p}(1-\hat{p}) \\ (1-\rho)\left(du\,(1+l_0+c_0)-l_0R_F^2\right) & \text{with risk-neutral probability } \pi\,\hat{p}(1-\hat{p}) \\ 0 & \text{with risk-neutral probability } (1-\hat{p})^2 \end{cases} \quad \text{(A.19)}$$

where the promised return on equity conversion CoCos, R_{CE}, satisfies

$$R_{CE}^2 = R_F^2\,\frac{1-(1-\hat{p})\,\hat{p}\pi\rho\,\dfrac{(u-d)D_0}{dC_0}}{\hat{p}^2+\hat{p}(1-\hat{p})\left(1+(1-\pi)\right)}\ . \quad \text{(A.20)}$$

Equating R_{CE} in (A.20) to R_C in equation (8) in Lemma 2 shows that they are equal when condition (5) in the text holds. This is equivalent to having both CoCos' date 2 payoffs and their corresponding stock distributions being the same such that $\rho\left(duA_0^*-D_0R_F^2\right)=wC_0R_C^2$.

<u>Proof of Proposition 1</u>

Our proof first shows that when π(1-w) = 0, the CoCo-issuing bank's stock returns become more extreme relative to those of the bank without CoCos. Then, as π(1-w) increases due to π increasing from zero or w decreasing from 1, the CoCo-issuing bank's stock returns become less extreme and can be less extreme than the stock returns of the bank without CoCos.

When π(1-w) = 0, CoCos equal two-period debt that is subordinated to the bank's default-free deposits. From equation (8), the promised return on this subordinated debt, denoted $R_{C,0}$ is

$$R_{C,0} \equiv R_C^2 \,|_{\pi(1-w)=0} = \frac{R_F^2}{\hat{p}^2 + 2\hat{p}(1-\hat{p})} \tag{A.21}$$

Now note that the bank's stock returns would be the same if a single issue of fairly-priced, default-risky debt with principal $D_0 + C_0$ and promised return R_S replaced the bank's default-free deposits and subordinated debt. Analogous to R_D in equation (4), R_S, satisfies

$$R_S^2 = \frac{R_F^2 - (1-\hat{p})^2 d^2 \left(1 + \frac{1}{l_0 + c_0}\right)}{\hat{p}^2 + 2\hat{p}(1-\hat{p})} \tag{A.22}$$

Thus when $\pi(1\text{-}w) = 0$, $c_0 R_{C,0}^2 + l_0 R_F^2$ can be replaced with $(c_0 + l_0) R_S^2$ in the one- and two-period stock return distributions given in equations (6) and (7). Moreover, when $\pi(1\text{-}w) = 0$ there are only two nonzero payoff states in equations (6) and (7), and each is a function of the quantity $R_A^2 + \left(R_A^2 - R_S^2\right)(c_0 + l_0)$ where R_A^2 is the two-period return on the bank's assets. In equation (6), R_A^2 equals either $u\left(\hat{p}u + (1-\hat{p})d\right)$ or ud. In equation (7), R_A^2 equals either u^2 or ud. Note that

$$\begin{aligned} \frac{\partial\left(R_A^2 + \left(R_A^2 - R_S^2\right)(c_0 + l_0)\right)}{\partial c_0} &= \left(R_A^2 - R_S^2\right) - \frac{\partial R_S^2}{\partial c_0}(c_0 + l_0) \\ &= \left(R_A^2 - R_S^2\right) - \frac{(1-\hat{p})^2 d^2}{\left[\hat{p}^2 + 2\hat{p}(1-\hat{p})\right](c_0 + l_0)} \end{aligned} \tag{A.23}$$

which is greater the higher is R_A^2. Moreover, since the risk-neutral expected stock return must in equilibrium equal R_F per period, there must be a rise in the stock return in the high R_A^2 state and a fall in the stock return in the low R_A^2 state.[35]

Next, note that the bank issuing only deposits and shareholders' equity is equivalent to the case of $c_0 = 0$. Thus, from (A.23) as leverage increases from a rise in c_0 due to the addition of CoCos, the payoffs in the two states become more unequal due to the stock return falling in the low R_A^2 state and rising in the high R_A^2 state. Hence, when $\pi(1\text{-}w) = 0$, the stock return payoffs of a bank issuing CoCos are unambiguously more extreme than that of the bank without CoCos.

