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Europe's CoCos Provide a Lesson on Uncertainty

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Abstract

Contingent convertible bonds (CoCos) issued by European global systemically important banks (G-SIBs) as part of their total loss-absorbing capacity (TLAC) are meant to enhance financial stability by forcing investors to absorb losses when a bank is under stress. Coupon payments are made at issuers' discretion while loss absorption can be triggered at regulators' discretion. This study investigates price effects of four press releases by Deutsche Bank AG in February 2016 related to the bank's willingness and ability to make its upcoming CoCo coupon payments. Expected cash flow models capture changes in CoCo default risk, while event dates capture uncertainty effects. The price of a European G-SIB peer group portfolio declined a statistically significant 2.0-2.5 percent over two days in response to Deutsche Bank's first press release. Deutsche Bank's efforts to allay its own CoCo investors' concerns appeared to increase concerns among CoCo investors generally. The results show potential negative effects of regulatory discretion.

Keywords: Banking, regulation, capital, modeling, risk, uncertainty
JEL classifications: G12, G14, G21, G23, G28.

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1 Introduction

Contingent convertible bonds (CoCos) are issued by European banks, and meet the requirements to qualify as part of global systemically important banks' (G-SIBs) total loss-absorbing capacity (TLAC). CoCos are designed to enhance financial stability and prevent government bailouts by forcing bond investors to absorb losses when a bank is under stress, improving a bank's capital ratios. TLAC regulations create a unique type of uncertainty for CoCo investors.

Uncertainty introduced by European banking regulations affects contingent convertible bonds (CoCos) in two ways. One, as mandated by regulation, coupon payments are made at the discretion of the issuer. Specifically, for CoCos to qualify as additional Tier 1 (AT1) capital under Capital Requirements Directive IV (CRD IV), coupons are paid at the discretion of the issuing bank and are noncumulative, although the bank can be forced to reduce or suspend coupons under regulatory restrictions (Delivorias, 2016). Second, the bonds can be converted to equity or written down at the discretion of regulators.

Regulatory discretion can be viewed as a form of Knightian uncertainty — uncertainty that cannot be quantified. Uncertainty can be destabilizing through the introduction of excess volatility into financial asset pricing. CoCo market volatility in early 2016 provided an opportunity to investigate the unintended consequences of regulatory uncertainty associated with TLAC-eligible financial instruments. Uncertainty appeared to arise, at least in part, from the new regulation's interaction with multiple European accounting standards. CoCo issuers must calculate their Available Distributable Items (ADI) — the cash available to pay dividends and make AT1 payments, including CoCo coupons — under national laws applicable to each bank. Deutsche Bank AG uses German Generally Accepted Accounting Principles (GAAP) to compute its ADI, while other

European G-SIBs use International Financial Reporting Standards (IFRS). The German standard results in a more conservative measure of cash flows available than the IFRS standard.

Deutsche Bank reported an unexpectedly large 2015 loss in late January 2016. This loss, in combination with uncertainty about the bank's ADI under German accounting standards, led to concerns about Deutsche Bank's willingness and ability to make its upcoming CoCo coupon payments. Bloomberg, in reporting on Deutsche Bank's Jan. 28, 2016 earnings release, captured the mood of investors in an asset manager's reaction: "They're just too close to the wire. They said they were going to pay [CoCo coupons] today but they could just as easily have said they were going to skip. It's not worth the risk," (Glover, 2016).

Credit Suisse reported its own unexpectedly large 2015 loss on Feb. 4, 2016. Subsequent CoCo market volatility led Deutsche Bank to issue a press release on Feb. 8, 2016 outlining the bank's cash available to make upcoming AT1 payments. Four days later, the bank announced a tender offer to buy back debt. On Feb. 23, the bank announced the completion of the euro-denominated portion of its bond repurchase. On Feb. 29, the bank announced the preliminary results of the U.S. dollar-denominated bond repurchase. Details of Deutsche Bank's four February 2016 press releases are shown in **Figure 1**.

Figure 1. Deutsche Bank's CoCo-Related Press Releases

Date	Description
2/08/16	Stated one billion euros available to pay Additional Tier 1 (AT1) coupons of 350 million euros on Apr. 30, 2016. Estimated its pro-forma 2017 payment capacity is approximately 4.3 billion euros before impact from 2016 operating results. Also said final 2017 AT1 payment capacity will depend on 2016 operating results under German GAAP and movements in other reserves.
2/12/16	Announced public tender offer to purchase certain series of euro- and U.S. dollar-denominated senior unsecured debt securities with a targeted acceptance volume of three billion euros and two billion U.S. dollars, respectively. Stated the bank's strong liquidity position allows it to repurchase these securities without any change to its 2016 funding plan.
2/23/16	Announced completion of euro-denominated bond repurchase. Stated the bank decided to further increase the purchase price by 1.5-2.6 percentage points. The resulting accepted total volume was 1.27 billion euros against a total tendered amount of 1.75 billion euros. Securities with a notional value of 0.48 billion euros were tendered at levels tighter than the final purchase spreads (higher than the final purchase prices) and were not accepted.
2/29/16	Announced initial results of U.S. dollar-denominated bond repurchase based on early tender price. During the first 10 business days of the tender period, 740 million U.S. dollars in securities were tendered by investors and accepted by the bank for purchase.

