CoCo Issuance and Bank Fragility*

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Abstract

The promise of contingent convertible capital securities (CoCos) as a 'bail-in' solution has been the subject of considerable theoretical analysis and debate, but little is known about their effects in practice. We undertake the first comprehensive empirical analysis of bank CoCo issues, a market segment that comprises over 730 instruments totaling $521 billion. Four main findings emerge: 1) the propensity to issue a CoCo is higher for larger and better-capitalized banks; 2) CoCo issues result in a statistically significant decline in issuers' CDS spread, indicating that they generate risk-reduction benefits and lower costs of debt (this is especially true for CoCos that convert into equity, that have mechanical triggers, and that are classified as Additional Tier 1 instruments); 3) CoCos with only discretionary triggers do not have a significant impact on CDS spreads; and 4) CoCo issues have no statistically significant impact on stock prices, except for principal write-down CoCos with a high trigger level, which have a positive effect.

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1. Introduction

If there is one term that epitomizes the infamy of the Global Financial Crisis of 2007-09, it is "too big to fail." Even when they sought to impose financial discipline on banks that had assumed excessive leverage, financial regulators were forced to accept bailouts as the only possible stabilizing intervention. The alternative of putting the failed banks through some form of resolution and imposing losses on bank creditors was considered too dangerous in the middle of the crisis. It is not surprising, therefore, that a major priority of regulators following the crisis was to increase banks' loss absorbing capacity, both as going concerns and as gone concerns.

One way of bringing about a swift and seamless re-capitalization of a distressed bank is through the conversion of contingent convertible capital securities (CoCos) previously issued by the bank. The automatic reduction in debt and increase in equity resulting from CoCo conversions can serve the dual roles of recapitalizing a going concern and reducing the cost of resolving a gone concern. The main appeal of CoCos according to early proponents was as going concern recapitalization mechanisms (see in particular, Flannery 2005 and 2016, Raviv 2004, Duffie 2009, McDonald 2013, Coffee 2011, Pennacchi, Vermaelen and Wolff 2014, and the Squam Lake Working Group 2010). The attraction of CoCos for regulators was also as gone concern resolution devices. An open question we investigate in our study is whether the bank CoCos that have been issued so far are primarily going concern or gone concern mechanisms.[1]

The early advocates of CoCos disagreed on their optimal design. In particular, should the trigger be a stock price floor or a minimum equity-capital ratio? Some of the proposals were criticized, most notably by Admati, DeMarzo, Hellwig and Pfleiderer (2013) and Sundaresan and Wang (2015), who argued that CoCos were excessively complex and their conversion could have destabilizing effects.[2] Another important issue with how CoCos were designed was the potential negative effect on risk-taking incentives of the issuing bank.[3] Several proposals of CoCo design also focused on the question of how CoCos should be modified to deal with systemic events.[4] Accordingly, a second general question we study is which CoCo designs were perceived as reducing bank fragility by financial markets.

In the immediate aftermath of the Global Financial Crisis, the debates among academics

[1] A *going concern* is a business that functions on the expectation that an event of bankruptcy / liquidation does not have a significant likelihood in the near future. A *gone concern* is a business that is either already in such a liquidation state or is likely to enter into one in the near future.

[2] While CoCos with accounting-based triggers have limited ability to respond in a timely way to the onset of a sudden crisis, market-value triggers immediately respond to news about realized or prospective bank losses and are more immune to accounting obfuscation (Flannery 2005 and 2009; Calomiris and Herring 2013). However, a potential shortcoming of market-based triggers is that they may invite stock price manipulation or speculative attacks (Hillion and Vermaelen, 2004). A broader concern is that market-based triggers can distort the information content of prices (Faure-Grimaud, 2002; Bond, Goldstein and Prescott, 2010; Glassermann and Nouri, 2016; Berg and Kaserer, 2015). There are several proposals that address these latter concerns, including Bulow and Klemperer (2014), Flannery (2009), Duffie (2009), Calomiris and Herring (2013), Pennacchi, Vermaelen, and Wolff (2013), Pennacchi and Tchistyi (2019a).

[3] CoCos with conversion terms that transfer value to equity holders upon conversion may encourage additional risk-taking (Berg and Kaserer, 2015). Excess risk-taking incentives can, however, be mitigated by exposing bank executive compensation to CoCo price risk (Bolton, Mehran, and Shapiro 2015 and Hilscher and Raviv 2014). Flannery (2005), Calomiris and Herring (2013) and Martynova and Perotti (2018) urge that CoCos should dilute the ownership of preexisting equityholders and should convert well before bank leverage approaches the point of non-viability. One difficulty with these CoCo designs, however, is that bank equityholders have little incentive to issue such CoCos. Chen, Glasserman, Nouri, and Pelger (2013) and Albul, Jaffee, and Tchistyi (2012) show that equityholders have a positive incentive to issue CoCos when they also benefit from a lower default risk (for example, via lower costs of debt rollovers).

[4] The essence of these proposals is that the CoCo trigger should be contingent on some measure of systemic risk (Kashyap, Rajan, and Stein, 2008; Squam Lake Working Group, 2009; Caballero and Kurlat, 2008). CoCos can also be a macroprudential tool if they implement counter-cyclical equity buffers (Bolton and Samama, 2012; Zeng, 2013).

were mirrored by differences in opinions and preferences among national bank regulators. Nevertheless, the introduction of the Basel III framework, which allowed banks to meet part of their regulatory capital requirements with CoCo instruments, created incentives for banks to issue CoCos. As the number of jurisdictions implementing Basel III grew, banks responded by raising a substantial amount of capital in the form of CoCo issuance. Between January 2009 and December 2015, banks around the world issued a total of $521 billion in CoCos through 731 different issues.

In this paper, we undertake a systematic empirical analysis of bank CoCo issuance by assembling the most comprehensive CoCo dataset to date. Beyond investigating the effects of differences in CoCo designs, our study seeks to address two fundamental questions: What drives bank CoCo issuance decisions? And how do CoCo issues affect issuers' balance sheets?

To determine the factors driving CoCo issuance, we perform a duration analysis and estimate which bank characteristics are associated with issuance propensity and security design. Our first main finding is that larger banks and banks with relatively strong balance sheets were among the first wave of CoCo issuers.

We also conduct an event study to evaluate the impact of CoCo issuance on the issuer's balance sheet. In particular, we estimate the announcement effect of a CoCo issue on the issuer's CDS spreads and equity prices, breaking the effect down by key issuer characteristics and CoCo contract features. Several striking results emerge from this analysis. First, the overall impact of a CoCo issue on the issuer's CDS spread is negative and strongly statistically significant, indicating that, according to market participants, a CoCo issue unambiguously strengthens the issuer's balance sheet. When we break down the effect by CoCo conversion mechanism, we find that the impact on CDS spreads of CoCos that convert into equity is much stronger than the respective impact of principal write-down CoCos.

When we further separate the announcement effects by the type of trigger mechanism, we strikingly find that the presence of a mechanical trigger makes all the difference. More concretely, only CoCos that have a mechanical trigger (in addition to a discretionary trigger) have a significant negative impact on the issuer's CDS spread. In other words, the issuance of a CoCo with only a regulatory discretionary trigger is seen to have no significant effect on the bank's credit risk by the market. We also find that the level of the mechanical trigger matters. The impact of high-trigger CoCos on CDS spreads is stronger than that of low-trigger CoCos.

All in all, we find that CoCo issuance has generally contributed to reducing bank fragility. But not all instruments are equal in this regard. The CoCos that have the strongest strengthening effect on bank balance sheets are the ones that (1) absorb losses by converting to equity, (2) have a mechanical trigger or (3) have an Additional Tier 1 (AT1) designation.[5]

We also look at the announcement effects on bank equity prices and find that for the full sample, there is no significant impact of CoCo issuance on the issuer's stock price. This is consistent with the predictions of our simple theoretical model, which does not generate a clear directional prediction about the impact of CoCo issuance on the value of the issuing bank equity. This reflects the fact that while a CoCo issue may strengthen a bank's balance

[5]The implicit assumption behind the above conclusions (and throughout our analysis) is that CoCo issuance is not substituting for tier-1 equity issuance; rather, CoCos are issued on top of equity.

sheet, it may do so at the behest of shareholders. Interestingly, however, one type of CoCo – a principal write-down CoCo with a high trigger – does have a positive and statistically significant impact on the issuer's equity price.

Our paper contributes to the wider literature of empirical studies of financial contracts (see Roberts and Sufi 2009, for a survey). Because our financial contracts are publicly traded, we are able to shed light on market reactions to particular designs, which is typically not possible for venture capital contracts or syndicated bank loans.

Our paper is also related to the study by Vallee (2019), who examines hybrid bonds issued by European banks between 1998 and 2012, which have similar features to CoCos structured as reverse convertible bonds. Vallee (2019) studies the effects of the ex-post conversion of these hybrid bonds during the financial crisis of 2007-09, finding that conversion had the intended effects predicted by CoCo theories.

The remainder of the paper is organized as follows. Section 2 provides the institutional background of the CoCo market, describes our CoCo data set, and presents an overview of the sample. Section 3 sketches a simple theoretical model and presents its key predictions. Section 4 presents the empirical analyses. Section 4.1 contains several duration analyses on the propensity of a bank to issue a CoCo. Section 4.2 reports the estimates of the impact of CoCo issuance on the CDS spread and the stock price of the issuing bank, as well as the differential effects of the main CoCo contract features. Section 5 discusses open questions about the future design of CoCos and offers concluding comments.

2. Institutional background and data

2.1. The CoCo instruments

CoCos have two defining features – a trigger modifying the debt repayment terms and a conversion mechanism. A CoCo can have one or more *triggers*. In the case of multiple triggers, the conversion mechanism is activated when any trigger is breached. Under Basel III rules, all CoCos are required to have a discretionary trigger, which allows regulators to activate the conversion mechanism if they decide that the issuer has reached the *point of non-viability* (PONV). In addition, some CoCos have a mechanical trigger, which is defined relative to the capital ratio of the CoCo-issuing bank. Indeed, the mechanical triggers of all the CoCos that have been issued thus far are defined in terms of the ratio of the issuing bank's Common Equity Tier 1 (CET1) capital to its risk-weighted assets (RWA).[6]

The *conversion mechanism* is the second key characteristic of a CoCo. Recapitalization through conversion can occur in two ways. A *mandatory conversion* (MC) CoCo increases CET1-capital by converting into common equity at a pre-defined conversion rate. The conversion rate can be based on (1) the market price of the stock at the time the trigger is breached, (2) a pre-specified price (e.g. the stock price at issuance), or (3) a combination of the two. *Principal write-down* (PWD) CoCos repair the issuing bank's balance sheet by writing down the principal amount. The write-down can be either permanent or temporary,

[6] In contrast, the theoretical literature has focused on market-value based triggers; see e.g. Flannery 2005, 2009; Calomiris and Herring 2013.

and can be either full or partial.[7]

Basel III rules contain two key contingent capital terms.[8] First, all AT1 and T2 CoCos must include a discretionary trigger, also known as a point of non-viability (PONV) trigger. Second, all AT1 CoCos classified as liabilities must have a mechanical trigger, with a minimum trigger level of 5.125% (in terms of CET1/RWA).[9] However, the Basel III framework does not specify a particular conversion, implicitly treating PWD-CoCos and MC-CoCos in a symmetric fashion.[10]

2.2. Data

We have compiled the most comprehensive dataset on global CoCo issuance to date by combining a number of data sources and inputs from banking regulation and supervision experts from the major CoCo-issuing jurisdictions. In the first step of our data compilation process, we obtained an initial set of CoCo instruments from commercial data providers such as Bloomberg and Dealogic. In the second step, we augmented the initial dataset with additional information from supplementary sources (such as individual CoCo instrument prospectuses and other bank statements and documents). In the third step, we consulted with banking regulation and supervision experts from the Basel Committee of Banking Su-

[7]Avdjiev, Kartasheva, and Bogdanova (2013) provide further details on CoCo contract features and bank capital regulations related to CoCos.

[8]The regulatory minimum capital requirements under the Basel III framework are (RWA-based) ratios of 4.5% for CET1, 6% for Tier 1 capital (CET1 + AT1), and 8% for total capital (CET1 + AT1 + T2). All instruments other than those in CET1 are optional – i.e. banks have the option to meet all their capital requirements using only CET1. For more details, see Basel Committee on Banking Supervision (2011).

[9]The latter requirement does not apply to AT1 CoCos classified as equity (i.e. preferred shares.)

[10]In some jurisdictions, e.g., Switzerland, national supervisors supplement the Basel III minimum capital levels by requiring G-SIB banks to have additional capital layers filled with CoCos. See FINMA (2015).

pervision Working Group on Capital to resolve contradictory information (on the characteristics of individual CoCo instruments) in the sources used in the first two steps. Finally, in order to further improve the quality and coverage of our data set, we ensured that every single CoCo instrument used in our benchmark analysis had been vetted by banking regulation and supervision experts from the respective CoCo-issuing jurisdictions. The implementation of the above four steps has greatly enhanced the quality and coverage of our dataset, setting it apart from the partial datasets used in other empirical studies on CoCo instruments (Ammann et al, 2017; Hesse, 2016) and case studies of individual CoCo instruments (Berg and Kaserer, 2015).

The sample in our benchmark analysis consists exclusively of CoCos issued by banks and excludes those issued by insurance companies and other non-bank financial institutions. Furthermore, we focus on CoCos that have at least one (mechanical or discretionary) contractual trigger.[11]

Our data includes the main terms of CoCo term-sheets, their regulatory classification, and key issuer characteristics. We track the most important terms: the conversion mechanism (principal write-down or mandatory conversion to equity), the trigger type (mechanical or discretionary), and the trigger level (for CoCos that have a mechanical trigger). We also gather information on each CoCo instrument's regulatory capital classification (Additional Tier 1 or Tier 2).

As for issuer characteristics, we track daily issuer equity prices and CDS spreads (for

[11] In this paper, we focus on loss absorption mechanism triggers and we do not analyze coupon cancellation triggers. Also we do not include CoCos that have only a statutory trigger.

senior unsecured debt). We construct benchmark indices in which banks are grouped based on their country/region of operations: "Australia and New Zealand," "Canada," "Europe," and "Japan." For equity prices, we use market capitalization-weighted Datastream bank country/regional equity indices. For CDS spreads, we calculate equally-weighted averages of the CDS spreads of banks operating in the respective county/regions. In order to obtain a more representative set of banks included in each country/regional CDS index, we augment the constituents of the MARKIT iTraxx and CDX indices with additional banks, which (i) operate in the respective CoCo-issuing jurisdictions, and (ii) have liquid CDS instruments for senior unsecured debt.[12]

In our empirical analysis of the determinants of CoCo issuance, we take the universe of potential CoCo issuers to be the top 500 banks (by total assets in 2009) in CoCo-issuing advanced economies. This sample encompasses both banks that eventually issue one or more CoCo securities and banks that could issue, but choose not to. We obtain annual data on the major balance-sheet variables for these 500 banks from Bankscope.

2.3. Sample overview

An overview of the CoCo market through the end of 2015 is presented in Table 1. Between 2009 and 2015, there have been 731 CoCo issues for a combined issuing volume of $521 billion. The size of the average CoCo issue is $713 million. This figure conceals a wide variation in

[12]All the additional banks that we include in our augmented country/regional CDS indices have (senior unsecured debt) CDS spreads reported by Markit on at least 75% of the business days in our sample. In our benchmark empirical exercises, we use the values of each country/regional CDS index on a given date only if a CDS spread is reported for at least 75% of the banks included in the respective country/region on that date.

individual CoCo issue sizes, which range from $2 million to $7 billion.

[Insert Table 1 here.]

The last column of Table 1 provides a break-down of CoCo issuance by region. European issuers account for 39% of the CoCo market. Another 14% of CoCo issuance is from banks domiciled in non-European advanced economies. One notable absence from the list of CoCo-issuing jurisdictions is the United States[13].

CoCos vary substantially in terms of contract characteristics. Our sample is roughly evenly split between the two main conversion mechanisms. There have been $283 billion worth of PWD-CoCos issued globally between 2009 and 2015. The respective global volume of MC-CoCos is only slightly smaller: $220 billion. The large majority (approximately three quarters) of the PWD-CoCos in our sample have a full and permanent principal write-down clause. Temporary PWD-CoCos account for less than 20% of the PWD-CoCos, while the respective share of partial PWD-CoCos is only 7% (see Online Appendix Table D1).

The left-hand panel of Figure 1 breaks down the evolution of CoCo issuance by the loss-absorption mechanism. Even though MC-CoCos dominated in the early years, the issuance of PWD instruments picked up over time. Growing demand by fixed income investors for CoCos and shareholder incentives to issue PWD-CoCos are important factors that contributed to this trend.

[Insert Figure 1 here.]

[13]We have not included the AT1 preferred shares and the T2 subordinated debt instruments issued by US banks since all of them have only *statutory* triggers. As discussed above, we focus on contingent convertible capital instruments with at least one *contractual* trigger.

Slightly over half of the CoCos in our sample have a mechanical trigger in addition to the discretionary trigger present in all CoCos in our sample. The total volume of CoCos with a mechanical trigger is $292 billion (or 56% of the global aggregate), and the amount of CoCos with only a discretionary trigger is $229 billion (or 44% of the global aggregate).

The majority ($205 billion) of the CoCos with a mechanical trigger have trigger levels that do not exceed 5.125%, which is the minimum trigger level (in terms of CET1/RWA) required for a CoCo to be classified as AT1 capital under Basel III. About $87 billion worth of CoCos have a mechanical trigger level that is higher than 5.125%.[14] Slightly more than half (55%) of all CoCos are classified as AT1 capital. The rest are classified as T2 capital. In the early years, issuance of AT1 instruments was slightly more prevalent than that of T2 instruments (Figure 1, right-hand panel). As issuance by emerging market economy (EME) banks picked up in 2014 and 2015, so did the share of T2 CoCos.

3. Main Hypotheses

Our empirical analysis focuses on two key questions. What bank characteristics determine whether a bank issues a CoCo of a given design? What is the impact of CoCo issuance on the market prices of other claims on the issuing bank? To guide our empirical analysis, we develop a simple theoretical model that generates several predictions on these two questions. In the model, the bank has assets and liabilities in place that currently satisfy regulatory

[14]Another potentially relevant critical capitalization level is the Capital Conservation Buffer Requirement (CBR). When an issuer's capital buffer falls below the CBR, it is constrained in its ability to continue its existing dividend and coupon payouts.

capital requirements. However, the bank is at risk of violating these requirements if it incurs a loss in a future crisis state. The bank decides whether to issue a CoCo now, in order to buttress its balance sheet to be able to withstand a loss without violating its capital requirements, or to risk having to go through a costly recapitalization in the crisis state. As a trade-off to fire-sale recapitalization costs in a crisis, the bank faces CoCo issuance costs. These issuance costs include underwriting fees and dilution costs to shareholders due to asymmetric information. The formal analysis of the model is carried out in Appendix A. Here, we briefly sketch the model before stating the main predictions.