[35] By high return state we mean the state when bank assets return u in both periods. The low asset return state is when bank assets return u in one period and d in the other. Recall that for both a bank that issues CoCos and one that does not, shareholders' equity always receives zero when bank assets return d in both periods.

Now consider how the stock return distribution changes relative to this $\pi(1\text{-}w) = 0$ case when $\pi(1\text{-}w)$ increases due to a rise in π from 0 or a fall in w from 1. A comparison of two-period stock returns in this general case for different states are given in the following table:

Table A.1 Comparison of Two-Period Stock Returns

States	$\pi(1\text{-}w) = 0$	$\pi(1\text{-}w) > 0$	Risk-neutral probability
u, u	$u^2(1+l_0+c_0)-(c_0R_{C,0}^2+l_0R_F^2)$	$u^2(1+l_0+c_0)-(c_0R_C^2+l_0R_F^2)$	$\hat{p}^2$
u,d or d,u no WD	$ud(1+l_0+c_0)-(c_0R_{C,0}^2+l_0R_F^2)$	$ud(1+l_0+c_0)-(c_0R_C^2+l_0R_F^2)$	$(2-\pi)\hat{p}(1-\hat{p})$
d, u and WD	$ud(1+l_0+c_0)-(c_0R_{C,0}^2+l_0R_F^2)$	$ud(1+l_0+c_0)-(c_0wR_C^2+l_0R_F^2)$	$\pi\hat{p}(1-\hat{p})$

When $\pi>0$ and $w<1$, it can be verified from equation (8) and (A.21) that $R_C^2 > R_{C,0}^2$ but $wR_C^2 > R_{C,0}^2$. Therefore, from inspection of the stock returns in Table A.1, one can see that the stock return in the high asset return state, (u,u), is unambiguously lower when $\pi(1\text{-}w) > 0$ compared to the case of $\pi(1\text{-}w) = 0$. Therefore, since the risk-neutral expected stock return must in equilibrium equal R_F per period, there must be a rise in the average stock return in the low asset return state (u,d) or (d,u) compared to the case of $\pi(1\text{-}w) = 0$. Moreover, since from equation (8) R_C^2 is monotonically increasing in $\pi(1\text{-}w)$, stock returns in the high state decline, and average stock returns in the low state rise, monotonically as $\pi(1\text{-}w)$ increases.

The following table makes a similar comparison for one-period stock returns.

Table A.2 Comparison of One-Period Stock Returns

States	$\pi(1\text{-}w) = 0$	$\pi(1\text{-}w) > 0$	Risk-neutral probability
u	$\frac{(1+l_0+c_0)u(\hat{p}u+(1-\hat{p})d)-(c_0R_{C,0}^2+l_0R_F^2)}{R_F}$	$\frac{(1+l_0+c_0)u(\hat{p}u+(1-\hat{p})d)-(c_0R_C^2+l_0R_F^2)}{R_F}$	$\hat{p}$
d, no conversion	$\hat{p}\frac{ud(1+l_0+c_0)-(c_0R_{C,0}^2+l_0R_F^2)}{R_F}$	$\hat{p}\frac{ud(1+l_0+c_0)-(c_0R_C^2+l_0R_F^2)}{R_F}$	$(1-\pi)(1-\hat{p})$
d, conversion	$\hat{p}\frac{ud(1+l_0+c_0)-(c_0R_{C,0}^2+l_0R_F^2)}{R_F}$	$\hat{p}\frac{ud(1+l_0+c_0)-(wc_0R_C^2+l_0R_F^2)}{R_F}$	$\pi(1-\hat{p})$