Sources: Deutsche Bank (2016a, 2016b, 2016c, and 2016d)

We investigate changes in prices of other European G-SIBs' CoCos in response to Deutsche Bank's press releases.[1] Our focus is the effect on Deutsche Bank's peers rather than on the bank itself. CoCo value changes are modeled as a function of changes in their probability-weighted cash flows to capture the price effects from changes in default risk as captured by banks' credit default swap (CDS) spreads. For equity-conversion CoCos, value changes of the instruments are also modeled using an equity derivatives approach. Price effects from uncertainty not captured by the market's reassessment of the expected bond cash flows are estimated using dummy variables associated with the dates of the four press releases. These event price effects capture Knightian

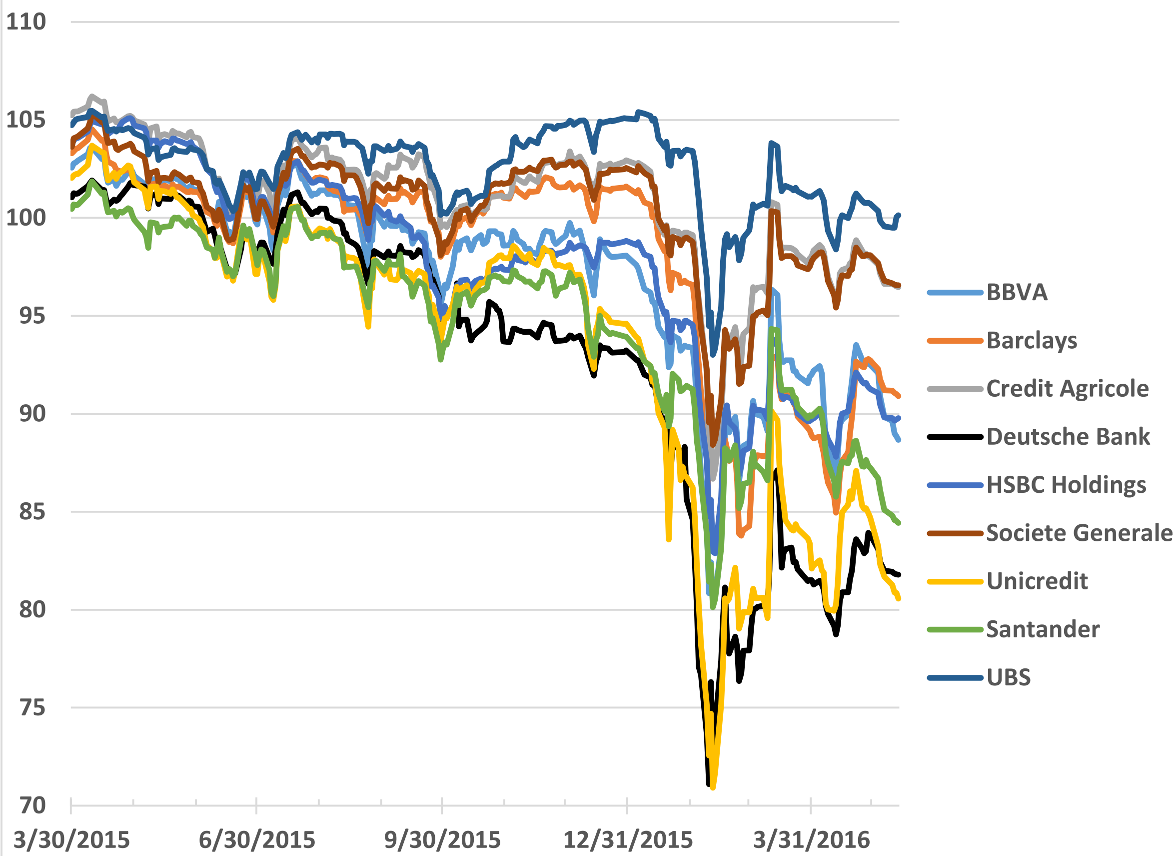
[1] We also include BBVA in our sample. The bank was included in the Financial Stability Board's 2014 list of G-SIBs and dropped from the 2015 list.

uncertainty, which differs from measurable risk in that a probability distribution of potential outcomes cannot be estimated.