3.1. Model

The model tracks the balance sheet of a bank over two periods and two states of nature: one in which the bank realizes a profit, and one in which it incurs a loss. The bank has the choice of issuing a CoCo at date 0 in order to forestall a costly recapitalization at date 1 in the state of nature in which it incurs a loss. We assume that shareholders and creditors are risk neutral, and shareholders are protected by limited liability. We normalize the risk-free rate to zero.

3.1.1. Date 0

Before any CoCo issuance, the bank's balance sheet has assets $A > 0$. On the liability side, the bank has deposits with face value D and senior unsecured debt with face value B. The bank's book equity (and its CET1-capital) is given by $E = CET1 = A - D - B$. We assume that at date 0, the bank does not have any other (non-CET1) capital: $AT1+T2=0$. Therefore, the bank's total capital is $TK = CET1 + AT1 + T2 = E$. Without loss of generality, we also assume that the bank's assets have a risk-weight of 100%, so that $RWA = A$. Therefore, at this stage, the bank's CET1-capital ratio is given by $\kappa_0 = \frac{CET1}{RWA} = \frac{E}{A}$ and is equal to the bank's total capital ratio $\varkappa_0 = \frac{CET1+AT1+T2}{RWA} = \frac{E}{A}$.

The bank's assets generate unit losses l in a bad state of the world with probability θ and generate unit profits π in a good state with probability $(1-\theta)$. Naturally, we assume that $\pi - \theta(l+\pi) > 0$, so that investment in risky assets is not dominated by investment in safe assets.

We denote the minimum regulatory required (CET1) capital ratio to be $\overline{\kappa} > 0$, and we assume that $\kappa_0 \geq \overline{\kappa}$ at date 0. However, following a loss at date 1, it is possible that $\kappa_1 < \overline{\kappa}$.

We consider two forms of recapitalization: (i) issuance of a CoCo at date 0, which will be converted following a loss at date 1; or (ii) asset sales at fire-sale prices in the bad state at date 1.

At date 0, the bank can choose to issue a CoCo in a competitive capital market. The CoCo has face value F, a coupon P, a trigger κ_C which is defined over the ratio of $CET1/RWA$, and the terms of conversion to equity or principal write-down described below. We assume that the proceeds from the CoCo issue are invested in a portfolio with the same risk characteristics as legacy assets A. Furthermore, we consider a situation where the bank issues CoCos in the amount to be compliant with the regulatory capital requirement in the loss state but does not benefit from issuing higher amounts.[15] This property reflects the fact that banks tend to have scale limits.[16] In addition, imposing a constraint on the size of CoCo issuance ensures that the bank does not use CoCos to increase its leverage, which is a theoretical possibility, albeit not a very realistic one.

In line with Basel III guidelines, the newly-issued CoCos in our model are classified as either Additional Tier 1 (AT1) or Tier 2 (T2) capital. As a consequence, CoCo issuance has no impact on the bank's CET1-capital, which remains $CET1^F = E$, but increases the bank's total capital $TK^F = CET1^F + AT1 + T2 = E + F$. Thus, after the issuance of a CoCo with face value F, the bank's CET1-capital ratio becomes $\kappa_0^F = \frac{E}{A+F}$, while its total capital ratio becomes $\varkappa_0^F = \frac{E+F}{A+F}$.

[15]The minimum CoCo amount necessary to be compliant with the regulatory requirements in the loss state will also depend on the CoCo terms which will be determined in equilibrium, as we clarify below.

[16]For the supporting empirical analysis on the decreasing returns to scale in banking, see e.g. Berger and Humphrey (1994) and the literature which followed. In the context of our model, the optimal scale of operations can be obtained in an extension where the bank faces decreasing returns to scale and has an optimal size prior to issuing a CoCo. Then the bank chooses to issue the amount necessary to comply with the regulatory requirement. We present the model extension in Appendix B. However, for simplicity of exposition we take the motive for CoCo issuance to comply with capital requirements in a future loss state as given in the rest of the paper.

3.1.2. Date 1

If the bank incurs a loss at date 1, its key balance sheet items (before any potential CoCo conversion) can be written as follows:

$$CET1_l = (A+F)(1-l)-(D+B+F+P). \tag{1}$$

$$RWA_l = (A+F)(1-l). \tag{2}$$

$$\kappa_l = \frac{CET1_l}{RWA_l} = \frac{(A+F)(1-l)-(D+B+F+P)}{(A+F)(1-l)} \tag{3}$$

If the bank makes a profit at date 1, its key balance sheet items (before any potential CoCo conversion) can be written as follows:

$$CET1_\pi = (A+F)(1+\pi)-(D+B+F+P). \tag{4}$$

$$RWA_\pi = (A+F)(1+\pi). \tag{5}$$

$$\kappa_\pi = \frac{CET1_\pi}{RWA_{l_\pi}} = \frac{(A+F)(1+\pi)-(D+B+F+P)}{(A+F)(1+\pi)}. \tag{6}$$

If the bank's CET1-capital ratio stays above κ_C (i.e. if $\kappa_1 = \frac{CET1_1}{RWA_1} \geq \kappa_C$), CoCo investors receive the principal F and a coupon payment P. If the trigger is breached (i.e. if $\kappa_1 = \frac{CET1_1}{RWA_1} < \kappa_C$), the CoCo converts, either into equity or through a principal write-down.

We restrict attention to the cases in which the CoCo is triggered only if the bank incurs a loss at date 1. That is,

$$\kappa_l = \frac{(A+F)(1-l)-(D+B+F+P)}{(A+F)(1-l)} < \kappa_C \leq \frac{(A+F)(1+\pi)-(D+B+F+P)}{(A+F)(1+\pi)} = \kappa_\pi. \tag{7}$$

Mandatory conversion to equity CoCos (MC-CoCos). If the bank's CET1-capital ratio drops below κ_C, the CoCo is converted to equity. The conversion of the MC-CoCo increases the value of CET1-capital (from $CET1_l = (A+F)(1-l)-(D+B+F+P)$ to $CET1_l^{MC} = (A+F)(1-l)-(D+B)$) by removing the CoCo principal amount (F) and the CoCo coupon payment (P) from the liabilities of the bank.

In lieu of a principal and coupon payment, CoCo investors receive a fraction $\alpha > 0$ of the bank's post-MC conversion equity ($CET1_l^{MC}$):

$$\alpha CET1_l^{MC} = \alpha\left[(A+F)(1-l)-(D+B)\right]. \tag{8}$$

The original shareholders retain the remaining fraction $(1-\alpha)$ of the bank's post-MC conversion equity ($CET1_l^{MC}$):

$$(1-\alpha)CET1_l^{MC} = (1-\alpha)\left[(A+F)(1-l)-(D+B)\right]. \tag{9}$$

We define F^{MC} as the minimum MC-CoCo amount the bank needs to raise to have a regulatory-capital ratio at least as high as the minimum required CET1-capital ratio $\overline{\kappa}$:

$$\frac{CET1_l^{MC}}{RWA_l^{MC}} = \frac{(A + F^{MC})(1-l) - (D+B)}{(A+F^{MC})(1-l)} = \overline{\kappa}, \tag{10}$$

or

$$F^{MC} = \frac{D + B - A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})}. \tag{11}$$

Hence, the minimum MC-CoCo amount is increasing in the leverage ratio $((D+B)/A)$, the magnitude of the loss (l), and the minimum required CET1-capital ratio $(\overline{\kappa})$.

Principal write-down CoCos (PWD-CoCos). If the bank's CET1-capital ratio drops below κ_C, the CoCo is converted through a principal write-down. The conversion of the PWD-CoCo increases CET1-capital (from $CET1_l = (A+F)(1-l) - (D+B+F+P)$ to $CET1_l^{PWD} = (A+F)(1-l) - (D+B+\eta F)$) by reducing the CoCo principal amount from F to ηF and removing the CoCo coupon payment (P) from the liabilities of the bank. CoCo investors receive no coupon payment and the principal is reduced to ηF, where $0 \leq \eta < 1$.

We define F^{PWD} as the minimum PWD-CoCo amount the bank needs to raise to have a regulatory capital ratio at least as high as the minimum required CET1-capital ratio $\overline{\kappa}$:

$$\frac{CET1_l^{PWD}}{RWA_l^{PWD}} = \frac{(A + F^{PWD})(1-l) - (D+B+\eta F^{PWD})}{(A+F^{PWD})(1-l)} = \overline{\kappa}, \tag{12}$$

or

$$F^{PWD} = \frac{D + B - A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa}) - \eta}. \tag{13}$$

As in the case of MC-CoCos, the minimum amount of PWD-CoCos needed is increasing in the leverage ratio ($(D+B)/A$), the magnitude of the loss (l), and the minimum required CET1-capital ratio ($\overline{\kappa}$). It is further increasing in the fraction of the principal amount retained by CoCo-holders after a partial write-down (η). In the case of a full write-down ($\eta = 0$), $F^{PWD} = F^{MC}$. Moreover, the admissible region for η is bounded by $\eta < (1-l)(1-\overline{\kappa})$. That is, a larger potential loss requires a larger contractual write-down ratio $(1-\eta)$.

Asset sale after a loss. If the bank does not issue CoCos at date 0, it has to liquidate some assets at fire-sale prices in order to de-lever in the bad state at date 1. To retire a Δ amount out of its senior unsecured debt B, the bank needs to sell $(1+\lambda)\Delta$ of its assets, where $\lambda > 0$ measures the fire-sale discount, or, equivalently, $\frac{1}{1+\lambda}$ is the discounted (fire-sale) price. The minimum amount Δ needs to be such that the bank's new equity-capital ratio is compliant:

$$\frac{A(1-l) - (1+\lambda)\Delta - (D+B-\Delta)}{A(1-l) - (1+\lambda)\Delta} \geq \overline{\kappa}. \tag{14}$$

Thus,

$$\Delta = \frac{1}{\overline{\kappa}(1+\lambda) - \lambda}[D + B - (1-\overline{\kappa})A(1-l)]. \tag{15}$$

Recapitalizing the bank by selling some of the assets at a discount is feasible if only if $\Delta > 0$, which implies the following restriction on the fire-sale discount: $\frac{\lambda}{1+\lambda} \leq \overline{\kappa}$. Furthermore, the bank is solvent after the liquidation only if $A(1-l) - (D+B) - \frac{\lambda}{\overline{\kappa}(1+\lambda)-\lambda}[D + B - (1-\overline{\kappa})A(1-l)] > 0$. Thus, liquidation is a viable way to recapitalize the bank only when the fire sale discount is not too high and when the bank's loss in the low state is not too large.

3.2. Determinants of CoCo issuance at date 0

The decision whether to issue CoCos rests with the shareholders of the issuing bank, who evaluate the relative costs of CoCo issuance today versus contingent recapitalization tomorrow, with the goal of shareholder value maximization. We consider the question of when it is in bank shareholders' interest to issue CoCos (1) in a situation of full information and (2) in a situation of asymmetric information, where bank shareholders know more about the bank's profits and losses than outside investors do.

3.2.1. Recapitalization under full information

Under the full information benchmark, there are two basic observations. First, a well-capitalized bank, which is able to satisfy the capital requirements $\overline{\kappa}$ even after incurring losses l, does not ever need to recapitalize at date 1. As we assume that the bank issues CoCos only for the purpose of complying with the regulatory requirement in the case of incurring a loss at date 1, a well-capitalized bank has no reason to issue a CoCo.[17] Second, a bank that is insolvent after incurring losses at date 1, i.e. $A(1-l) < D + B$, could be saved if it issues CoCos at date 0, but shareholders of such a bank are strictly worse off issuing either an MC or a PWD-CoCo, compared to the outcome of declaring bankruptcy under limited liability. Thus, only shareholders of those banks that are under-capitalized but remain solvent after a loss may find CoCos attractive to forestall a costly fire-sale of assets in the bad state of nature.

[17]In other words, as we assume that the bank has reached efficient scale at date 0, a well-capitalized bank has no reason to issue a CoCo. Also see footnote 14.

The intermediate case can be characterized by a range of losses l such that $0 < \frac{A(1-l)-(D+B)}{A(1-l)} < \overline{\kappa}$. CoCo issuance must satisfy investors' participation constraints. Given the terms of an MC-CoCo contract (F^{MC}, α, P) the participation constraint of MC-CoCo investors is

$$\theta\alpha[(A+F^{MC})(1-l)-(D+B)]+(1-\theta)(F^{MC}+P) \geq F^{MC}, \tag{16}$$

where F^{MC} is defined by (11). Thus the terms of the MC-CoCo (F^{MC}, α, P) paying zero profit to investors must satisfy[18]

$$P^{MC} = \frac{\theta}{1-\theta}\left(\frac{D+B-A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})} - \alpha\frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B)\right). \tag{17}$$

Analogously, the terms of a PWD-CoCo contract (F^{PWD}, η, P) imply the following participation constraint for the PWD-CoCo investors:

$$\theta\eta F^{PWD}+(1-\theta)(P+F^{PWD}) \geq F^{PWD}, \tag{18}$$

where F^{PWD} is defined by (13). Thus, the zero-profit condition to investors gives us the following solution:[19]

$$P^{PWD} = \frac{\theta(1-\eta)}{1-\theta}\frac{D+B-A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})-\eta}. \tag{19}$$

[18]Note that it is reasonable to require that $P^{MC} \geq 0$, which puts an upper bound on the equity conversion ratio α: $\alpha \leq \alpha_{\max} = \min\{1, \frac{(D+B)-A(1-l)(1-\overline{\kappa})}{(1-l)\overline{\kappa}(D+B)}\}$.

[19]Again, it is reasonable to ensure that $P^{PWD} \geq 0$. As such, the write-down ratio of the PWD CoCo must satisfy $\eta \leq \eta_{\max} = (1-l)(1-\overline{\kappa})$.

Interestingly, while the minimum issuance amount required to comply with the regulatory ratio F^{MC} is independent of the share α promised to investors in the loss state, the minimum issuance amount of a PWD CoCo, F^{PWD}, increases in the debt principal repayment promised to investors in the loss state η. As the bank aims to minimize the issuance amount F^{PWD}, it issues a PWD CoCo with full principal write-down, $\eta = 0$.

Under full information, the Modigliani-Miller logic applies and the optimal CoCo contract is indeterminate between a MC CoCo with terms (α, P^{MC}) that satisfy (17) or a PWD CoCo that is fully written down in the loss state, i.e. $\eta = 0$, and pays a premium P^{PWD} defined by (19). The expected payoff of a bank issuing either an MC or a PWD CoCo with $\eta = 0$ CoCo is

$$\begin{aligned} \Pi^{MC} &= \Pi^{PWD} = \theta[A(1-l) - (D+B)] + (1-\theta)[A(1+\pi) - (D+B)] \\ &\quad + F^{MC}(\theta(1-l) + (1-\theta)(1+\pi) - 1). \end{aligned} \tag{20}$$

The bank compares the expected payoff of recapitalization by issuing a CoCo to the alternative of recapitalizing through asset sales. In the bad state, at date 1, the bank needs to liquidate Δ defined by (15). Under fire-sale liquidation, the bank's shareholders obtain the expected payoff

$$\begin{aligned} \Pi^{L} &= \theta[A(1-l) - (D+B)] + (1-\theta)[A(1+\pi) - (D+B)] \\ &\quad - \frac{\theta\lambda}{\overline{\kappa}(1+\lambda) - \lambda}[D + B - A(1-\overline{\kappa})(1-l)] \end{aligned} \tag{21}$$

which is decreasing in the fire-sale discount λ. As $\Pi^{MC} = \Pi^{PWD} > \Pi^{L}$, the bank always prefers to issue a CoCo at date 0 rather than liquidate assets in the loss state at date 1. The reason is that a CoCo allows the bank to transfer payoffs between the profit and the loss states at a fair price, while assets can be liquidated only at a discount λ.

Predictions from the analysis under full information. The coupon payment P is increasing in the probability of a bad state θ, the leverage of the bank $((D + B)/A)$, the capital requirement $\overline{\kappa}$, and the size of the loss l. Similarly, the principal F is increasing in the leverage of the bank $((D + B)/A)$, the capital requirement $\overline{\kappa}$, and the size of the loss l.

In sum, there is an inverse U-shaped relation between the issuing bank's incentives to issue a CoCo and the bank's fundamental strength as measured by equity capitalization. When the bank's capitalization is very low, its shareholders have little incentive to issue CoCos, since most of the benefits of the CoCo issue go to senior unsecured debt holders and not equity holders. When the bank's capitalization is very high, it has no need to issue CoCos. It is mostly for intermediate equity capitalization levels that equity holders have an incentive to issue CoCos. In this case, equity holders, along with senior unsecured debt holders, benefit from the CoCo issue by avoiding a costly recapitalization in a crisis.

3.2.2. Recapitalization under asymmetric information

In this scenario, bank issuers know more about their balance sheets than outside investors. Not only is this a more realistic assumption, but it also explains why the announcement of a CoCo issue moves prices. It conveys information to investors and thereby potentially moves both the issuer's stock price and CDS spreads. Asymmetric information also results in mispricing of the CoCo and therefore may raise issuance costs.

To be able to capture most of the interesting informational effects, we allow for four different bank types in terms of the size of their losses in the crisis state: LL, L, H, and HH, with ex-ante prior probability belief distribution ν_{LL}, ν_L, ν_H, and ν_{HH}, where $\nu_i > 0$, and $\Sigma_i \nu_i = 1$. Type LL is a well-capitalized bank, such that $\frac{A(1-l_{LL})-D-B}{A(1-l_{LL})} \geq \overline{\kappa}$. Types L and H have identical losses $l_L = l_H = l$, such that they remain solvent after incurring these losses, $A(1-l) - D - B > 0$, but the loss l is sufficiently high to induce the capital ratio to fall below the minimum requirement: $\frac{A(1-l)-D-B}{A(1-l)} < \overline{\kappa}$. The two types differ in the probability of loss, $\theta_L < \theta_H$. Finally, type HH has a loss l_{HH} that results in insolvency: $A(1-l_{HH}) - D - B < 0$.[20]

Denote Π_i^* the full information payoff of the optimal MC or PWD contracts defined by (20) for type θ_i, $i = H, L$.