Moreover, for sufficiently high values of $\pi(1\text{-}w)$, the stock returns for CoCo issuing banks become less extreme compared to a bank that issues no CoCos but only deposits and shareholders' equity. To see this, consider one-period stock returns when $\pi(1\text{-}w) = 1$. This is the polar case where when bank assets earn the low return over the first period, CoCos are always written down at a complete loss to CoCo investors. For this case equation (6) becomes

$$\frac{S_1}{S_0} = \begin{cases} \dfrac{(1+l_0+c_0)u\left(\hat{p}u+(1-\hat{p})d\right)-\left(c_0R_C^2+l_0R_F^2\right)}{R_F} & \text{with risk-neutral probability } \hat{p} \\ \hat{p}\,\dfrac{ud\,(1+l_0+c_0)-l_0R_F^2}{R_F} & \text{with risk-neutral probability } (1-\hat{p}) \end{cases} \tag{A.24}$$

where $R_C^2 = \dfrac{R_F^2}{\hat{p}^2+\hat{p}(1-\hat{p})}$. Comparing shareholders' payoff when bank assets earn a first period low return, which is the second line in (A.24), we see that it is unambiguously larger than that when the bank does not issue CoCos, which is the second line in equation (2). This is because $ud\,(1+l_0+c_0)-l_0R_F > ud\,(1+l_0)-l_0R_D^2$ since $R_F < R_D$. Therefore, since the equilibrium risk-neutral expected stock return must be maintained at R_F per period, the return to shareholders when bank assets earn the high return over the first period must be less for a bank that issues CoCos compared to a bank that does not issue CoCos. As a result, the one-period shareholder returns are less extreme for the bank that issues CoCos compared to the bank that does not.

<u>Proof of Proposition 2</u>

First consider the yield on write down CoCos in equation (8) versus subordinated debt in equation (A.21) noting that $R_C^2 > R_{C,0}^2$ when $\pi > 0$ and $w < 1$. Moreover, since

$$\frac{\partial R_C^2}{\partial \pi} = \frac{R_F^2\,\hat{p}(1-\hat{p})(1-w)}{\left[\hat{p}^2+\hat{p}(1-\hat{p})\left(2-\pi(1-w)\right)\right]^2} > 0\ , \tag{A.25}$$

then a decline in π reduces R_C and the spread, R_C - $R_{C,0}$. Similarly, for equity conversion CoCos

$$\frac{\partial R_{CE}^2}{\partial \pi} = R_F^2\,\hat{p}(1-\hat{p})\frac{1-\rho\dfrac{(u-d)D_0}{dC_0}\left(\hat{p}^2+2\hat{p}(1-\hat{p})\right)}{\left[\hat{p}^2+\hat{p}(1-\hat{p})\left(1+(1-\pi)\right)\right]^2} \tag{A.26}$$

is positive when ρ satisfies equation (5) consistent with $w < 1$.

Internet Appendix: Stock Volatility Tests Based on Outstanding CoCos

Table IA1 – Equity Conversion (EC) Cocos and Stock Return Volatility – Outstanding model