In Appendix A we solve for the Bayes-Nash (*signalling*) equilibria of this model. In particular, we show that the following semi-separating equilibrium exists.

Proposition 1 *There exists $\overline{\nu}_{HH}$ such that for any $\nu_{HH} > \overline{\nu}_{HH}$ the following strategies constitute a semi-separating Bayes-Nash equilibrium:*

i) Neither types LL or HH issue CoCos,

ii) Types L and H raise the amount $F = \frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}$. Type L offers an MC-CoCo with $\alpha_L \in [\widehat{\alpha}, 1]$, where $\widehat{\alpha} = \frac{D+B-(1-\overline{\kappa})A(1-l)}{(D+B)\overline{\kappa}(1-l)}$. Type H offers either a PWD-CoCo with $\eta = 0$

[20]We assume for simplicity that the unsecured debt B is issued before the market learns any information about bank types, so that B is not type-dependent. The model could be generalized to allow for type-dependent unsecured debt obligations without affecting the analysis.

or an MC-CoCo with $\alpha \in [0, \widehat{\alpha}]$*. Both types obtain full information payoffs* Π_i^**,* $i = L, H$*.*

Intuitively, all MC CoCos and PWD CoCos with $\eta = 0$ provide the same loss absorption benefits in the loss state in terms of avoiding the fire-sales and complying with the regulatory requirements. However, the bank type L with lower probability of a loss can signal its type and consequently reduce its costs of issuance by offering an MC CoCo with higher $\alpha \geq \widehat{\alpha}$, causing net losses to shareholders and net gains to CoCo investors, conditional on conversion occurring. Such a CoCo is less costly to type L bank's shareholders because with $\theta_L < \theta_H$, the probability of conversion is relatively low. However, if the type H bank tried to mimic the type L bank by issuing the same type of CoCo, its ex-post cost to shareholders would be relatively high. This dissuades the type H bank from mimicking and pooling with the type L bank. Thus, the type H bank's better choice is to separate and pay the full information cost of issuing a CoCo that leads to shareholder net gains (and CoCo investor losses) conditional on conversion, which is an MC CoCo with $\alpha < \widehat{\alpha}$ or a PWD CoCo with $\eta = 0$.

One implication of the model is that type H is indifferent between an MC CoCo with low α and a PWD CoCo with $\eta = 0$. In our data sample, PWD CoCos with full principal write down, i.e. $\eta = 0$, are quite common, but there is no MC CoCo with zero or very low α. This could be due to the existence of institutional constraints that prevent banks from issuing MC CoCos that promise no equity to investors post conversion. The institutional constraints have a straightforward implication for the interpretation of the model's predictions. Namely, if the issuance of MC CoCos with $\alpha = 0$ is not possible, type H issues a PWD CoCo with $\eta = 0$. In sum, the observed PWD CoCos with $\eta = 0$ signal issuance by type H , while the

MC CoCos with α significantly different from zero signal issuance by type L.

3.3. CoCo issuance and the value of other bank claims

An implication of Proposition 1 is that the announcement of a CoCo issuance lowers credit default swap spreads, given that the revised probability of the worst loss outcome, which impairs senior unsecured debt, is decreased by the CoCo issuance. The announcement of a CoCo issue results in a (weak) increase in the value of senior unsecured bonds, given that the bank is better capitalized after the CoCo issue. It also implies that the CoCos will be issued by mid-capitalized banks, i.e. types H and L. Furthermore, for the institutional reasons which require a reasonable equity share to be offered to CoCo investors upon conversion, MC CoCo issuance signals type L and thus has a bigger impact on CDS spreads compared to PWD CoCo issuance which signals type H.

The predicted stock price reaction, however, is harder to pin down. CoCo issuance induces both a positive effect on the expected value of the bank (due to the lower risk of recapitalization at fire-sale prices) and a negative signaling impact about potential losses. From Proposition 1, CoCos are issued by types L and H, but not by types LL and HH. Hence, the announcement of a CoCo issue may induce a positive or a negative stock price reaction depending on prior beliefs $(\nu_{LL}, \nu_L, \nu_H, \nu_{HH})$ and realized losses $(l_{LL}, l_L, l_H, l_{HH})$.

Proposition 2 *If* $l \leq \frac{\nu_{LL} l_{LL} + \nu_{HH} l_{HH}}{1-\nu_L-\nu_H}$, *the announcement of a CoCo issue triggers a positive stock price reaction. A positive stock price reaction for a bank that issues an MC CoCo with* $\alpha > \widehat{\alpha}$ *will exceed that of a bank that issues an MC CoCo with* $\alpha < \widehat{\alpha}$ *or a PWD CoCo with*

$\eta = 0$. If $l > \frac{\nu_{LL} l_{LL} + \nu_{HH} l_{HH}}{1 - \nu_L - \nu_H}$, the announcement of a CoCo issue triggers a negative stock price reaction.

Predictions from the analysis under asymmetric information. First, CoCo issuance, whatever its design, decreases the inferred probability of the worst type HH, and increases the recovery value of senior unsecured debt. Then either MC or PWD CoCo issuance decreases the bank's CDS spreads. In addition, issuance of an MC CoCo signals that the issuing bank is type L, and thus has a stronger effect on CDS spreads compared to issuance of a PWD CoCo, which signals that the bank is type H. However, there is no clear prediction for the issuing bank's share price. The reason is that the decision to issue a CoCo conveys a "mixed" signal about the health of the issuer's balance sheet. If the market prior is that the issuer has a very strong balance sheet, then the issuance of a CoCo is bad news; but if the market prior is that the bank is under-capitalized, then the issuance of a CoCo is good news.

4. Empirical Analyses

We conduct two main sets of empirical exercises. First, we perform duration analyses in order to investigate the main determinants of the propensity of a bank to issue a CoCo. Second, we estimate the impact of CoCo issuance on the CDS spread and the stock price of the issuing bank, as well as the differential effects of the main CoCo contract features.

In both of our benchmark empirical analyses, we focus on CoCos classified as liabilities and issued by banks from advanced economies. We do not include CoCos issued by banks from EMEs, since the considerable degree of heterogeneity in the timing of the Basel III implementation across EME jurisdictions could introduce a significant amount of noise in the empirical analyses. We do not include CoCos classified as preferred shares in our benchmark empirical analyses for a couple of reasons. First, as discussed above, CoCos that are classified as preferred shares are exempt from the requirement to have a mechanical trigger with a minimum level of 5.125% in order to be eligible to qualify as AT1 capital. Second, CoCos classified as preferred shares are concentrated in a very small number of jurisdictions and represent a tiny fraction of our overall sample.

4.1. Determinants of CoCo issuance

The first question we analyze concerns banks' propensity to issue CoCos. We focus on an "unconditional" sample of banks that could be potential CoCo issuers. We restrict the sample to the top 500 banks (ranked by total assets in 2009) in the set of CoCo-issuing advanced economies, among which 48 are CoCo issuers. Our main specification builds on the sample of the 500 largest banks, plus all the CoCo issuers from advanced economies that are not among the top 500, a total of 523 banks. We also provide sensitivity analyses (in Online Appendix Table D2) on just the 500 banks to mitigate the concern of selection bias from including smaller issuers.

We present two estimation models to capture the propensity for CoCo issuance among all potential banks. The first method is a duration model, in which we link the time it takes for a bank to issue a CoCo (from the beginning of our sample period, January 2009[21])

[21] CoCos were only beginning to be considered as a financing option by banks in 2009.

to the characteristics measured at the starting point. Duration length is naturally censored at zero, and banks that did not issue CoCos by December 2015 remain in the sample and are treated as right-censored observations (i.e., their duration to issuance is coded as being greater than 84 months). The second method is a hazard model, in which we estimate the real-time determinants for the first CoCo issuance by a bank in any given month during our sample period. Once a bank issues CoCos for the first time, all future monthly observations belonging to this bank drop out of the observation. As in the duration analysis, banks without any issuance by December 2015 are treated as being censored at the end of the sample period.

We perform several duration analyses that are reported in Table 2. Banks that were more eager to resort to CoCos for capital-building are expected to issue sooner, hence a negative coefficient implies higher propensity to issue. The first set of results, reported in Panel A, is from a two-sided Tobit regression of *time to issue*, or the number of months from January 2009 to the time of the first CoCo issue. A two-sided Tobit method is used because the dependent variable is potentially censored at zero or at the maximum length of the sample period. The independent variables include key bank balance sheet characteristics.

[Insert Table 2 here.]

The independent variables we focus on are: (i) *total assets* (in logs); (ii) *Tier 1* (Tier-1 capital); (iii) *G-SIB* (a dummy variable for G-SIB status); (iv) *gross loans*; (v) *deposits*; (vi) *trading Securities;* and (vii) *long-term funding.* All variables, except *total assets,* are scaled by total assets and expressed as percentage points. All bank characteristics are measured at the beginning of the sample period, in January 2009. We break down *deposits* into *customer deposits* and *bank deposits,* since the risk profile of banks with mostly customer deposits is likely to be significantly different from that of banks with mostly bank deposits.[22] We also track interbank lending on both the liability and asset sides through the variables *interbank borrowing* and *interbank assets.*

Our main findings are as follows. First, the coefficient on *total assets* is negative and significant for all specifications. That is, our first result implies that larger banks are quicker to issue CoCos over our sample period. This confirms the anecdotal evidence that smaller banks take longer to test the market for new financing vehicles.[23]

Second, the coefficient on *Tier 1* is negative and statistically significant in most specifications. Recall that our theoretical prediction is that inadequately capitalized banks are less likely to issue CoCos. Based on the coefficient in column (1), a one-percentage-point increase in Tier 1 capital (including CET1 and AT1, with an average ratio of 7.0% in 2009) is associated with a 3.8-month shortening in the time to issuance, out of a sample average of *55.7* months (from January 2009) for all issuers. To take into account the potential non-monotonicity in the relation, we add the square of the variable *Tier 1* (or $Tier$ 1 ˆ 2), in specification (3). Although the coefficient on the squared term is negative, it is insignificant. This is likely due to the fact that the increasing regulatory benchmark during our benchmark

[22] "Customer deposits" are defined as the sum of current customer deposits (customer transaction accounts which can be withdrawn on demand or on short notice), savings customer deposits (a customer account with limitations on the timing or number of withdrawals per period but no set maturity date) and term customer deposits (a customer account with a set maturity date). "Bank deposits" cover deposits from banks, loans and repos from banks.

[23] See, e.g., "Coco bonds: Mass conversion," *Economist,* September 13th, 2014.

window implied issuance needs for most banks. As a consequence, hardly any banks in our sample were in an "extremely well-capitalized" state, which prevented the non-monotonicity in the theoretical model from taking effect.

Third, on the asset side of bank balance sheets, the coefficients on both *gross loans* and *trading securities* are negative and significant. A higher value of the *trading securities* variable is typically interpreted as an indication of greater risk-taking by a bank (Roengpitya et al, 2014). Every percentage point increase in *trading securities* (with an average of 17.8%) predicts a 0.9 month reduction in the expected time to first issuance.

Fourth, on the liability side, deposits are commonly considered to be a reliable and sticky source of bank financing, as opposed to wholesale funding, which is more sensitive to changes in interest rates and more prone to "runs" in response to negative information about bank profitability. Indeed, Huang and Ratnovski (2011) suggest that wholesale funding was one of the major sources of bank vulnerability during the financial crisis. Consistent with their analysis, we find that banks that are predominantly financed by deposits are significantly (at the 5% level) less likely to issue CoCos. The coefficient of 0.810 for *deposits* suggests that for every 10 percentage point increase in deposits relative to total assets, a bank waits on average 8.1 more months before issuing its first CoCo. Further breaking down *deposits* into *customer deposits* and *bank deposits,* we observe that both elements are highly significant.

Finally, column (5) in Panel A shows that an increase in *interbank assets* has no significant effect, but that banks more reliant on *interbank borrowing* are significantly less likely to issue CoCos. In the interbank market, a few banks tend to play the role of market makers by channeling the excess deposits of smaller banks without access to lending opportunities to medium-sized and larger banks with ample lending opportunities (Fecht et al., 2011).

Next, we use the Cox (1972) proportional hazards model to analyze banks' propensity to issue CoCos in each month during our sample period, based on characteristics measured at each point in time. Results are reported in Panel B of Table 2. Here, a higher coefficient means a higher probability of initiating Coco issuance in a given month, conditional on no issuance in months prior to the previous month. Each coefficient, once exponentiated, can be interpreted as an "odds ratio" of issuance by a bank in a given month.

The results of the Cox hazards analysis mostly reinforce those reported in Panel A: larger banks, as well as banks with more loans and marketable securities, are more likely to issue a CoCo. The opposite is true for banks with more deposits and more interbank borrowing. Note, however, that Tier 1 capital adequacy no longer matters at the monthly frequency, except when both *Tier 1* and (*Tier 1^2),* are included as regressors, suggesting that the negative relation between core capital and propensity of CoCo issuance is most prominent among banks with low levels of *Tier 1* capital.

One could argue that the European debt crisis, ending around 2013, would have changed the quality of the banks' balance sheets in a major way and also affected their relationship to CoCo issuance. For this purpose, we divide up the sample to the 2009-2013 and 2014-2015 subsamples on which we perform the hazard analyses separately. Results, reported in Online Appendix Table D3, are qualitatively similar.

Panels C and D of Table 2 break down CoCo issuance into PWD-CoCo and MC-CoCo issues at the bank-month level using the Fine and Gray (1999) competing risk model. Under this model, the first issue of a CoCo with a particular loss-absorbing mechanism (PWD or MC) is considered the realization of one type of risk, with the other possible form of loss-absorbing mechanism interpreted as a "competing risk." Accordingly, this model estimates the propensity to issue a particular type of CoCo instrument, taking into account that another type of CoCo is also available in the issuer's choice set.

The estimated coefficients in Panels C and D suggest that there are no considerable differences between PWD CoCos and MC CoCos with respect to most of the key determinants of CoCo issuance. The only notable exception is related to Tier 1 capital, which tends to be more consistently significant for PWD-CoCos.

Finally, within PWD-CoCos, some have permanent and some have temporary write-downs. The latter offers the possibility of a "write-up" if the bank restores its financial health, while the former does not. Most CoCos that have been issued so far have a permanent principal write-down mechanism. A sensitivity analysis (reported in Online Appendix Table D4) based on a competing risk (between the two types of PWD-CoCos) hazard model shows that permanent PWD issuance is more closely related to banks' systematic status and their assets/liability structure (such as loans and trading securities), while the temporary PWD issuance is more significantly associated with asset size and capital adequacy (as measured by Tier 1 capital). Such a contrast shows that, on a relative scale, permanent PWD-CoCo issuances focus on risk management, while temporary PWD instruments serve to restore capital adequacy as needed.

4.2. Impact of CoCo issuance on CDS spreads and equity

4.2.1. Empirical set-up

The issuance of a CoCo reduces the probability of default by providing an additional layer of loss-absorbing capacity.[24] Thus CoCo issuance is expected to lower CDS spreads, as our theoretical analysis suggests. However, Proposition 2 explains that the effect of issuing a CoCo on the issuer's stock price is more difficult to determine a priori.

We assess the announcement effect of issuing CoCos on CDS spreads and equity prices using two different empirical approaches. First, we follow the estimation methodology used in James (1987) to determine the impact of CoCo issuance. In addition to assessing the overall effect, we also examine how it depends on the main CoCo contract features (conversion mechanism, trigger type, trigger level, etc.) and on issuer characteristics (size, capital cushion over trigger level, G-SIB status, geographical location, etc.). Second, we estimate the impact of CoCo issuance on CDS spreads and equity prices in a standard cross-sectional regression framework. Online Appendix C contains a detailed description of the empirical methodology used in this section.

The event date for CoCo issuance is not always clearly defined. Unlike in other event studies, where all relevant information is simultaneously announced to all market participants at a clearly defined point in time, for CoCo issues there is no single point in time when an upcoming issue is publicly announced. Instead, information about an upcoming issue spreads among market participants in a diffusion-like process. Still, the issue date often reveals

[24] As discussed in the Introduction, our analysis is based on the implicit assumption that CoCos are issued on top of (rather than instead of) CET1.

additional value-relevant information, such as the over-subscription status of the issue.

Due to the above reasons, we adopt a conservative approach in selecting the event date and the window size for our benchmark exercise. When measuring the impact of CoCo issuance on CDS spreads, we select an 11-day window (in units of trading days), which starts ten business days before the issuance date (t-10) and ends at the issuance date (t): [t-10, t]. When measuring the impact on equity prices, we select a shorter six-day window, which starts five business days before the issuance date (t-5) and ends at the issuance date (t): [t-5, t]. We select a shorter event window for equity prices than for CDS spreads since the former tend to be more informationally sensitive than the latter (Dang et al, 2013; Holmström, 2015; Dang et al, 2017). As a result, equity prices are more likely than CDS spreads to have their reaction to CoCo issuance be "contaminated" by other information that is revealed during the event window.[25]

4.2.2. Impact on bank CDS spreads

We estimate the change in issuers' CDS spreads (on senior unsecured debt) around CoCo issuance dates. Table 3 reports the results of this estimation.

[Insert Table 3 here.]

Our main finding is that the overall impact of CoCo issuance on the CDS spread of the issuing bank is negative and strongly statistically significant. The z-value (-2.70) indicates

[25]We also conduct robustness checks, in which we explore a number of alternative window sizes and event dates. The outcomes of these exercises, which, as summarized in Section 4.2.2, suggest that our main results are robust to all of the alternative window specifications we examine.

that the cumulative change vis-à-vis the benchmark during the 11-day event window is negative and statistically significant at the 1% level.[26]

The economic significance is also meaningful. The average prediction error (APE) for the full sample is approximately 3 bps. Once prediction errors are weighted by the (US dollar) volume of each issue, the estimated impact increases to 5 bps. Furthermore, the estimated economic impact varies considerably across CoCo sub-groups, ranging from 2 to 22 bps.

We next break down the full sample into subsamples sorted by the most important CoCo contract terms and issuer characteristics. Our first sorting variable is the conversion mechanism (mandatory conversion or principal write-down). The impact of mandatory conversion (MC) CoCos on CDS spreads tends to be considerably stronger than the impact of principal write-down (PWD) CoCos. The estimated impact of MC-CoCo issuance is negative and statistically significant at the 1% level (with a z-value of −3.07). Roughly two-thirds (63%) of the prediction errors in the MC-CoCo subsample have a negative sign and the Wilcoxon signed rank statistic is statistically significant at the 1% level. The coefficient for the impact of PWD-CoCo issuance is also negative, but it is not statistically significant.