This table reports results from regression equation (13) where the dependent variable is a measure of stock return volatility. Specifically, the dependent variable is stock return standard deviation in Column 1, the number of crashes in Column 2, the number of jumps in Column 3, the number of crashes minus the number of jumps in Column 4, negative conditional skewness in Column 5, down-to-up volatility in Column 6, Value at Risk, one-day, 97.5% in Column 7, and Expected Shortfall in Column 8. The main variables of interest are the indicator variables identifying the outstanding of equity conversion CoCo bonds. All variables are defined in Table 1. Control variables that are lagged one year are Size, ROA, Loans/TA, Cost-income ratio, Total capital ratio and Capital quality as defined in Table 1.All continuous regressors are standardized and winsorized at the 1 and 99 percentiles. All models include bank and country×year fixed effects. Robust standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. ***, **, * denote that estimates are statistically significant at the 1, 5 and 10% levels.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	VOL	N_CRASH	N_JUMP	CRASH_JUMP	NCSKEW	DUVOL	VaR	ES
Pre_CoCo_Out_EC	-0.007	0.247	-0.137	0.376	0.221	0.117	-0.002	-0.003
	(-0.147)	(1.305)	(-1.498)	(1.629)	(0.627)	(0.521)	(-0.746)	(-0.799)
CoCo_Out_EC	0.046	-0.593***	-0.101	-0.505***	-0.187	0.063	-0.001	-0.006
	(0.916)	(-2.969)	(-0.858)	(-2.653)	(-0.660)	(0.297)	(-0.278)	(-1.402)
Post_CoCo_Out_EC	-0.053	-0.236	0.218	-0.443**	-0.205	-0.388**	-0.006**	-0.005
	(-0.660)	(-1.289)	(1.373)	(-2.165)	(-0.897)	(-2.178)	(-2.398)	(-1.005)
Size	-0.506**	-0.278	-0.550	0.241	0.390	0.118	-0.010	-0.020
	(-2.208)	(-0.559)	(-1.459)	(0.339)	(0.522)	(0.232)	(-0.690)	(-1.213)
ROA	-0.309***	-0.101	-0.073	-0.020	0.046	-0.029	-0.016**	-0.015**
	(-3.435)	(-0.914)	(-0.360)	(-0.073)	(0.207)	(-0.176)	(-2.253)	(-2.347)
Loans/TA	0.346**	0.135	-0.161	0.301	0.418*	0.394**	0.009**	0.008*
	(2.509)	(1.146)	(-1.113)	(1.560)	(1.876)	(2.513)	(2.588)	(1.924)
Cost-income ratio	-0.037	-0.003	-0.003	0.011	-0.047	-0.013	-0.001	0.000
	(-1.541)	(-0.090)	(-0.073)	(0.181)	(-0.626)	(-0.233)	(-0.373)	(0.191)
Total capital ratio	-0.022	0.019	0.121*	-0.106	-0.025	0.031	0.003	0.004
	(-0.521)	(0.284)	(1.846)	(-1.148)	(-0.247)	(0.438)	(1.580)	(1.638)
Capital quality	-0.013	-0.082	-0.000	-0.085	0.003	0.022	0.000	-0.000
	(-0.410)	(-1.450)	(-0.010)	(-0.975)	(0.042)	(0.399)	(0.452)	(-0.090)
Constant	0.565***	0.431***	0.301***	0.113	0.059	0.121	0.056***	0.086***
	(6.813)	(3.000)	(2.705)	(0.550)	(0.231)	(0.710)	(11.412)	(14.907)
Observations	400	400	400	400	400	400	400	400
R-squared	0.690	0.409	0.409	0.435	0.366	0.393	0.814	0.797
Number of banks	98	98	98	98	98	98	98	98

Table IA2 – Write-down (WD) CoCos and Stock Return Volatility – Outstanding model