In economic terms, the size of the estimated impact of MC-CoCo issuance on CDS spreads is also considerably larger than the impact of PWD-CoCo issuance. The simple average prediction error for MC-CoCos (−5.0 bps) is roughly three and a half times higher than that for PWD-CoCos (−1.4 bps). When we weight prediction errors by the size of each respective CoCo issue, the estimated impact of issuing MC-CoCos is −8.4 bps, whereas the impact of

[26]The second statistic we examine is the proportion of negative prediction errors. It has a value of 57% and is statistically significant at the 5% level by the Wilcoxon signed rank statistic.

issuing PWD-CoCos is −2.4 bps.

The significant differences between the estimated impacts of issuing MC-CoCos and PWD-CoCos on the CDS spread of the issuing bank points to the potential importance of the signaling role of the conversion mechanism. In line with the predictions of the model, the market participants interpret the issuance of an MC CoCo as better news about the bank's risk profile compared to the issuance of a PWD CoCo. The above empirical results are also consistent with earlier theoretical findings (e.g. Chan and van Wijnbergen (2017), Hilscher and Raviv (2014), Berg and Kaserer (2015)), which predict that MC CoCos with high conversion ratios reduce risk-taking incentives, while PWD CoCos increase risk-taking incentives.

A second major finding is that the presence of a mechanical trigger in CoCo term sheets plays a very important role. The estimated impact of issuing a CoCo with a mechanical trigger is negative and statistically significant at the 5% level (with a z-value of −2.22). That subsample of CoCos has an average prediction error of −3.3 bps and weighted average prediction error of −4.8 bps. In contrast, the estimated impact of issuing a CoCo that only has a discretionary trigger, while also negative, is not statistically significant.

There are a number of explanations for this key finding. CoCos with only a discretionary trigger are more akin to pure "gone concern" instruments and inherit all of the uncertainties associated with regulatory intervention in a bank resolution. At what point will the CoCo be triggered? What happens in resolution? Will the CoCo be totally or partially wiped out? Will it be the only debt instrument to be bailed in? All of these uncertainties compound to make valuing the CoCo and assessing its impact on the value of senior unsecured debt very difficult. In contrast, CoCos that also have a mechanical trigger combine features of both “gone concern” and “going concern” instruments. As a consequence, such CoCos are likely to absorb losses while the bank is still a going concern, which is desirable from the perspective of senior unsecured debt holders.

The level of the mechanical trigger is also important for the CDS market reaction. The estimated impact of issuing CoCos with a high trigger (above the minimum trigger for AT1 classification of 5.125%) on CDS spreads is negative and statistically significant at the 10% level. The estimated impact of CoCos with a low trigger (less than or equal to 5.125%) is also negative, but is not statistically significant. CoCos with a high trigger are closer to “going concern” CoCos, as they are more likely to convert before the PONV than low-trigger CoCos. Thus, they provide higher-quality protection to unsecured bondholders of the CoCo-issuing bank.

A third major result is that the impact of CoCo issuance on CDS spreads is affected by the interaction of the main CoCo design features. Namely, MC-CoCos with a mechanical trigger have a negative and statistically significant impact of -6.2 bps. This is a greater magnitude than the impact of the corresponding one-dimensional subcategories (MC-CoCos or CoCos with a mechanical trigger). This implies that the above two characteristics interact with each other to boost the impact of CoCos on CDS spreads. Intuitively, the combination of the signaling effect (associated with the MC feature) and the automatic loss absorption (associated with the mechanical trigger feature) is the most favorable design for senior unsecured debt holders. Meanwhile, the impact of MC-CoCos with a discretionary trigger is also negative, but it is only statistically significant at the 10% level and its magnitude (−1.5 bps) is considerably smaller.

A fourth important finding is that the size of the CoCo issue (as a share of RWA) matters. Large CoCo issues have a negative and statistically significant (at the 5% level) impact on CDS spreads, but small issues have no statistically significant effect. The weighted average impact on the issuing bank's CDS spread is considerably higher for larger issues (−7.2 bps) than for smaller issues (−1.7 bps). The larger the issue, the thicker the layer of protection that CoCos provide to the senior unsecured bondholders. Moreover, the fact that the bank was able to place a relatively large issue in itself reveals that investors have confidence in the overall healthiness of the bank.

A fifth important result is that the regulatory classification of CoCo instruments also plays an important role. AT1 CoCos have a negative and highly significant (at the 1% level) impact on CDS spreads. In contrast, the impact of T2 CoCos is insignificant. The weighted average prediction error is −6.7 bps for AT1 CoCos and only −0.4 bps for T2 CoCos. Intuitively, the enhanced design features associated with the higher quality AT1 capital instruments provide better protection for the senior creditors of the issuing bank.

Our results also suggest that CoCo issuance tends to have a bigger effect on the CDS spreads of smaller issuers. The impact of CoCos issued by banks with *total assets* of less than $1 trillion is negative and statistically significant at the 1% level. In contrast, the impact of CoCo issuance on CDS spreads tends to be insignificant for banks whose *total* *assets* exceed $1 trillion. Splitting banks according to their G-SIB classification generates similar results.[27] That is, the impact of CoCos issued by banks that are not classified as G-SIBs is highly significant while the impact of CoCos issued by G-SIBs is not statistically significant. This latter finding could be interpreted as indicating that market participants believe that only G-SIBs benefit from an implicit government guarantee.

We turn next to the results of our cross-sectional regression analysis of the impact of CoCo issuance on CDS spreads. In contrast to the James (1987) methodology (where we can only examine one explanatory variable at a time), the multi-variate regression set-up allows us to simultaneously examine the impact of the key variables of interest, while controlling for a number of other potentially relevant bank characteristics. One potential concern about the James (1987) methodology could be that if MC-CoCos are more likely to be issued by better-capitalized banks, the impact estimates could be biased due to the fact that we are not controlling for the issuing bank's capitalization levels. The cross-sectional regression set-up allows us to control for such potentially relevant variables.[28]

The results from the cross-sectional regressions, which are reported in Table 4, are in line with the key results obtained using the James (1987) methodology. The first set of cross-sectional regressions examines the effect of the conversion mechanism (Table 4, Panel A). In

[27]For the latter data split, we classify CoCo-issuing banks according to their G-SIB status at the time of CoCo issuance (for G-SIB lists by year, see FSB (2016)).

[28]In addition to estimating the multi-variate regressions discussed in the main text, we also address any concerns about potential biases in the impact estimates (due to correlations between the main CoCo contract features and the characteristics of the issuing bank) by examining the joint distributions of variable pairs for which such concerns could arise. The relevant summary statistics from that exercise are presented in Online Appendix Table D7. They reveal that there are no strong correlations in any of the major variable pairs that we examine. This should further alleviate any concerns about a potential bias in the impact estimates obtained using the James (1987) methodology.

line with the results obtained using the James (1987) methodology, the main finding is that the impact of MC-CoCo on CDS spreads is much more negative and significant than that of PWD-CoCos (specification (1)). In the baseline specification, the impact of MC-CoCos is negative and statistically significant at the 5% level. Once additional dummy controls are included, the impact of MC-CoCos is still negative and statistically significant at the 5% level for AT1 instruments (specification (2)) and for repeat issuers (specification (4)). In contrast, the estimated impact of PWD-CoCos is not statistically significant in any of the examined specifications.

[Insert Table 4 here.]

The second set of results provides insights into the impact of the trigger type (Table 4, Panel B). In line with the results obtained using the James (1987) methodology, the impact of CoCos with mechanical triggers is negative and statistically significant at the 5% level (Column 1). In contrast, the impact of CoCos that only have a discretionary trigger is not statistically significant. The negative impact of mechanical-trigger CoCos appears to be stronger for non-G-SIBs (Column 2) and for repeat issuers (Column 3). The last regression in Panel B examines two-dimensional splits of the main CoCo design features (Column 4). They indicate that the impact of MC-CoCos with a mechanical trigger (MC/MT CoCos) is negative and statistically significant at the 5% level. The impacts of the other three CoCo types (MC/DT, PWD/MT, PWD/DT) are also negative, but not statistically significant.

The third set of regressions investigates the effect of changing the level of the mechanical trigger (Table 4, Panel C). The estimates from the baseline specification indicate that both high-trigger and low-trigger CoCos have a negative impact, which is statistically significant at the 10% level (Column 1). The specifications with additional dummy controls reveal that the high-trigger CoCos of repeat issuers have a negative and strongly statistically significant (at the 1% level) impact (Column 3). In contrast, the impact of repeat issuers' low-trigger CoCos is statistically significant only at the 10% level. Interestingly, the impact of first-time issuers' CoCos is not statistically significant, regardless of the trigger level.

4.2.3. Impact on bank equity prices

Our theoretical analysis does not yield clear-cut predictions on the effects of CoCo issuance on equity prices. Table 5 reports the results using the same methodologies as in Table 3, but replacing CDS spreads with stock prices as an independent variable. For the overall sample, the impact of CoCo issuance is not statistically significant. This most likely reflects the same ambiguity that we discuss in our theoretical predictions. The results for the one-dimensional subsample splits along the main CoCo design features (conversion mechanism, trigger type, trigger level) are also insignificant.

[Insert Table 5 here.]

The two-dimensional subsample splits generate the most interesting results for the impact of CoCo issuance on equity prices. The most important finding is that issuing a PWD-CoCo with a high trigger has a positive and statistically significant (at the 5% level) impact on the equity price of the issuing bank. Conversely, the impact of high-trigger MC-CoCos on equity prices is negative, albeit not statistically significant.

Finally, we examine the impact of CoCo issuance on equity prices in cross-sectional regressions. The main results, which are presented in Table 6, are in line with the ones obtained using the James (1987) methodology. When examined on a stand-alone basis, the main CoCo design features (conversion mechanism, trigger type, trigger level) do not have a statistically significant impact on equity prices.

[Insert Table 6 here.]

The regression specifications that include two-dimensional (CoCo design feature) dummies generate the most interesting and statistically significant results (Columns 1-3). Just as for the estimates generated using the James (1987) methodology, the cross-sectional regression coefficients imply that the impact of PWD-CoCos with a high trigger on equity prices is positive and statistically significant (at the 5% level). Furthermore, the impact of PWD-CoCos with a mechanical trigger is also positive and statistically significant (Columns 4-5). However, its estimated magnitude is somewhat smaller than the impact of PWD-CoCos with a high trigger. Thus, the positive impact of PWD-CoCos on stock prices appears to be present for all PWD-CoCos with a mechanical trigger. Nevertheless, it is stronger for high-trigger PWD-CoCos (which absorb losses relatively early) than for low-trigger PWD-CoCo (which absorb losses relatively late).

We check for robustness by re-estimating our benchmark results, along with all of the key sub-sample break-downs, for a number of alternative windows. More specifically, we test CDS spreads on the following windows: $[t-10; t+5]$, $[t-10; t+1]$, $[t-9; t]$, and $[t-8; t+5]$. For the impact on equity prices, we adopt the following alternative windows: $[t-5; t+1]$,

$[t-6; t]$, $[t-6; t+1]$ and $[t-6; t-1]$. We find that our main results are robust to all of the above alternative specifications. More concretely, the estimated impact of CoCo issuance on CDS spreads remains negative and strongly significant for all of the above alternative event windows. Similarly, just as in our benchmark results, the impact on CDS spreads is negative and statistically significant for MC CoCos, for CoCos with a mechanical trigger, for large CoCo issues, for AT1 CoCos, and for CoCos issued by smaller banks. Meanwhile, the estimated impact of CoCo issuance on equity prices is insignificant for all alternative event windows, just as in the case of the benchmark event window. Furthermore, the estimated impact of PWD CoCos with a high trigger on equity prices is positive and statistically significant for all alternative event windows, in line with the benchmark window results.[29]

5. Conclusion

Overall, our analysis indicates that CoCos can contribute to reducing bank fragility. The CoCo market is no longer a small niche market. Although CoCos are deemed to be complex by many commentators, possibly too complex for retail investors, there appears to be a sufficiently large institutional investor clientele that stands ready to hold them. One reason why CoCos are perceived to be so complex is that there is a great variety of CoCo designs, as we have shown. Moreover, the designs that have been chosen by issuers are quite different from those recommended by the large theoretical literature on CoCos (e.g., Albul et al (2016), Chen et al (2017), Glasserman and Nouri (2016), Pennacchi and Tchistyi (2019a,

[29] While we do not report those results in the paper due to space constraints, all of them are available upon request.

2019b), Chan and van Wijnbergen (2016)).

The change in the mix of CoCo designs is primarily driven by a combination of experimentation, issuer incentives and investor demand. Now that the CoCo market is reaching maturity, it is important to find out which designs are desirable and which ones are not from a financial stability point of view, as well as where CoCo design can possibly be simplified with a view to standardizing this market.

But is this a desirable development from a financial stability perspective? We have shown that the issuance of MC CoCos has a stronger impact on CDS spreads, which may suggest that MC CoCos have a superior design from the point of view of reducing bank fragility. However, one has to recognize that the effect combines the choice of CoCo terms by the issuing bank and the information revealed to investors by the bank's actions. This points to a trade-off in terms of the combined effects of contractual features and overall issuance volumes for financial stability that any efforts to standardize CoCo instruments would have to take into account. Other potential avenues for standardization include: (i) reconsidering the benefits of CoCos with only discretionary triggers; (ii) requiring higher triggers, so that CoCos are more like "going concern" than "gone concern" instruments; (iii) revisiting the merits of T2 CoCos; (iv) considering whether to increase CoCo requirements with the goal of increasing their overall loss-absorbing capacity.

We have explored only a subset of questions on the effects of CoCos on issuing banks' balance sheets. An important open question for the immediate future concerns the investor clientele of CoCos. Unfortunately, the lack of information on the buy side makes it difficult to know the distribution of CoCo holdings and assess whether CoCos reduce rather than redistribute risks in the banking system. CoCos would enhance the stability of issuing banks and the banking system at large only if the holders of CoCos were long-term investors unconnected to the banking system.

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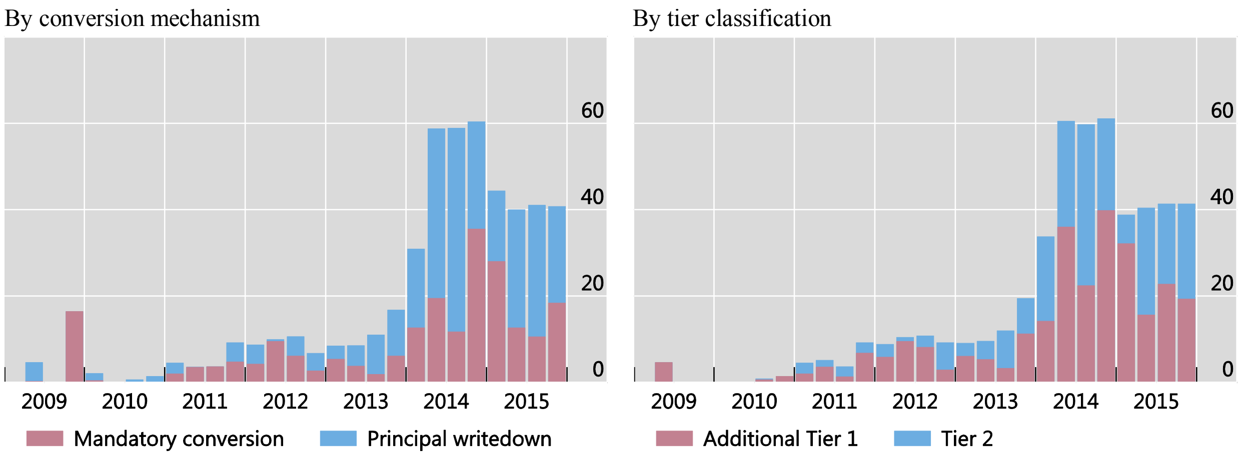
The evolution of the CoCo market

Issued amount, in USD billion

Figure 1



Note: In some periods, there are minor differences between the quarterly issued amounts in the left- and right-hand panels due to incomplete information (on tier classification or conversion mechanism) for a small number of CoCos issued in the respective periods.

Sources: Bloomberg; Dealogic; authors' calculations.

Table 1. CoCo issuance, 2009–2015

This table reports the amount issued (in billions of US dollars) of contingent convertible capital securities(CoCos) that (i) have been issued by banks between January 2009 and December 2015 and (ii) have at least one (mechanical or discretionary) contractual trigger. The number of issues is indicated in parenthesis. Individual subcategories do not always add up to the respective reported totals due to missing data and/or rounding. The *GSIB* designation refers to a global systemically important bank. The trigger threshold 5.125% is the minimum required for a CoCo to quality as additional tier 1 (AT1) capital under Basel III. Sources: Bloomberg; Dealogic.