This table reports results from regression equation (13) where the dependent variable is a measure of stock return volatility. Specifically, the dependent variable is stock return standard deviation in Column 1, the number of crashes in Column 2, the number of jumps in Column 3, the number of crashes minus the number of jumps in Column 4, negative conditional skewness in Column 5, down-to-up volatility in Column 6, Value at Risk, one-day, 97.5% in Column 7, and Expected Shortfall in Column 8. The main variables of interest are the indicator variables identifying the outstanding of write-down CoCo bonds. All variables are defined in Table 1. Control variables that are lagged one year are Size, ROA, Loans/TA, Cost-income ratio, Total capital ratio and Capital quality as defined in Table 1.All continuous regressors are standardized and winsorized at the 1 and 99 percentiles. All models include bank and country×year fixed effects. Robust standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. ***, **, * denote that estimates are statistically significant at the 1, 5 and 10% levels.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	VOL	N_CRASH	N_JUMP	CRASH_JUMP	NCSKEW	DUVOL	VaR	ES
Pre_CoCo_Out_WD	0.029	-0.171	-0.074	-0.087	-0.082	-0.072	-0.001	-0.005*
	(0.552)	(-1.085)	(-0.456)	(-0.380)	(-0.372)	(-0.431)	(-0.484)	(-1.925)
CoCo_Out_WD	0.038	0.088	0.311**	-0.228	-0.066	0.070	0.005**	0.009***
	(1.295)	(0.507)	(2.432)	(-1.236)	(-0.312)	(0.411)	(2.291)	(2.720)
Post_CoCo_Out_WD	-0.048	-0.044	-0.074	0.041	-0.170	-0.062	-0.002	-0.006
	(-1.314)	(-0.237)	(-0.466)	(0.177)	(-0.593)	(-0.319)	(-0.959)	(-1.302)
Size	-0.517**	-0.306	-0.503	0.175	0.267	0.132	-0.008	-0.019
	(-2.241)	(-0.586)	(-1.292)	(0.231)	(0.343)	(0.253)	(-0.572)	(-1.129)
ROA	-0.307***	-0.039	-0.097	0.069	0.093	0.004	-0.016**	-0.014**
	(-3.390)	(-0.307)	(-0.463)	(0.234)	(0.391)	(0.021)	(-2.094)	(-2.097)
Loans/TA	0.337**	0.165	-0.136	0.314	0.414*	0.374**	0.009**	0.009**
	(2.459)	(1.285)	(-0.947)	(1.634)	(1.758)	(2.356)	(2.575)	(2.153)
Cost-income ratio	-0.039	0.007	0.005	0.014	-0.048	-0.014	-0.001	0.001
	(-1.627)	(0.162)	(0.119)	(0.218)	(-0.651)	(-0.240)	(-0.327)	(0.302)
Total capital ratio	-0.022	-0.033	0.140**	-0.177*	-0.053	0.009	0.003	0.003
	(-0.547)	(-0.475)	(2.132)	(-1.928)	(-0.553)	(0.131)	(1.401)	(1.477)
Capital quality	-0.015	-0.086	-0.002	-0.086	-0.003	0.023	0.000	-0.000
	(-0.464)	(-1.470)	(-0.050)	(-0.958)	(-0.030)	(0.405)	(0.415)	(-0.205)
Constant	0.558***	0.373***	0.229**	0.120	0.155	0.104	0.052***	0.083***
	(7.626)	(2.851)	(2.063)	(0.622)	(0.751)	(0.675)	(11.178)	(14.417)
Observations	400	400	400	400	400	400	400	400
R-squared	0.691	0.373	0.413	0.416	0.365	0.383	0.813	0.798
Number of banks	98	98	98	98	98	98	98	98

Table IA3 – Equity Conversion (EC) CoCos, Write-down (WD) CoCos, and Stock Return Volatility – Outstanding model