	Conversion mechanism		Trigger				Tier classification		GSIB designation		Total
	Principal write-down	Mandatory conversion	Mechanical All levels	Mechanical <=5.125	Mechanical >5.125	Discretionary only	AT 1	Tier 2	GSIB	Non-GSIB	
Advanced economies	124.3 (182)	154.7 (194)	206.7 (243)	125.7 (174)	81.0 (69)	73.3 (142)	188.3 (228)	73.2 (117)	124.4 (108)	155.6 (277)	280.0 (385)
Euro area	43.6 (56)	41.7 (41)	73.1 (83)	55.2 (61)	17.9 (22)	12.5 (16)	75.7 (83)	8.1 (15)	36.7 (32)	48.8 (67)	85.6 (99)
Non-euro area Europe	58.1 (84)	61.2 (68)	111.9 (136)	48.7 (89)	63.1 (47)	8.1 (22)	75.6 (86)	27.6 (33)	69.3 (43)	50.6 (115)	111.9 (158)
Switzerland	29.4 (28)	8.4 (4)	33.8 (30)	24.9 (22)	8.9 (8)	4.3 (4)	19.2 (20)	18.9 (14)	33.6 (18)	4.5 (16)	38.1 (34)
United Kingdom	10.7 (6)	51.7 (60)	62.4 (66)	16.9 (37)	45.5 (29)	0 (0)	41.5 (27)	4.2 (3)	32.7 (19)	29.7 (47)	62.4 (66)
Other	18.0 (50)	1.0 (4)	15.7 (40)	6.9 (30)	8.7 (10)	3.7 (18)	14.9 (39)	4.5 (16)	3.0 (6)	16.4 (52)	19.4 (58)
Non-European AEs	22.6 (42)	51.8 (85)	21.8 (24)	21.8 (24)	0 (0)	52.7 (104)	37.0 (59)	37.5 (69)	18.4 (33)	56.1 (95)	74.5 (128)
Emerging market economies	158.6 (258)	65.1 (26)	85.6 (72)	79.5 (53)	6.1 (19)	155.9 (274)	86.6 (75)	147.8 (264)	69.4 (24)	172.0 (322)	241.5 (346)
Emerging Asia	130.0 (193)	62.2 (20)	64.7 (32)	62.5 (19)	2.2 (13)	134.1 (211)	68.7 (53)	123.5 (188)	69.1 (18)	129.7 (225)	198.8 (243)
Other EMEs	28.6 (65)	2.9 (6)	20.9 (40)	16.9 (34)	3.9 (6)	21.8 (63)	17.9 (22)	24.2 (76)	0.4 (6)	42.3 (97)	42.7 (103)
Total	282.9 (440)	219.8 (220)	292.3 (315)	205.2 (227)	87.1 (88)	229.2 (416)	274.9 (303)	221.0 (381)	193.8 (132)	327.7 (599)	521.5 (731)

Table 2. Propensity to Issue CoCos: Duration Analyses

This table analyses the propensity of banks to issue CoCos using duration analysis. The sample consists of "potential" issuers, defined as the 500 banks with the highest total assets in CoCo-issuing advanced economy jurisdictions, plus the advanced economy CoCo issuers in our sample that are not among the top 500. The sample is from January 2009 through December 2015. Panel A presents results from regressions using a Tobit regression where the dependent variable is *Time to Issue* (in months from January 2009). Panel B presents results from the Cox (1972) proportional hazards model using time-varying covariates at the bank-month level. Panel C (D) presents results from the Fine and Gray (1999) competing risk hazards model, at the bank-month level, where the issuance of any principal write-down (mandatory conversion) CoCos is the "main risk" and the issuance of any mandatory conversion (principal write-down) CoCos is the "competing risk." For Panels B – D, observations drop out of the sample right after a bank issues any CoCo for the first time. Banks without any issuance are treated as being censored at the end of the sample period. All dependent variables except *Total assets* and *GSIB* are scaled by total assets, expressed in percentage points. The independent variables are as follows: *Total Assets* (in logarithm), *Tier 1* (Tier 1 capital), *GSIB* (indicating a global systemically important bank), *Gross Loans*, *Trading Securities*, *Long Term Funding*, *Deposits* (the sum of bank deposits and customer deposits), *Tier 1 ^ 2* (the square of Tier 1), *Customer deposits*, *Bank deposits*, *Interbank borrowing* (the sum of deposits from banks, repos, and cash collateral), and *Interbank assets* (the sum of loans and advances to banks, reverse repos, and cash collateral). The t-statistics are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Duration to First CoCo Issuance

	(1)	(2)	(3)	(4)	(5)
Total assets	-11.019***	-14.317***	-10.844***	-9.641**	-16.537***
	(-4.36)	(-4.63)	(-3.53)	(-3.22)	(-4.65)
Tier 1	-3.760**	-3.834**	2.821	-2.974*	-2.682
	(-2.29)	(-2.26)	(0.57)	(-1.79)	(-1.44)
GSIB		-14.859	-13.531	-19.052*	-12.933
		(-1.33)	(-1.22)	(-1.71)	(-1.14)
Gross loans		-0.605**	-0.885***	-0.853***	-0.663**
		(-2.78)	(-3.60)	(-3.46)	(-2.59)
Trading securities		-0.873**	-0.732*	-0.942**	-1.225**
		(-2.28)	(-1.90)	(-2.32)	(-2.89)
Long term funding		-0.156	0.378	0.312	-0.114
		(-0.79)	(1.42)	(1.21)	(-0.56)
Deposits			0.810**		
(Bank+Customer)			(3.30)		
Tier 1 ^ 2			-0.385		
			(-1.24)		
Customer deposits				0.684**	
				(2.92)	
Bank deposits				2.025***	
				(4.14)	
Interbank borrowing					0.833**
					(2.44)
Interbank assets					-0.154
					(-0.45)
Number of observations	512	510	510	510	506

Panel B: Hazards to First CoCo Issuance

	(1)	(2)	(3)	(4)	(5)
Total assets	0.449***	0.530***	0.515***	0.429***	0.581***
	(6.19)	(6.10)	(5.16)	(4.59)	(5.94)
Tier 1	0.002	0.002	0.461*	0.002	0.048
	(0.29)	(0.34)	(1.91)	(0.36)	(0.88)
GSIB		0.330	0.355	0.285	0.253
		(1.06)	(1.13)	(0.89)	(0.80)
Gross loans		0.018***	0.032***	0.034***	0.022***
		(3.92)	(4.38)	(4.33)	(2.81)
Trading securities		0.037***	0.033**	0.040***	0.055***
		(3.02)	(2.48)	(2.66)	(3.92)
Long term funding		0.013**	-0.004	-0.004	0.009
		(2.16)	(-0.47)	(-0.52)	(1.45)
Deposits			-0.026***		
(Bank+Customer)			(-3.86)		
Tier 1 ^ 2			-0.026		
			(-1.52)		
Customer deposits				-0.018***	
				(-2.68)	
Bank deposits				-0.117***	
				(-4.94)	
Interbank borrowing					-0.036***
					(-2.98)
Interbank assets					-0.017
					(-1.35)
Number of observations	3323	3323	3323	3323	3296

Panel C: Hazards to First Principal Write-Down Issuance (with Mandatory Conversion as Competing Risk)

	(1)	(2)	(3)	(4)	(5)
Total assets	0.419***	0.473***	0.495***	0.350**	0.588***
	(3.49)	(3.30)	(3.27)	(2.27)	(4.48)
Tier 1	0.002**	0.002**	0.461**	0.002**	0.097**
	(2.05)	(2.36)	(2.28)	(2.51)	(2.04)
GSIB		0.580	0.633*	0.591	0.505
		(1.55)	(1.65)	(1.51)	(1.29)
Gross loans		0.016***	0.026***	0.028***	0.015*
		(3.23)	(3.21)	(3.21)	(1.71)
Trading securities		0.036***	0.032**	0.038***	0.046***
		(3.54)	(2.51)	(2.58)	(3.28)
Long term funding		0.019***	0.006	0.004	0.020***
		(3.47)	(0.76)	(0.54)	(3.03)
Deposits			-0.025***		
(Bank+Customer)			(-3.74)		
Tier 1 ^ 2			-0.020*		
			(-1.95)		
Customer deposits				-0.017***	
				(-2.69)	
Bank deposits				-0.103***	
				(-4.07)	
Interbank borrowing					-0.023**
					(-2.11)
Interbank assets					-0.018
					(-1.63)
Number of observations	3323	3323	3323	3323	3296

Panel D: Hazards to Mandatory Conversion Issuance (with Principal Write-Down as Competing Risk)

	(1)	(2)	(3)	(4)	(5)
Total assets	0.399***	0.505***	0.396**	0.423**	0.482**
	(2.98)	(2.83)	(2.04)	(2.08)	(2.33)
Tier 1	-0.002	-0.019	1.160	-0.022	-0.034
	(-0.04)	(-0.22)	(1.62)	(-0.31)	(-0.36)
GSIB		-0.303	-0.241	-0.304	-0.216
		(-0.51)	(-0.40)	(-0.50)	(-0.36)
Gross loans		0.019***	0.038***	0.041***	0.031**
		(3.92)	(4.07)	(2.98)	(2.12)
Trading securities		0.035**	0.031	0.037*	0.061***
		(2.18)	(1.55)	(1.71)	(3.23)
Long term funding		-0.002	-0.028***	-0.022**	-0.009
		(-0.30)	(-2.76)	(-2.15)	(-1.17)
Deposits			-0.030***		
(Bank+Customer)			(-4.18)		
Tier 1 ^ 2			-0.103*		
			(-1.76)		
Customer deposits				-0.019***	
				(-2.75)	
Bank deposits				-0.122***	
				(-3.06)	
Interbank borrowing					-0.053**
					(-2.33)
Interbank assets					-0.011
					(-0.57)
Number of observations	3323	3323	3323	3323	3296

Table 3. Impact of CoCo Issuance on Issuers' CDS Spreads: Cumulative Prediction Error (CPE) Analyses

This table examines the impact of CoCo issuance on issuing banks' CDS spreads using the methodology of James (1987). The average cumulative prediction errors (ACPE) for each category are calculated as equally-weighted averages of the cumulative prediction errors (CPE_j) for the set of CoCo instruments that belong to each category. The weighted average prediction errors (WACPE) are calculated as issued, amount-weighted averages of the CPE for the set of CoCo instruments that belong to each category. For each CoCo instrument j, CPE_j is defined as the cumulative prediction error (derived from a CAPM model, estimated over a period of 200 business days, excluding the 40 business days centred around the event date) of its issuer's CDS spread over the event window, which starts 10 business days before the issuance date (t-10) and ends on the issuance date (t). The "Z-value" is defined as Z = √N (ACSPE), where ACSPE is the average cumulative standardized prediction error and N is the sample size. "Proportion negative" is the proportion of negative CPE_j. The test statistic is a Wilcoxon signed rank statistic. The null hypothesis is that the proportion of negative prediction errors equals 0.5. The trigger threshold 5.125% is the minimum required for a CoCo to quality as additional tier 1 (AT1) capital under Basel III. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers CoCo instruments issued by banks in advanced economies between January 2009 and December 2015.

		Average cumulative prediction error (ACPE)	Z-value	Proportion negative	Weighted average cumulative prediction error (WACPE)	Sample size
All CoCos		-2.66***	-2.70	0.57**	-4.81	136
Conversion mechanism						
Principal write-down (PWD)		-1.35	-1.07	0.54	-2.40	87
Mandatory conversion (MC)		-4.97***	-3.07	0.63***	-8.37	49
Trigger						
Mechanical trigger		-3.25**	-2.22	0.55**	-4.80	83
<=5.125		-3.36	-1.38	0.60	-5.57	50
>5.125		-3.08*	-1.83	0.48	-3.91	33
Discretionary trigger only		-1.08	-1.15	0.58	-2.14	50
PWD and mechanical trigger		-1.61	-1.18	0.55	-2.36	53
PWD and trigger<=5.125		-0.82	-0.63	0.57	-0.67	37
PWD and trigger>5.125		-3.42	-1.20	0.50	-6.38	16
PWD and discretionary trigger only		-0.89	-0.22	0.52	-2.51	33
MC and mechanical trigger		-6.15**	-2.13	0.57*	-8.26	30
MC and trigger<=5.125		-10.58	-1.64	0.69	-21.71	13
MC and trigger>5.125		-2.76	-1.39	0.47	-2.43	17
MC and discretionary trigger only		-1.46*	-1.66	0.71*	-1.24	17
Additional Tier 1		-4.17***	-2.63	0.57**	-6.69	75
Tier 2		-0.67	-1.00	0.57	-0.35	60
CoCo issue size	<median	-1.76	-1.46	0.58*	-1.66	79
(amount issued/ RWA)	>=median	-4.36**	-2.56	0.57*	-7.21	54
Issuer size	<$1000bn	-4.04***	-2.63	0.62***	-8.97	68
(total assets)	>=$1000bn	-1.54	-1.25	0.54	-2.18	65
Issuer	GSIB	-1.53	-1.15	0.53	-2.03	72
	Non-GSIB	-3.93***	-2.72	0.63***	-9.74	64
European issuance		-3.15**	-2.20	0.55*	-5.33	93
Non-European issuance		-1.59	-1.58	0.63	-2.38	43
Distance to trigger	<median	-5.78	-1.37	0.55	-9.13	31
(Regulatory T1 capital/RWA)	>=median	-2.13*	-1.84	0.57*	-1.83	49
First-time issuer		-2.90	-0.40	0.48	-6.17	40
Repeat issuer		-2.55***	-2.93	0.61***	-4.01	94

Table 4. Impact of Coco Issuance on Issuers' CDS Spreads: Cross-Sectional Regression Analyses

This table examines the impact of CoCo issuance on issuing banks' CDS spreads using multivariate, cross-sectional regression analysis. The dependent variable (CPE_j) in all specifications is the cumulative prediction error (derived from a CAPM model, estimated over a period of 200 business days, excluding the 40 business days centred around the event date) of the CDS spread of the issuer of the CoCo instrument j over the event window, which starts 10 business days before the issuance date (t-10) and ends on the issuance date (t). The independent variables are: a dummy variable for CoCos with a principal write-down (PWD) conversion mechanism; a dummy variable for CoCos with a high trigger (HT), defined as a mechanical trigger>5.125, the minimum for a CoCo to quality as tier 1 capital; a dummy variable for CoCos with a low trigger (LT), defined as a mechanical trigger<=5.125; a dummy variable for CoCos with only a discretionary trigger (DT); a dummy variable for CoCos classified as tier 1 instruments (Tier 1); a dummy variable for CoCos issued by a globally systemically important bank (GSIB); a dummy variable for CoCos issued by a bank with no prior CoCo issuances (first-time issuer); CoCo issue size (defined as the CoCo amount issued/the risk-weighted assets of the issuing bank) and the tier 1 ratio, leverage ratio and size of the issuing bank (measured by the log of total assets)). All continuous variables are demeaned. *, ** and *** indicate significance at 10%, 5% and 1%, respectively, based on a standard t-test for individual coefficients and on a Wald test for the sums of coefficients; t-statistics (in parenthesis) are clustered by issuing bank. The sample covers CoCo instruments issued by banks in advanced economies between January 2009 and December 2015.

Panel A: Conversion mechanism

	(1)	(2) DC: Tier 1	(3) DC: GSIB	(4) DC: First-time issuer
Constant	-5.60**	-2.40*	-5.04*	-5.61**
	(-2.40)	(-1.86)	(-1.88)	(-2.51)
Principal write-down (PWD)	3.87	1.28	3.09	3.83
	(1.34)	(0.60)	(0.96)	(1.25)
Tier 1/ RWA	0.15	0.19	0.19	0.15
	(0.42)	(0.53)	(0.49)	(0.41)
Amount issued/ RWA	-2.35	-1.21	-2.54	-2.21
	(-0.85)	(-0.45)	(-0.92)	(-0.77)
Log (total assets)	-0.02	0.64	-1.45	0.08
	(-0.01)	(0.46)	(-0.87)	(0.06)
Leverage ratio	0.28	0.53	0.56	0.35
	(0.20)	(0.37)	(0.40)	(0.26)
Dummy control (DC)		-6.50	2.81	-0.47
		(-1.60)	(0.70)	(-0.07)
PWD*DC		4.55	1.23	0.56
		(0.97)	(0.29)	(0.08)
Overall impacts				
PWD	-1.73			
MC	-5.60**			
PWD; DC=0		-1.11	-1.95	-1.78
MC; DC=0		-2.40*	-5.04*	-5.61**
PWD; DC=1		-3.07	2.09	-1.69
MC; DC=1		-8.90**	-2.23	-6.08
Number of observations	133	132	133	131

Panel B: Trigger type

	(1)	(2) DC: GSIB	(3) DC: First-time issuer	(4) DC: PWD
Constant	-4.80**	-5.60**	-6.09**	-8.07**
	(-2.13)	(-2.13)	(-2.46)	(-2.21)
Discretionary trigger only (DT)	1.81	3.83	3.38	5.35
	(0.84)	(1.37)	(1.51)	(1.36)
Tier 1/ RWA	0.63	0.62	0.72*	0.52
	(1.62)	(1.54)	(1.89)	(1.33)
Amount issued/ RWA	-5.06	-4.44	-6.06*	-5.10
	(-1.41)	(-1.26)	(-1.71)	(-1.35)
Log (total assets)	0.16	-1.66	0.09	0.24
	(1.42)	(1.69)	(1.40)	(1.49)
Leverage ratio	-0.06	0.28	-0.08	0.30
	(-0.05)	(0.21)	(-0.06)	(0.22)
Dummy control (DC)		5.77**	3.43	5.31
		(2.33)	(1.29)	(1.54)
DT*DC		-1.86	-6.08	-5.87
		(-0.58)	(-1.47)	(-1.41)
Overall impacts				
DT	-3.00			
Mechanical trigger (MT)	-4.80**			
DT; DC=0		-1.77	-2.71	
MT; DC=0		-5.60**	-6.09**	
DT; DC=1		2.14	-5.36	
MT; DC=1		0.17	-2.66	
PWD;MT				-2.75
MC;MT				-8.07**
PWD;DT				-3.28
MC;DT				-2.72
Number of observations	130	130	129	130

Panel C: Trigger level

	(1)	(2) DC: GSIB	(3) DC: First-time issuer
Constant	-4.20*	-2.39	-7.44***
	(-1.72)	(-0.95)	(-2.60)
Low trigger (LT)	-0.97	-6.00	2.02
	(-0.29)	(-1.12)	(0.68)
Discretionary trigger only (DT)	1.22	0.92	4.77
	(0.55)	(0.38)	(1.62)
Tier 1/ RWA	0.63*	0.64	0.81*
	(1.65)	(1.62)	(1.93)
Amount issued/ RWA	-5.16	-4.65	-6.31*
	(-1.38)	(-1.27)	(-1.70)
Log (total assets)	0.10	-2.08	0.03
	(0.07)	(-1.08)	(0.02)
Leverage ratio	-0.12	0.56	-0.05
	(-0.08)	(0.39)	(-0.04)
Dummy control (DC)		3.33	6.93*
		(0.82)	(1.95)
LT*DC		6.40	-6.42
		(1.09)	(-0.96)
DT*DC		1.26	-9.54**
		(0.29)	(-2.03)
Overall impacts			
LT	-5.16*		
DT	-2.98		
HT	-4.20*		
LT; DC=0		-8.38*	-5.42*
DT; DC=0		-1.46	-2.67
HT; DC=0		-2.39	-7.44***
LT; DC=1		1.35	-4.91
DT; DC=1		3.13	-5.28
HT; DC=1		0.94	-0.51
Number of observations	130	130	129

Table 5. Impact of CoCo Issuance on Issuers' Equity Prices: Cumulative Prediction Error (CPE) Analyses

This table examines the impact of CoCo issuance on issuing banks' equity prices using the methodology of James (1987). The average cumulative prediction errors (ACPE) for each category are calculated as equally-weighted averages of the cumulative prediction errors (CPE_j) for the set of CoCo instruments that belong to each category. The weighted average prediction errors (WACPE) are calculated as issued amount-weighted averages of the CPE for the set of CoCo instruments that belongs to each category. For each CoCo instrument j, CPE_j is defined as the cumulative prediction error (derived from a CAPM model, estimated over a period of 200 business days, excluding the 40 business days centred around the event date) of its issuer's equity price over the event window, which starts 5 business days before the issuance date (t-5) and ends on the issuance date (t). The "Z-value" is defined as $Z = \sqrt{N}$ (ACSPE), where ACSPE is the average cumulative standardized prediction error and N is the sample size. "Proportion negative" is the proportion of negative CPE_j. The test statistic is a Wilcoxon signed rank statistic. The null hypothesis is that the proportion of negative prediction errors equals 0.5. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers CoCo instruments issued by banks in advanced economies between January 2009 and December 2015.

		Average cumulative prediction error (ACPE)	Z-value	Proportion negative	Weighted average cumulative prediction error (WACPE)	Sample size
All CoCos		0.15	0.76	0.35	0.27	170
Conversion mechanism						
Principal write-down (PWD)		0.27	1.03	0.29	1.16	103
Mandatory conversion (MC)		-0.04	-0.07	0.88	-0.74	67
Trigger						
Mechanical trigger		0.40	1.02	0.23	0.60	97
<=5.125		-0.17	0.73	0.29	0.04	65
>5.125		1.55	0.73	0.55	1.32	32
Discretionary trigger only		-0.24	-0.07	0.95	-0.38	67
PWD and mechanical trigger		0.69	1.56	0.15	1.91	60
PWD and trigger<=5.125		-0.19	0.66	0.36	0.20	47
PWD and trigger>5.125		3.87**	2.10	0.22	7.33	13
PWD and discretionary trigger only		-0.44	-0.44	0.69	-0.57	39
MC and mechanical trigger		-0.08	-0.35	0.92	-0.82	37
MC and trigger<=5.125		-0.12	0.32	0.65	-0.34	18
MC and trigger>5.125		-0.04	-0.80	0.66	-1.07	19
MC and discretionary trigger only		0.04	0.41	0.86	-0.11	28
Additional Tier 1		0.23	0.71	0.26	0.35	92
Tier 2		0.06	0.35	0.79	0.13	78
CoCo issue size	<median	0.33	1.44	0.12	0.14	92
(amount issued/ RWA)	>=median	0.37	-0.17	0.99	0.43	69
Issuer size	<$1000bn	0.65	1.30	0.27	1.75	96
(total assets)	>=$1000bn	-0.04	0.09	0.85	-0.74	67
Issuer	GSIB	0.06	0.35	0.79	-0.27	74
	Non-GSIB	0.22	0.70	0.48	1.13	96
European issuance		0.17	0.37	0.58	0.43	111
Non-European issuance		0.11	0.78	0.46	-0.24	59
Distance to trigger	<median	1.40*	1.65	0.19	1.66	40
(Regulatory T1 capital/RWA)	>=median	0.29	0.50	0.38	-0.26	51
First-time issuer		0.76	1.62	0.10	1.36	57
Repeat issuer		-0.23	-0.45	0.78	-0.41	108

Table 6. Impact of Coco Issuance on Issuers' Equity Prices: Cross-Sectional Regression Analyses

This table examines the impact of CoCo issuance on issuing banks' equity prices using multivariate, cross-sectional regression analysis. The dependent variable (CPE_j) in all specifications is the cumulative prediction error (derived from a CAPM model, estimated over a period of 200 business days, excluding the 40 business days centred around the event date) of the equity price of the issuer of CoCo instrument j over the event window, which starts 5 business days before the issuance date (t-5) and ends on the issuance date (t). The independent variables are: a dummy variable for CoCos with a Principal write-down (PWD) conversion mechanism; a dummy variable for CoCos with a high trigger (HT), defined as a mechanical trigger>5.125, the minimum for a CoCo to quality as tier 1 capital; a dummy variable for CoCos with a low trigger (LT), defined as a mechanical trigger<=5.125; a dummy variable for CoCos with only a discretionary (DT); a dummy variable for CoCos classified as tier 1 instruments (Tier 1); a dummy variable for CoCos issued by a globally systemically important bank (GSIB); a dummy variable for CoCos issued by a bank with no prior CoCo issuances (first-time issuer); CoCo issue size (defined as CoCo amount issued/ risk-weighted assets of the issuing bank) and the tier 1 ratio, leverage ratio and size of the issuing bank (measured by the log of total assets)). All continuous variables are demeaned. *, ** and *** indicate significance at 10%, 5% and 1%, respectively, based on a standard t-test for individual coefficients and on a Wald test for sums of coefficients; t-statistics (in parenthesis) are clustered by issuing bank. The sample covers CoCo instruments issued by banks in advanced economies between January 2009 and December 2015.

Conversion mechanism and trigger level

	(1)	(2) DC: GSIB	(3) DC: First-time issuer	(4)	(5) DC: GSIB	(6) DC: First-time issuer
Constant	-0.44	-0.71	-0.63	0.40	0.98	-0.05
	(-0.77)	(-1.07)	(-1.06)	(0.55)	(1.3)	(-0.05)
Principal write-down (PWD)	-0.10	0.50	-0.28	1.07	1.32	1.08
	(-0.16)	(0.59)	(-0.41)	(1.02)	(1.16)	(1.04)
High trigger (HT)	0.61	1.38	0.37			
	(0.63)	(1.01)	(0.37)			
Low trigger (LT)	1.05	1.59*	0.92			
	(1.37)	(1.88)	(1.18)			
Discretionary trigger only (DT)				-0.78	-1.78*	-0.55
				(-0.98)	(-1.75)	(-0.66)
Tier 1/ RWA	-0.27*	-0.28	-0.24	-0.28*	-0.29	-0.24
	(-1.71)	(-1.58)	(-1.59)	(-1.69)	(-1.51)	(-1.58)
Amount issued/ RWA	-0.28	-0.40	-0.46	-0.29	-0.44	-0.49
	(-0.23)	(-0.32)	(-0.38)	(-0.21)	(-0.34)	(-0.38)
Log (total assets)	-0.36	-0.16	-0.34	-0.42	-0.10	-0.40
	(-0.96)	(-0.33)	(-0.87)	(-1.03)	(-0.18)	(-0.95)
Leverage ratio	-0.51*	-0.52*	-0.55*	-0.60*	-0.60**	-0.64**
	(-1.81)	(-1.88)	(-1.92)	(-1.92)	(-2.03)	(-2.04)
Dummy control (DC)		-1.11	0.83		-1.68	0.96
		(-1.07)	(1.18)		(-1.44)	(1.4)
PWD*LT	0.15	-0.10	0.29			
	(0.16)	(-0.10)	(0.3)			
PWD*HT	4.09**	3.33*	4.24**			
	(2.07)	(1.67)	(2.04)			
PWD*DT				-1.22	-0.56	-1.44
				(-1.11)	(-0.49)	(-1.23)

Overall impacts						
PWD*HT	4.16**	4.51**	3.71**			
MC*HT	0.17	0.67	-0.26			
PWD*LT	0.66	1.28*	0.30			
MC*LT	0.62	0.88	0.29			
PWD*DT	-0.54	-0.21	-0.91	-0.53	-0.04	-0.95
MC*DT	-0.44	-0.71	-0.63	-0.38	-0.80	-0.59
PWD*MT				1.47**	2.30**	1.04
MC*MT				0.40	0.98	-0.05
Number of observations	155	155	154	155	155	154

Online Appendices

A. A simple analytical framework

A.1. Recapitalization under full information

We consider a bank which would fail to meet the regulatory capital requirement in the loss state

$$\frac{A(1-l)-(D+B)}{A(1-l)} < \overline{\kappa},$$

but remains solvent, $A(1-l)-(D+B) > 0$.

The bank can recapitalize by issuing CoCos in the amount F at date 0 or by liquidating assets Δ in the loss state at date 1. To recapitalize with CoCos, the bank needs to issue the MC CoCo amount

$$F^{MC} = \frac{D+B-A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})} > 0, \tag{22}$$

or the PWD CoCo amount

$$F^{PWD} = \frac{D+B-A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})-\eta} > 0. \tag{23}$$

To satisfy the investors' participation constraint, the bank needs to promise to investors the premium

$$P^{MC} = \frac{\theta}{1-\theta}[\frac{D+B-A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})} - \alpha\frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B)], \tag{24}$$

$$P^{PWD} = \frac{\theta(1-\eta)}{1-\theta} \frac{D + B - A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa}) - \eta}. \tag{25}$$

Note that the parameter restriction for $P^{PWD} \geq 0$ is $\eta < (1-l)(1-\overline{\kappa})$.

To deleverage by asset liquidation in the loss state, the bank needs to sell Δ such that

$$\frac{A(1-l) - (1+\lambda)\Delta - (D + B - \Delta)}{A(1-l) - (1+\lambda)\Delta} \geq \overline{\kappa}. \tag{26}$$

The minimum liquidation amount is

$$\Delta = \frac{1}{\overline{\kappa}(1+\lambda) - \lambda}[D + B - (1-\overline{\kappa})A(1-l)]. \tag{27}$$

A bank issuing an MC CoCo in the amount F^{MC} at the premium P^{MC} obtains the expected payoff

$$\begin{aligned}
\Pi^{MC} &= \theta(1-\alpha)[(A + F^{MC})(1-l) - (D+B)] \\
&\quad +(1-\theta)[(A + F^{MC})(1+\pi) - (D+B) - (F^{MC} + P^{MC})] \\
&= \theta[A(1-l) - (D+B)] + (1-\theta)[A(1+\pi) - (D+B)] \\
&\quad +F^{MC}(\theta(1-l) + (1-\theta)(1+\pi) - 1)
\end{aligned}$$

A bank issuing a PWD CoCo in the amount F^{PWD} at the premium P^{PWD} obtains the expected payoff

$$\begin{aligned}\Pi^{PWD} &= \theta[(A+F^{PWD})(1-l)-(D+B+\eta F^{PWD})] \\ &\quad +(1-\theta)[(A+F^{PWD})(1+\pi)-(D+B)-(F^{PWD}+P^{PWD})] \\ &= \theta[A(1-l)-(D+B)]+(1-\theta)[A(1+\pi)-(D+B)] \\ &\quad +F^{PWD}(\theta(1-l)+(1-\theta)(1+\pi)-1)\end{aligned}$$

Given that the bank aims to issue the minimum amount required to satisfy the regulatory capital constraint in the loss state, it would choose η to minimize F^{PWD}, i.e. $\eta = 0$. Note that for $\eta = 0$, the bank obtains the same expected payoff with either an MC or a PWD CoCo.

Suppose the bank recapitalizes by liquidating the assets at fire-sale prices at date 1. The bank's expected payoff in case of liquidation is

$$\begin{aligned}\Pi^{L} &= \theta[A(1-l)-(D+B)]+(1-\theta)[A(1+\pi)-(D+B)] \\ &\quad -\frac{\theta\lambda}{\overline{\kappa}(1+\lambda)-\lambda}[D+B-(1-\overline{\kappa})A(1-l)].\end{aligned}$$

To select its recapitalization strategy, the bank compares CoCo issuance payoff $\Pi^{MC} = \Pi^{PWD}$ and the asset liquidation payoff Π^{L}. Note that $\Pi^{MC} = \Pi^{PWD} > \Pi^{L}$. The reason is that a CoCo allows the bank to transfer payoffs between the profit and the loss states at a fair price, while asset liquidation can be done only at a discount. Hence, the bank always prefers to issue a CoCo at date 0 rather than recapitalize by liquidating assets in the loss state at date 1.

A.2. Proof of Proposition 1

A.2.1. Feasible payoffs

The state-contingent payoffs of the bank issuing an MC CoCo are

$$\begin{aligned} w_l^{MC} &= (1-\alpha)[(A+F)(1-l)-(D+B)] \\ &= (1-\alpha)\frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B), \end{aligned} \tag{28}$$

$$\begin{aligned} w_\pi^{MC} &= (A+F)(1+\pi)-(D+B)-(F+P) \\ &= A(1+\pi)-(D+B)+(\pi-\frac{\theta}{1-\theta})\frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}+\alpha\frac{\theta}{1-\theta}\frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B) \end{aligned} \tag{29}$$

Then the set of feasible allocations attained by issuing an MC CoCo is

$$w_l^{MC}=\frac{1-\theta}{\theta}[A(1+\pi)-(D+B)]+\frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B)+(\pi\frac{1-\theta}{\theta}-1)\frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}-\frac{1-\theta}{\theta}w_\pi^{MC}. \tag{30}$$

It is a segment located between the MC contracts with $\alpha=0$ and $\alpha=1$, where

$$w_l^{MC}(\alpha=0)=\frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B),$$

$$w_\pi^{MC}(\alpha=0) = A(1+\pi) - (D+B) + (\pi - \frac{\theta}{1-\theta})\frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)},$$

and

$$w_l^{MC}(\alpha=1) = 0$$

$$w_\pi^{MC}(\alpha=1) = A(1+\pi) - (D+B) + (\pi - \frac{\theta}{1-\theta})\frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)} + \frac{\theta}{1-\theta}\frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B)$$

The state-contingent payoffs of a bank issuing a PWD CoCo are

$$\begin{aligned} w_l^{PWD} &= (A+F)(1-l) - (D+B) - \eta F \\ &= A(1-l) - (D+B) + (1-l-\eta)\frac{D+B-A(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})-\eta} \end{aligned} \tag{31}$$

$$\begin{aligned} w_\pi^{PWD} &= (A+F)(1+\pi) - (D+B) - (P+F) \\ &= A(1+\pi) - (D+B) + (\pi - \frac{\theta(1-\eta)}{1-\theta})\frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)-\eta}. \end{aligned} \tag{32}$$

As the bank aims to minimize CoCo issuance amount F^{PWD} defined by (23), it sets $\eta = 0$. The state contingent payoffs of a PWD-CoCo with $\eta = 0$ are the same as those of an MC contract with $\alpha = 0$,

$$w_l^{PWD}(\eta=0) = \frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B) = w_l^{MC}(\alpha=0),$$

$$w_\pi^{PWD}(\eta=0) = A(1+\pi) - (D+B) + (\pi - \frac{\theta}{1-\theta})\frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)} = w_\pi^{MC}(\alpha=0).$$

The state contingent payoffs of a bank recapitalizing by selling the assets in the loss state are

$$w_l^L = A(1-l) - (D+B) - \frac{\lambda}{\overline{\kappa}(1+\lambda)-\lambda}[D+B-(1-\overline{\kappa})A(1-l)], \tag{33}$$

$$w_\pi^L = A(1+\pi) - (D+B). \tag{34}$$

A.2.2. Equilibrium CoCo issuance

Figure A displays the equilibrium state-contingent payoffs $G_H B$ for type θ_H and BE for type θ_L under asymmetric information. In contrast to the case of full information, issuing CoCos under the terms corresponding to $G_L B$ by type θ_L would induce a profitable deviation by type θ_H from a contract on $G_H BC$ to a contract on $G_L B$ and lead to a violation of the investors' participation constraint. Similarly, issuing a CoCo under the terms corresponding to BC by type θ_H would induce a profitable deviation by type θ_L from a contract on $G_L BE$ to a contract on BC, leading to a violation of the investors' participation constraint.

Formally, the incentive compatibility of contracts which induce allocations $G_H B$ for type θ_H and BE for type θ_L can be verified by checking the following constraints:

$$\theta_H w_{lH} + (1-\theta_H) w_{\pi H} \geq \theta_H w_{lL} + (1-\theta_H) w_{\pi L}, \tag{35}$$

$$\theta_L w_{lL} + (1-\theta_L) w_{\pi L} \geq \theta_L w_{lH} + (1-\theta_L) w_{\pi H}, \tag{36}$$

where w_{li} and $w_{\pi i}$ are the state contingent payoffs of type θ_i, $i = L, H$, for any $(w_{lH}, w_{\pi H}) \in G_H B$ and $(w_{lL}, w_{\pi L}) \in BE$.

Note that points G_H and G_L correspond to allocations induced by an MC contract with $\alpha = 0$ and a PWD contract with $\eta = 0$, and point B corresponds to the state-contingent payoffs

$$w_\pi^B = [A(1+\pi) - (D+B)] + \pi \frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)},$$

$$w_l^B = \frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B) - \frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}.$$

This allocation is implemented by an MC CoCo contract with $\alpha = \widehat{\alpha}$, where

$$\widehat{\alpha} = \frac{D+B-A(1-\overline{\kappa})(1-l)}{\overline{\kappa}(1-l)(D+B)}. \tag{37}$$

To verify (35), first note that

$$\theta_H w_{lH} + (1-\theta_H) w_{\pi H} = \Pi_H^*$$

Allocations $(w_{lL}, w_{\pi L}) \in BE$ are defined by (30), thus the RHS of (35) can be written as

$$\begin{aligned} & \theta_H w_{lL} + (1-\theta_H) w_{\pi L} \\ = \; & -\frac{\theta_H - \theta_L}{\theta_L} w_{\pi L} + \theta_H [\frac{1-\theta_L}{\theta_L}(A(1+\pi) - (D+B)) \\ & + \frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B) + (\pi \frac{1-\theta_L}{\theta_L} - 1) \frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}] \end{aligned}$$

That is, the deviation payoff $\theta_H w_{lL} + (1-\theta_H) w_{\pi L}$ is decreasing in $w_{\pi L}$. Hence the maximum deviation payoff on the segment BE is attained at point B where

$$w_{\pi L} = [A(1+\pi) - (D+B)] + \pi \frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}. \tag{38}$$

At this point,

$$\theta_H w_{lL} + (1-\theta_H) w_{\pi L} = \Pi_H^*$$

and $\theta_H w_{lL} + (1-\theta_H) w_{\pi L} < \Pi_H^*$ for all other points on BE. Hence, (35) holds for all contracts on section BE.