This table reports results from regression equation (13) where the dependent variable is a measure of stock return volatility. Specifically, the dependent variable is stock return standard deviation in Column 1, the number of crashes in Column 2, the number of jumps in Column 3, the number of crashes minus the number of jumps in Column 4, negative conditional skewness in Column 5, down-to-up volatility in Column 6, Value at Risk, one-day, 97.5% in Column 7, and Expected Shortfall in Column 8. The main variables of interest are the indicator variables identifying the outstanding of both equity conversion and write-down CoCo bonds. All variables are defined in Table 1. Control variables that are lagged one year are Size, ROA, Loans/TA, Cost-income ratio, Total capital ratio and Capital quality as defined in Table 1.All continuous regressors are standardized and winsorized at the 1 and 99 percentiles. All models include bank and country×year fixed effects. Robust standard errors are clustered at the bank level and robust t-statistics are reported in parentheses. ***, **, * denote that estimates are statistically significant at the 1, 5 and 10% levels.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	VOL	N_CRASH	N_JUMP	CRASH_JUMP	NCSKEW	DUVOL	VaR	ES
Pre_Coco_Out_EC	-0.009	0.258	-0.102	0.352	0.181	0.121	-0.002	-0.003
	(-0.179)	(1.368)	(-1.214)	(1.548)	(0.529)	(0.543)	(-0.642)	(-0.760)
Coco_Out_EC	0.046	-0.607***	-0.117	-0.505**	-0.192	0.056	-0.001	-0.007
	(0.938)	(-3.104)	(-0.920)	(-2.623)	(-0.706)	(0.261)	(-0.364)	(-1.587)
Post_Coco_Out_EC	-0.043	-0.257	0.243	-0.485**	-0.216	-0.394**	-0.006**	-0.004
	(-0.566)	(-1.422)	(1.465)	(-2.307)	(-0.963)	(-2.139)	(-2.173)	(-0.872)
Pre_Coco_Out_WD	0.028	-0.244	-0.058	-0.174	-0.121	-0.109	-0.002	-0.006**
	(0.556)	(-1.479)	(-0.350)	(-0.743)	(-0.527)	(-0.623)	(-0.744)	(-2.026)
Coco_Out_WD	0.035	0.108	0.314**	-0.209	-0.056	0.067	0.005**	0.009***
	(1.212)	(0.601)	(2.490)	(-1.109)	(-0.271)	(0.397)	(2.171)	(2.724)
Post_Coco_Out_WD	-0.046	-0.021	-0.098	0.086	-0.147	-0.030	-0.002	-0.007
	(-1.276)	(-0.129)	(-0.626)	(0.415)	(-0.544)	(-0.169)	(-0.910)	(-1.321)
Size	-0.526**	-0.227	-0.516	0.259	0.317	0.134	-0.010	-0.020
	(-2.221)	(-0.450)	(-1.306)	(0.351)	(0.405)	(0.256)	(-0.646)	(-1.204)
ROA	-0.308***	-0.103	-0.084	-0.009	0.059	-0.030	-0.017**	-0.015**
	(-3.402)	(-0.950)	(-0.405)	(-0.036)	(0.259)	(-0.181)	(-2.258)	(-2.325)
Loans/TA	0.341**	0.156	-0.163	0.326*	0.425*	0.402**	0.009**	0.008*
	(2.435)	(1.321)	(-1.111)	(1.739)	(1.786)	(2.425)	(2.619)	(1.979)
Cost-income ratio	-0.039	0.003	0.001	0.014	-0.048	-0.011	-0.001	0.001
	(-1.571)	(0.075)	(0.029)	(0.240)	(-0.647)	(-0.185)	(-0.341)	(0.233)
Total capital ratio	-0.022	0.029	0.129*	-0.106	-0.024	0.036	0.003	0.004*
	(-0.518)	(0.409)	(1.921)	(-1.120)	(-0.238)	(0.491)	(1.654)	(1.799)
Capital quality	-0.016	-0.077	-0.002	-0.078	0.000	0.024	0.000	-0.000
	(-0.479)	(-1.371)	(-0.045)	(-0.892)	(0.005)	(0.415)	(0.433)	(-0.150)
Constant	0.562***	0.464***	0.235*	0.203	0.174	0.136	0.055***	0.087***
	(6.351)	(3.180)	(1.933)	(0.927)	(0.702)	(0.791)	(11.004)	(13.904)
Observations	400	400	400	400	400	400	400	400
R-squared	0.692	0.415	0.419	0.440	0.368	0.394	0.816	0.801
Number of banks	98	98	98	98	98	98	98	98