To verify (36) note that

$$\theta_L w_{lL} + (1-\theta_L) w_{\pi L} = \Pi_L^*.$$

Also note that the section $G_H B$ contains MC contracts (30) and the G_L corresponds to an MC contract with $\alpha = 0$ and a PWD contract with $\eta = 0$. For MC contracts inducing state contingent payoffs on segment $G_H B$, the deviation payoff of type θ_L is

$$\begin{aligned} & \theta_L w_{lH} + (1-\theta_L) w_{\pi H} \\ = \; & \frac{\theta_H - \theta_L}{\theta_L} w_{\pi H} + \theta_L [\frac{1-\theta_H}{\theta_H}[A(1+\pi) - (D+B)] \\ & + \frac{\overline{\kappa}}{1-\overline{\kappa}}(D+B) + (\pi \frac{1-\theta_H}{\theta_H} - 1) \frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}] \end{aligned}$$

which is increasing in $w_{\pi H}$. Thus, on the segment $G_H B$ it attains the maximum at point B, where

$$w_{\pi H} = [A(1+\pi) - (D+B)] + \pi \frac{D+B-A(1-\overline{\kappa})(1-l)}{(1-\overline{\kappa})(1-l)}.$$

At this point, the bank obtains a deviation payoff Π_L^* and it attains a deviation payoff $\theta_L w_{lH} + (1-\theta_L) w_{\pi H} < \Pi_L^*$ for any other MC contract on $G_H B$. Thus (36) holds for all contracts on $G_H B$.

The verification that contracts on sections DB and BC induce profitable deviations and lead to the violation of the investors' participation constraint is analogous and is omitted.

The incentive compatible allocations on the segments $G_H B$ for type θ_H and BE for type θ_L are implemented by the following CoCo contracts. Type θ_H issues either a PWD-CoCo with $\eta = 0$ or an MC-CoCo with $\alpha \in [0, \widehat{\alpha}]$, where $\widehat{\alpha}$ is defined by (37). Type θ_L issues an MC-CoCo with $\alpha \in [\widehat{\alpha}, 1]$.

Another set of necessary conditions is that types L and H prefer to separate rather than pool with types LL and HH by not issuing any CoCos. If types L and H shareholders do not issue CoCos and hold on to their shares, in the event of a loss, they must engage in a costly recapitalization via fire-sales (which is suboptimal). If they do not issue CoCos and sell their shares at date 0 in the secondary market, their shares are valued as if they were a weighted average of types LL and HH (we assume that share trading in the secondary market is entirely anonymous and therefore cannot signal the type of insiders). The posterior beliefs over bank types, conditional on no CoCo issuance, are

$$\nu_{HH}(N) = \frac{\nu_{HH}}{\nu_{HH} + \nu_{LL}} \text{ and } \nu_{LL}(N) = \frac{\nu_{LL}}{\nu_{HH} + \nu_{LL}}.$$

The value of shares conditional on no CoCo issuance is then

$$\Pi(N) = \nu_{HH}(N)\Pi^*_{HH} + \nu_{LL}(N)\Pi^*_{LL}.$$

Since $\Pi^*_{HH} < \Pi^*_H < \Pi^*_L < \Pi^*_{LL}$, a necessary condition for types H and L to prefer to separate is

$$\nu_{HH} > \overline{\nu}_{HH} \equiv \frac{\nu_{LL}(\Pi^*_{LL} - \Pi^*_H)}{\Pi^*_H - \Pi^*_{HH}}.$$

Finally, we must verify that types LL and HH are better off issuing no CoCos rather than imitating type H or type L. Type LL shareholders can achieve their full-information payoff Π^*_{LL} by not issuing CoCos and holding on to their shares. They cannot do better by imitating types L or H. As for type HH, insider shareholders benefit from being pooled with type LL and realizing the value $\Pi(N)$ by selling their shares at date 0. If they imitate L by issuing a CoCo contract, they will raise funds F that are insufficient to be able to absorb the loss l_{HH}. If the loss l_{HH} is large enough (e.g. such that $A(1 - l_{HH}) - D - B - F < 0$), they don't gain anything by imitating L and holding onto their shares. The last possibility is that they imitate type L by issuing an MC contract with $\alpha \in [\widehat{\alpha}, 1]$ and immediately sell their shares. We rule out this possibility by assuming that type L could prevent this imitation and separate itself from type HH by including a lock-up provision in the CoCo contract preventing insiders from selling their shares in the secondary market. ■

The logic behind the separation of types L and H is related to the analysis of Cremer and McLean (1985). Types L and H can separate by shifting promised repayments to CoCo investors to the relatively less likely state for their type.[30] The general principle behind Proposition 1 is that bank-issuer types with a lower probability of facing a loss can signal this lower probability by promising to repay more in the state of nature where they are incurring a loss.

A.3. Proof of Proposition 2

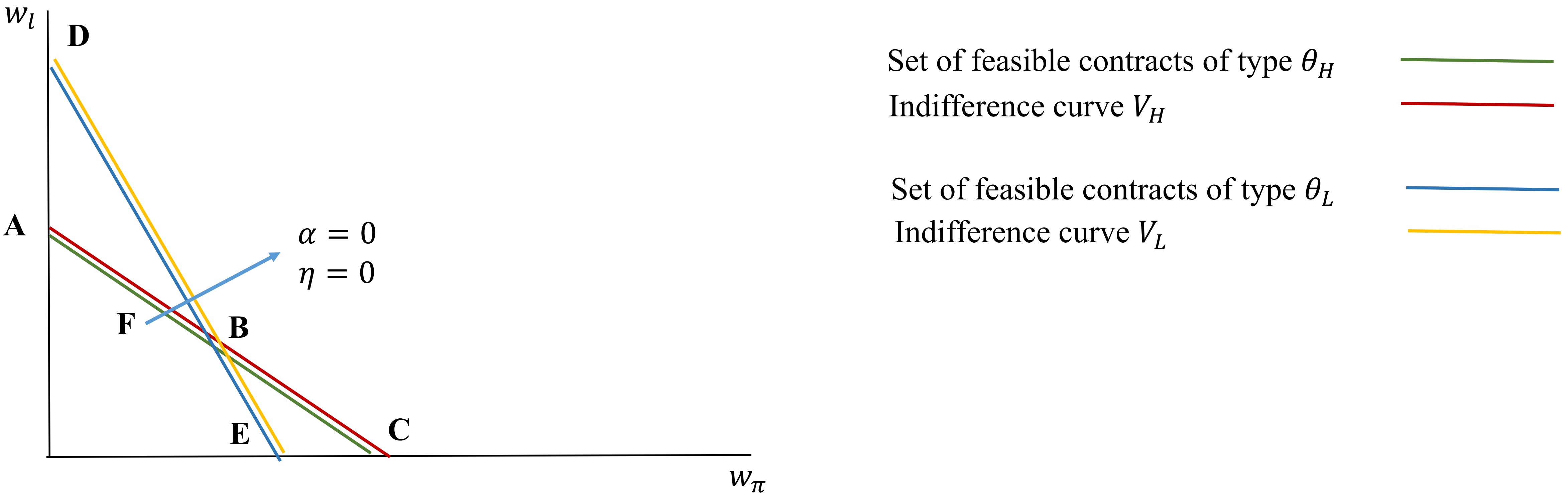
The stock price reaction of the announcement of a CoCo issue may be positive or negative depending on prior beliefs $(\nu_{LL}, \nu_L, \nu_H, \nu_{HH})$ and realized losses $(l_{LL}, l_L, l_H, l_{HH})$, where $l_H = l_L = l$. If

$$l < \nu_{LL} l_{LL} + \nu_L l_L + \nu_H l_H + \nu_{HH} l_{HH},$$

then the announcement of a CoCo issue is good news, which results in a positive stock price reaction. Otherwise, CoCo issuance is bad news, prompting a negative stock price reaction. Furthermore, a type L bank will always have a greater stock price reaction than a type H bank. As $\Pi_L^* > \Pi_H^*$, the stock price reaction of a bank type L which issues an MC CoCo with $\alpha > \widehat{\alpha}$ will exceed that of a type H bank which issues an MC CoCo with $\alpha < \widehat{\alpha}$ or a PWD CoCo with $\eta = 0$. Note that in either case, bank types L and H still decide to issue a CoCo to avoid a costly recapitalization. ■

[30] See J. Cremer and R. P. McLean (1985): "Optimal Selling Strategies Under Uncertainty for a Discriminating Monopolist When Demands Are Interdependent," Econometrica, 53, 345-361.

Figure A: Recapitalization under asymmetric information



B. A model with decreasing returns to scale

In this section, we present a model where a bank has decreasing returns to scale and, as a result, aims to limit CoCo issuance to the amount necessary to satisfy capital requirements in the low state. We capture decreasing returns to scale by assuming a piece-wise linear production function for simplicity, and assume that the return of the bank in the profit state is capped once assets reach a certain size. In the loss state, investing $A + F$ yields $(A + F)(1 - l)$. In the profit state, investing $A + F$ yields $(A + F)(1 + \pi)$ if $A + F \leq \widehat{A}$, and it yields $\widehat{A}(1 + \pi)$ if $A + F > \widehat{A}$. In this setting, the optimal bank size is equal to $\widehat{A}$. Further, without much loss of generality, we assume that prior to CoCo issuance, a bank operates at the optimal scale, $A = \widehat{A}$. Thus, as we show below, issuing CoCos involves both a regulatory cost and a benefit to the bank.

As in the basic model, we assume that the bank would fail to meet the regulatory capital requirement in the loss state,

$$\frac{\widehat{A}(1 - l) - (D + B)}{\widehat{A}(1 - l)} < \overline{\kappa}.$$

The bank can recapitalize by issuing a CoCo at date 0 or by liquidating assets Δ at date 1. To recapitalize with CoCos, the bank needs to issue at least the MC CoCo amount

$$F_{\min}^{MC} = \frac{D + B - \widehat{A}(1 - l)(1 - \overline{\kappa})}{(1 - l)(1 - \overline{\kappa})} > 0, \tag{39}$$

or at least the PWD CoCo amount

$$F_{\min}^{PWD} = \frac{D + B - \widehat{A}(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa}) - \eta} > 0. \tag{40}$$

To satisfy the investors' participation constraint, the bank needs to set the terms of the CoCo contract to satisfy

$$P^{MC} = \frac{\theta}{1-\theta}[F^{MC} - \alpha((\widehat{A} + F^{MC})(1-l) - (D+B))], \tag{41}$$

$$P^{PWD} = \frac{\theta}{1-\theta}(1-\eta)F^{PWD}. \tag{42a}$$

To deleverage by asset liquidation, the bank needs to sell Δ such that

$$\frac{\widehat{A}(1-l) - (1+\lambda)\Delta - (D+B-\Delta)}{\widehat{A}(1-l) - (1+\lambda)\Delta} \geq \overline{\kappa}. \tag{43}$$

The minimum liquidation amount is

$$\Delta = \frac{1}{\overline{\kappa}(1+\lambda) - \lambda}[D + B - (1-\overline{\kappa})\widehat{A}(1-l)]. \tag{44}$$

Consider first issuance of an MC CoCo in the amount F^{MC} at the premium P^{MC} which satisfy (41). The bank's expected payoff in this case is

$$\begin{aligned}\Pi^{MC} &= \theta(1-\alpha)[(\widehat{A}+F^{MC})(1-l)-(D+B)]+(1-\theta)[\widehat{A}(1+\pi)-(D+B)-(F^{MC}+P^{MC})] \\ &= \theta[\widehat{A}(1-l)-(D+B)]+(1-\theta)[\widehat{A}(1+\pi)-(D+B)]-(1-\theta(1-l))F^{MC}.\end{aligned}$$

Note that issuing a CoCo does not generate any return in the good state, as $\widehat{A}+F^{MC}$ exceeds the bank's optimal capacity $\widehat{A}$. The term $(1-\theta(1-l))F^{MC}$ measures the regulatory cost for the bank. A profit maximizing bank aims to minimize F^{MC} and sets $F^{MC}=F^{MC}_{\min}$ defined by (39). The bank obtains the payoff

$$\begin{aligned}\Pi^{MC} &= \theta[\widehat{A}(1-l)-(D+B)]+(1-\theta)[\widehat{A}(1+\pi)-(D+B)] \\ &\quad -(1-\theta(1-l))\frac{D+B-\widehat{A}(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})}.\end{aligned}$$

It is decreasing in the capital requirement $\overline{\kappa}$, bank's leverage $D+B$, and the loss amount l.

Consider issuance of a PWD CoCo in the amount F^{PWD} at the premium P^{PWD} which satisfy (42a). The bank's expected payoff is

$$\begin{aligned}\Pi^{PWD} &= \theta[(\widehat{A}+F^{PWD})(1-l)-(D+B+\eta F^{PWD})] \\ &\quad +(1-\theta)[\widehat{A}(1+\pi)-(D+B)-(F^{PWD}+P^{PWD})] \\ &= \theta[\widehat{A}(1-l)-(D+B)]+(1-\theta)[\widehat{A}(1+\pi)-(D+B)]-(l\theta(1-\eta)+(1-\theta))F^{PWD}\end{aligned}$$

Similarly to an MC CoCo, issuing a CoCo leads to the regulatory costs $(l\theta(1-\eta)+(1-$

$\theta))F^{PWD}$. A profit-maximizing bank sets $F^{PWD} = F^{PWD}_{\min}$. Then the payoff can be written as

$$\Pi^{PWD} = \theta[\widehat{A}(1-l) - (D+B)] + (1-\theta)[\widehat{A}(1+\pi) - (D+B)] - C(\eta),$$

where $C(\eta)$ is the cost if issuance,

$$C(\eta) = (l\theta(1-\eta) + (1-\theta))\frac{D+B-\widehat{A}(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})-\eta}$$

Note that the cost $C(\eta)$ is increasing in η,

$$\begin{aligned}\frac{dC}{d\eta} &= [l\theta(1-\eta)+(1-\theta)]\frac{D+B-\widehat{A}(1-l)(1-\overline{\kappa})}{((1-l)(1-\overline{\kappa})-\eta)^2} - l\theta\frac{D+B-\widehat{A}(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})-\eta} \\ &= \frac{D+B-\widehat{A}(1-l)(1-\overline{\kappa})}{((1-l)(1-\overline{\kappa})-\eta)^2}[1-\theta+\theta l(1-(1-l)(1-\overline{\kappa}))] > 0.\end{aligned}$$

Hence, the bank issues a PWD CoCo with $\eta = 0$. This contract obtains the same expected payoff as an MC CoCo,

$$\begin{aligned}\Pi^{PWD} &= \theta[\widehat{A}(1-l) - (D+B)] + (1-\theta)[\widehat{A}(1+\pi) - (D+B)] \\ &\quad -(1-\theta(1-l))\frac{D+B-\widehat{A}(1-l)(1-\overline{\kappa})}{(1-l)(1-\overline{\kappa})}.\end{aligned} \tag{45}$$

Suppose the bank recapitalizes by liquidating the assets at fire-sale prices at date 1. In this case, the bank sells the amount $(1+\lambda)\Delta$ of assets to retire Δ of its senior unsecured debt B to satisfy the capital requirement

$$\frac{\widehat{A}(1-l)-(1+\lambda)\Delta-(D+B-\Delta)}{\widehat{A}(1-l)-(1+\lambda)\Delta}\geq\overline{\kappa},$$

which requires the minimum amount

$$\Delta=\frac{1}{\overline{\kappa}(1+\lambda)-\lambda}[D+B-(1-\overline{\kappa})\widehat{A}(1-l)].$$

The bank's expected payoff in case of liquidation is

$$\begin{aligned}\Pi^{L} &= \theta[\widehat{A}(1-l)-(D+B)]+(1-\theta)[\widehat{A}(1+\pi)-(D+B)]\\ &\quad -\frac{\theta\lambda}{\overline{\kappa}(1+\lambda)-\lambda}[D+B-(1-\overline{\kappa})\widehat{A}(1-l)].\end{aligned}$$

To select its recapitalization strategy, the bank compares CoCo issuance payoff $\Pi^{MC}=\Pi^{PWD}$ and the asset liquidation payoff Π^{L}. It prefers to issue CoCos at date 0 when the liquidation costs are sufficiently high,

$$\lambda>\frac{\overline{\kappa}}{1-\overline{\kappa}}(1-\theta(1-l)). \tag{46}$$

Otherwise, the bank recapitalizes by liquidating assets in date 1.

This setting with decreasing returns to scale obtains the same qualitative predictions as the basic model presented in Section 3. The proofs are similar to the proofs presented in Appendix A, and are thus omitted.

C. Impact of CoCo issuance - Empirical methodology

We conduct our empirical analysis of the impact of CoCo issuance on CDS spreads and equity prices in two steps.

In the first part, we employ the event methodology used in James (1987). The prediction error associated with CoCo instrument j on day t is defined as:

$$PE_{jt} = R_{jt} - (\alpha_j + \beta_j R_{mt}),$$

where R_{jt} is the equity return or the change in the CDS spread on day t of the bank that has issued CoCo instrument j; R_{mt} is the return on the benchmark equity or CDS index on day t; α_j and β_j are the estimated coefficients from a CAPM over an estimation period of 200 business days that excludes the 40 business days centered around the event date.

The cumulative prediction error (CPE) of CoCo instrument j over an event window $(t_0 - T, t_0)$ is given by:

$$CPE_j =_{t=t_0-T}^{t_0} PE_{jt},$$

and the average cumulative prediction error (ACPE) over a sample of CoCo instruments of size N is:

$$ACPE = \frac{1}{N}{}_{j=1}^{N} CPE_j.$$

Tests of statistical significance are based on cumulative standardized prediction errors (CSPE) over the event window $(t_0 - T, t_0)$ that account for the number of days in the estimation period and the length of the event window so as to control for the increase in variance from prediction outside the estimation period. The cumulative standardized prediction error for bank j over the event window $(t_0 - T, t_0)$ is defined as:

$$CSPE_j =_{t=t_0-T}^{t_0} \frac{PE_{jt}}{S_{jt}},$$

where

$$S_{jt} = \left[TV_j^2 \left[1 + \frac{1}{M} + \frac{(R_{mt} - \bar{R}_m)^2}{{}_{i=1}^{M}(R_{mi} - \bar{R}_m)^2} \right] \right]^{\frac{1}{2}}$$

and M is the number of business days in the CAPM estimation, V_j^2 is the variance of the residual in CoCo instrument j's CAPM regression and $\bar{R}_m$ is the mean market return over the estimation period.

The average cumulative standardized prediction error (ACSPE) over the event window $(t_0 - T, t_0)$ is:

$$ACSPE = \frac{1}{N}{}_{j=1}^{N} CSPE_j.$$

Assuming the individual prediction errors are independent across instruments, the Z statistic

$$Z = \sqrt{N}(ACSPE)$$

is distributed as $N(0, 1)$ under the null hypothesis that the average cumulative standardized prediction error equals 0.

In the second part of our empirical examination of the impact of CoCo issuance on

CDS spreads and equity prices, we estimate multivariate cross-sectional regressions. More precisely, we focus on the following specification:

$$CPE_j = \alpha_j + \beta_j X_j, +u_j,$$

where CPE_j are the cumulative prediction errors (defined above) over the event window $(t_0 - T, t_0)$ and X_j is a set of characteristics of the instrument and the issuing bank. More concretely, we focus on the main CoCo contractual features such as the conversion mechanism, the trigger type, and the trigger level. In order to properly account for multiple issuance by a single bank over the sample period, we use clustered regressions, assuming that the errors are independent across banks, but allowing them to be correlated within banks.

Since all continuous right-hand variables are demeaned, the estimate for the intercept in each specification represents an estimate for the impact of issuing a CoCo with the contract characteristic for which no dummy variable is designated (evaluated at the respective means of all continuous right-hand variables). For example, in specification (1) in Table 4, the estimate for the intercept also represents an estimate for the (average) impact of issuing a CoCo with an MC conversion mechanisms since this is the estimated impact of issuing a CoCo when the PWD dummy is equal to 0 (i.e. when the conversion mechanism is not PWD, but MC).■

D. Additional Tables

Table D1. CoCo Issuance, by conversion mechanism, 2009–15

This table reports the amount issued (in billions of US dollars) of CoCos that (i) were issued by banks between January 2009 and December 2015 and (ii) have at least one (mechanical or discretionary) contractual trigger. The number of issues is indicated in parentheses. Individual subcategories do not always add up to the respective reported totals due to missing data and/or rounding. Sources: Bloomberg; Dealogic.

	Conversion mechanism				
	Principal write-down PWD	Full permanent PWD	Partial permanent PWD	Temporary PWD	Mandatory conversion MC
Advanced economies	124.3 (182)	75.1 (108)	7.1 (6)	42.1 (68)	154.7 (194)
Euro area	43.6 (56)	9.3 (23)	1.7 (1)	32.6 (32)	41.7 (41)
Non-euro area Europe	58.1 (84)	43.2 (43)	5.4 (5)	9.5 (36)	61.2 (68)
Switzerland	29.4 (28)	28.3 (24)	1.1 (4)	0 (0)	8.4 (4)
United Kingdom	10.7 (6)	10.7 (6)	0 (0)	0 (0)	51.7 (60)
Other	18.0 (50)	4.2 (13)	4.4 (1)	9.5 (36)	1.0 (4)
Non-European AEs	22.6 (42)	22.6 (42)	0 (0)	0 (0)	51.8 (85)
Emerging market economies	158.6 (258)	137.6 (215)	13.6 (26)	6.9 (16)	65.1 (26)
Emerging Asia	130.0 (193)	122.8 (174)	5.8 (10)	1.4 (9)	62.2 (20)
Other EMEs	28.6 (65)	14.8 (41)	7.8 (16)	5.5 (7)	2.9 (6)
Total	282.9 (440)	212.7 (323)	20.8 (32)	49.0 (84)	219.8 (220)

Table D2. Propensity to Issue CoCos: Duration Analyses with the Top 500 banks

This table analyses repeats the analysis in Table 2 Panel A except using the sample of the Top 500 banks only, i.e., not including CoCos from the advanced economy that are not among the top 500. The t-statistics are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Total assets	-8.957***	-11.673***	-9.019**	-7.798**	-15.243***
	(-3.437)	(-3.639)	(-2.848)	(-2.484)	(-3.961)
Tier 1	-2.884*	-3.003*	7.321	-2.297	-1.145
	(-1.693)	(-1.676)	(1.418)	(-1.301)	(-0.566)
GSIB		-10.172	-6.815	-12.418	-5.550
		(-0.826)	(-0.553)	(-0.994)	(-0.450)
Gross loans		-0.319	-0.592**	-0.537**	-0.331
		(-1.484)	(-2.425)	(-2.159)	(-1.319)
Trading securities		-0.926**	-0.854**	-0.986**	-1.182**
		(-2.351)	(-2.161)	(-2.350)	(-2.743)
Long term funding		-0.167	0.277	0.229	-0.177
		(-0.793)	(1.006)	(0.849)	(-0.821)
Deposits			0.645**		
(Bank+Customer)			(2.541)		
Tier 1 ^ 2			-0.631*		
			(-1.951)		
Customer deposits				0.584**	
				(2.364)	
Bank deposits				1.681***	
				(3.345)	
Interbank borrowing					0.676*
					(1.894)
Interbank assets					-0.317
					(-0.920)
Number of observations	493	491	491	491	486

Table D3. Propensity to Issue CoCos: Duration Analyses on Subsamples prior to and post European Debt Crisis

This table repeats the analysis in Table 2 Panel B except dividing the full sample into two subsamples 2009-2013 and 2014-2-15. The t-statistics are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Hazards to First CoCo Issuance 2009-2013

	(1)	(2)	(3)	(4)	(5)
Total assets	0.429***	0.499***	0.466***	0.384***	0.490***
	(4.35)	(4.31)	(3.49)	(3.05)	(3.80)
Tier 1	0.00126	0.00145	0.647*	0.00199	0.0945
	(0.21)	(0.23)	(1.71)	(0.32)	(1.30)
GSIB		0.0217	0.0207	-0.0115	0.0686
		(0.05)	(0.04)	(-0.02)	(0.15)
Gross loans		0.0157***	0.0301***	0.0309***	0.0155
		(2.69)	(2.94)	(2.85)	(1.44)
Trading securities		0.0297	0.0229	0.0222	0.0412**
		(1.64)	(1.08)	(0.99)	(2.21)
Long term funding		0.00499	-0.0169	-0.0136	0.00398
		(0.55)	(-1.22)	(-1.06)	(0.41)
Deposits			-0.0313***		
(Bank+Customer)			(-3.18)		
Tier 1 ^ 2			-0.0408		
			(-1.42)		
Customer deposits				-0.0233**	
				(-2.44)	
Bank deposits				-0.106***	
				(-3.58)	
Interbank borrowing					-0.0263*
					(-1.78)
Interbank assets					-0.0218
					(-1.29)
Number of observations	2493	2493	2493	2493	2472

Table D4. Propensity to Issue CoCos: Duration Analyses with Competing Risk between Temporary and Permanent PWD

This table repeats the analysis in Table 2 Panel C except focusing on the subsample of PWD CoCo issuance. In Panel A the main event is a permanent PWD issuance with a temporary PWD issuance serves as a competing risk. In Panel B the order of main and competing risks are reversed. The t-statistics are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Hazards to Permanent PWD Issuance (with Temporary PWD Issuance as Competing Risk)

	(1)	(2)	(3)	(4)	(5)
Total assets	0.333**	0.394**	0.403*	0.279	0.608***
	(2.11)	(2.02)	(1.85)	(1.34)	(3.40)
Tier 1	0.00105	0.00152	0.418*	0.00177	0.0771
	(1.13)	(1.53)	(1.75)	(0.45)	(1.04)
G-SIB		0.951**	1.056**	0.930**	0.832*
		(2.17)	(2.38)	(2.08)	(1.80)
Gross loans		0.0203***	0.0391***	0.0424***	0.0302**
		(4.16)	(4.49)	(3.85)	(2.04)
Trading securities		0.0395***	0.0384**	0.0502***	0.0685***
		(3.54)	(2.56)	(2.66)	(3.09)
Long-term funding		0.0212***	0.00140	-0.00196	0.0175**
		(3.46)	(0.14)	(-0.22)	(2.05)
Deposits			-0.0323***		
(Bank+Customer)			(-4.31)		
Tier 1 ^ 2			-0.0191*		
			(-1.73)		
Customer deposits				-0.0226***	
				(-3.10)	
Bank deposits				-0.168***	
				(-3.94)	
Interbank borrowing					-0.0489***
					(-2.71)
Interbank assets					-0.0277
					(-1.55)
Number of observations	3323	3323	3323	3323	3296

Panel B: Hazards to Temporary PWD Issuance (with Permanent PWD Issuance as Competing Risk)					
	(1)	(2)	(3)	(4)	(5)
Total assets	0.549***	0.600***	0.667***	0.535***	0.632***
	(3.08)	(3.08)	(3.57)	(2.68)	(3.25)
Tier 1	0.00255***	0.00279***	0.609	0.00293***	0.122***
	(2.69)	(2.88)	(1.43)	(2.94)	(3.36)
G-SIB		-0.300	-0.309	-0.368	-0.306
		(-0.42)	(-0.44)	(-0.51)	(-0.43)
Gross loans		0.00517	0.00553	0.00723	0.000986
		(0.54)	(0.43)	(0.53)	(0.11)
Trading securities		0.0262	0.0233	0.0272	0.0269
		(1.25)	(1.03)	(1.08)	(1.47)
Long-term funding		0.0107	0.00768	0.00667	0.0129
		(1.14)	(0.73)	(0.65)	(1.35)
Deposits			-0.0115		
(Bank+Customer)			(-1.11)		
Tier 1 ^ 2			-0.0282		
			(-1.09)		
Customer deposits				-0.00516	
				(-0.47)	
Bank deposits				-0.0465**	
				(-1.99)	
Interbank borrowing					-0.00228
					(-0.19)
Interbank assets					-0.0111
					(-0.82)
Number of observations	3323	3323	3323	3323	3296

Table D5. Impact of CoCo Issuance on Issuers' CDS Spreads: Cumulative Prediction Error (CPE) Analyses

This table examines the impact of CoCo issuance on issuing banks' CDS spreads using the methodology of James (1987). The average cumulative prediction errors (ACPE) for each category are calculated as equally-weighted averages of the cumulative prediction errors (CPEj) for the set of CoCo instruments that belong to each category. The weighted average cumulative prediction errors (WACPE) are calculated as issued, amount-weighted averages of the CPE for the set of CoCo instruments that belong to each category. For each CoCo instrument j, CPE_j is defined as the cumulative prediction error (derived from a CAPM model, estimated over a period of 200 business days, excluding the 40 business days centered around the event date) of its issuer's CDS spread over the event window, which starts 10 business days before the issuance date (t-10) and ends on the issuance date (t). The "Z-value" is defined as $Z = \sqrt{N}$ (ACSPE), where ACSPE is the average cumulative standardized prediction error and N is the sample size. "Proportion negative" is the proportion of negative CPE_j. The test statistic is a Wilcoxon signed rank statistic. The null hypothesis is that the proportion of negative prediction errors equals 0.5. The trigger threshold of 5.125% is the minimum required for a CoCo to qualify as additional tier 1 (AT1) capital under Basel III. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers CoCo instruments issued by banks in advanced economies between January 2009 and December 2015.

		ACPE	Z-value	Proportion negative	WACPE	Sample size
All CoCos		-2.66***	-2.70	0.57**	-4.81	136
Conversion mechanism						
Full permanent PWD		-1.11	-1.08	0.56	-1.39	50
Mandatory conversion (MC)		-4.97***	-3.07	0.63***	-8.37	49
Trigger						
Mechanical trigger (MT)		-3.25**	-2.22	0.55**	-4.80	83
<=5.125		-3.36	-1.38	0.60	-5.57	50
>5.125		-3.08*	-1.83	0.48	-3.91	33
Discretionary trigger only (DT)		-1.08	-1.15	0.58	-2.14	50
Full permanent PWD and MT		-0.74	-0.93	0.55	-0.41	22
Full permanent PWD and MT<=5.125		-0.63	-1.16	0.58	-1.08	12
Full permanent PWD and MT>5.125		-0.88	-0.12	0.50	0.69	10
Full permanent PWD and DT only		-1.36	-0.59	0.56	-2.80	27
MC and MT		-6.15**	-2.13	0.57*	-8.26	30
MC and MT<=5.125		-10.58	-1.64	0.69	-21.71	13
MC and MT>5.125		-2.76	-1.39	0.47	-2.43	17
MC and DT only		-1.46*	-1.66	0.71*	-1.24	17
Additional Tier 1		-4.17***	-2.63	0.57**	-6.69	75
Tier 2		-0.67	-1.00	0.57	-0.35	60
CoCo issue size	<median	-1.76	-1.46	0.58*	-1.66	79
(amount issued/ RWA)	>=median	-4.36**	-2.56	0.57*	-7.21	54
Issuer size	<$1000bn	-4.04***	-2.63	0.62***	-8.97	68
(total assets)	>=$1000bn	-1.54	-1.25	0.54	-2.18	65
Issuer	G-SIB	-1.53	-1.15	0.53	-2.03	72
	Non-G-SIB	-3.93***	-2.72	0.63***	-9.74	64
European issuance		-3.15**	-2.20	0.55*	-5.33	93

Non-European issuance		-1.59	-1.58	0.63	-2.38	43
Distance to trigger	<median	-5.78	-1.37	0.55	-9.13	31
(Regulatory T1 capital/RWA)	>=median	-2.13*	-1.84	0.57*	-1.83	49
First-time issuer		-2.90	-0.40	0.48	-6.17	40
Repeat issuer		-2.55***	-2.93	0.61***	-4.01	94

Table D6. Impact of CoCo Issuance on Issuers' Equity Prices: Cumulative Prediction Error (CPE) Analyses

This table examines the impact of CoCo issuance on issuing banks' equity prices using the methodology of James (1987). The average cumulative prediction errors (ACPE) for each category are calculated as equally-weighted averages of the cumulative prediction errors (CPE_j) for the set of CoCo instruments that belong to each category. The weighted average cumulative prediction errors (WACPE) are calculated as issued amount-weighted averages of the CPE for the set of CoCo instruments that belongs to each category. For each CoCo instrument j, CPE_j is defined as the cumulative prediction error (derived from a CAPM model, estimated over a period of 200 business days, excluding the 40 business days centered around the event date) of its issuer's equity price over the event window, which starts 5 business days before the issuance date (t-5) and ends on the issuance date (t). The "Z-value" is defined as $Z = \sqrt{N}$ (ACSPE), where ACSPE is the average cumulative standardized prediction error and N is the sample size. "Proportion negative" is the proportion of negative CPE_j. The test statistic is a Wilcoxon signed rank statistic. The null hypothesis is that the proportion of negative prediction errors equals 0.5. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample covers CoCo instruments issued by banks in advanced economies between January 2009 and December 2015.

		ACPE	Z-value	Proportion negative	WACPE	Sample size
All CoCos		0.15	0.76	0.35	0.27	170
Conversion mechanism						
Full permanent PWD		-0.11	-0.17	0.52	-0.18	58
Mandatory conversion (MC)		-0.04	-0.07	0.88	-0.74	67
Trigger						
Mechanical trigger (MT)		0.40	1.02	0.23	0.60	97
<=5.125		-0.17	0.73	0.29	0.04	65
>5.125		1.55	0.73	0.55	1.32	32
Discretionary trigger only (DT)		-0.24	-0.07	0.95	-0.38	67
Full permanent PWD and MT		0.17	0.05	0.52	0.06	25
Full permanent PWD and MT<=5.125		0.09	-0.01	0.56	-0.24	18
Full permanent PWD and MT>5.125		0.38	0.10	0.43	0.85	7
Permanent PWD and DT only		-0.36	-0.32	0.52	-0.57	31
MC and MT		-0.08	-0.35	0.92	-0.82	37
MC and MT<=5.125		-0.12	0.32	0.65	-0.34	18
MC and MT>5.125		-0.04	-0.80	0.66	-1.07	19
MC and DT only		0.04	0.41	0.86	-0.11	28
Additional Tier 1		0.23	0.71	0.26	0.35	92
Tier 2		0.06	0.35	0.79	0.13	78
CoCo issue size	<median	0.33	1.44	0.12	0.14	92
(amount issued/ RWA)	>=median	0.37	-0.17	0.99	0.43	69
Issuer size	<$1000bn	0.65	1.30	0.27	1.75	96
(total assets)	>=$1000bn	-0.04	0.09	0.85	-0.74	67
Issuer	G-SIB	0.06	0.35	0.79	-0.27	74
	Non-G-SIB	0.22	0.70	0.48	1.13	96
European issuance		0.17	0.37	0.58	0.43	111
Non-European issuance		0.11	0.78	0.46	-0.24	59

Distance to trigger	<median	1.40*	1.65	0.19	1.66	40
(Regulatory T1 capital/RWA)	>=median	0.29	0.50	0.38	-0.26	51
First-time issuer		0.76	1.62	0.10	1.36	57
Repeat issuer		-0.23	-0.45	0.78	-0.41	108

Table D7. CoCo Issuance, 2009–15

This table reports the amount issued (in billions of US dollars) of CoCos that (i) were issued by banks between January 2009 and December 2015 and (ii) have at least one (mechanical or discretionary) contractual trigger. The number of issues is indicated in parentheses. Individual subcategories do not always add up to the respective reported totals due to missing data and/or rounding. The number of issues for some individual categories may exceed the respective number of issues in Tables 3, 5, C5 and C6 due to the exclusion of duplicate instruments and preferred shares from the benchmark analysis and the fact that CDS spreads and equity prices are not available for some CoCo-issuing banks. The G-SIB designation refers to a global systemically important bank. The trigger threshold of 5.125% is the minimum required for a CoCo to qualify as additional tier 1 (AT1) capital under Basel III. Sources: Bloomberg; Dealogic.

	Mechanical trigger			Discretionary trigger only	Tier classification		Distance to trigger		GSIB designation	
	All levels	<=5.125	>5.125		AT 1	Tier 2	>= median	< median	GSIB	Non-GSIB
Conversion mechanism										
Principal write-down	96.6 (117)	33.1 (32)	63.5 (85)	27.5 (65)	80.3 (111)	42.3 (67)	48.2 (55)	46.7 (47)	81.4 (83)	42.9 (99)
Mandatory conversion	110.1 (126)	47.9 (37)	62.3 (89)	38.8 (66)	108.1 (117)	29.9 (41)	18.3 (17)	71.2 (60)	43.0 (25)	111.7 (169)
Mechanical trigger: all levels					158.6 (182)	29.6 (22)	66.5 (72)	118.0 (107)	102.2 (69)	104.5 (174)
<=5.125					65.5 (56)	13.8 (12)	19.0 (19)	61.0 (44)	43.3 (27)	37.7 (42)
> 5.125					93.1 (126)	15.8 (10)	47.5 (53)	57.0 (63)	58.9 (42)	66.9 (132)
Discretionary trigger only					23.8 (40)	43.3 (91)	N.A.	N.A.	18.3 (38)	48.7 (93)
Tier classification										
AT 1							46.5 (56)	106.6 (100)	89.4 (63)	98.9 (165)
Tier 2							20 (15)	9.6 (6)	34.9 (45)	38.3 (72)
Distance to trigger										
>= median									47.7 (32)	18.8 (40)
< median									54.5 (37)	63.5 (70)