Using a 95 percent confidence level, we find a statistically significant 2.0-2.5 percent decline in the price of a peer group portfolio of CoCos over two days in response to Deutsche Bank's press release detailing its ability to make upcoming CoCo coupon payments. The results contribute to the literature on the effect of regulatory uncertainty on asset prices, which has focused on stocks. In particular, we trace out the market's re-evaluation of the estimated future cash flows of CoCos and capture the price effects of uncertainty associated with the discretionary coupon payments.

As shown in **Figure 2**, European G-SIB CoCos in the sample experienced declining prices before February 2016, perhaps in response to deteriorating expectations for Europe's banking industry. Moreover, prices remained below par values for most CoCos in the sample as of the end of this study's investigation period in mid-May 2016.

Figure 2. Prices of CoCos in Sample Compared to Deutsche Bank's Over Time Period of Investigation

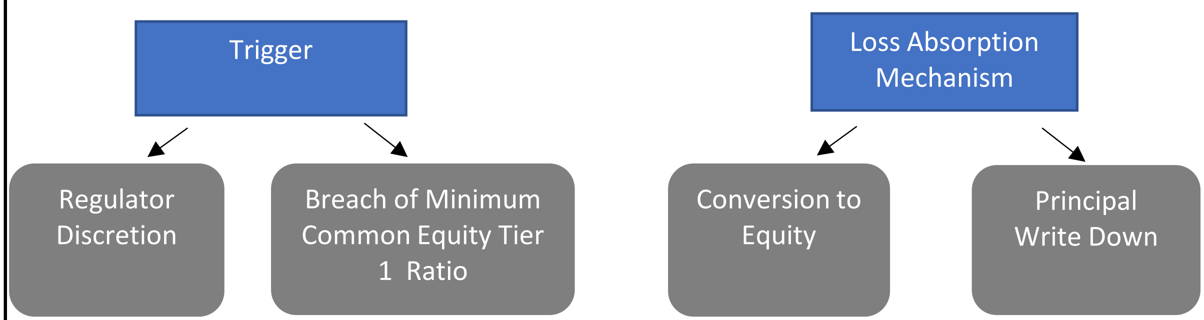


Source: Bloomberg Finance L.P.

2 Contingent Convertible Bonds

A CoCo has two defining characteristics — a loss-absorbing mechanism and the trigger that activates that mechanism (see **Figure 3** and Avdjiev, Kartasheva, and Bogdanova, 2003). CoCos can absorb losses via a principal write-down or conversion into common equity. The trigger can be either the breach of a minimum common equity Tier 1 capital ratio (CET1) as stated in the bond contract or the decision by bank supervisors to activate the loss-absorbing mechanism if they think it necessary to prevent the issuing bank's insolvency. When activated, CoCos have a clearly defined conversion ratio or write-down percentage specified in the bond contract. Some CoCos can later be written up again once the firm has stabilized.

Figure 3. Contingent Convertible Bond Triggers and Loss-Absorption Mechanisms



Sources: Avdjiev et al (2013), authors' analysis

CoCos occupy one of two possible places within the Basel III loss-absorbing hierarchy. CoCos issued as AT1 capital have higher CET1 triggers than CoCo bonds issued as Tier 2 capital. This study examines the price impacts on CoCos issued as AT1 capital, which represents the larger part of the market.

There are differences among CoCos issued by the European G-SIBs because these banks are under the jurisdiction of various European and national regulators, and each one influences the type and structure of the debt. While CoCos used as AT1 instruments are governed by CRD IV and the Capital Requirements Regulation, CRD IV allows for each country to add on to, but not take away from, the requirements (Bank of England, 2015). Switzerland, headquarters for European G-SIBs Credit Suisse and UBS, has not adopted CRD IV, but has adopted Basel III (Nordal and Stefano, 2014).

Since CoCo coupon payments are discretionary and non-cumulative, failing to make a payment does not force the issuer into default. Moreover, if a CoCo issuer does not meet certain regulatory requirements, it is prohibited from making its CoCo coupon payments even if it has the cash on hand. Prior to February 2016, there were questions about how regulatory capital requirements affected maximum distributable amount (MDA) restrictions on AT1 payments, including CoCo coupons. Under CRD IV, if a bank's total capital falls below the sum of its Pillar 1, Pillar 2, and CRD buffer requirements, it must calculate MDA according to a regulatory formula that restricts its use of earnings to pay distributions (Mesnard and Magnus, 2016). In late December 2015, the European Banking Authority clarified that both Pillar 1 and Pillar 2 requirements should be included in minimum capital requirements for the purpose of determining MDA (European Banking Authority, 2015). When a bank's combined buffer requirement falls below the minimum required ratio, MDA is applied on a sliding scale. Before this clarification, MDA restrictions on AT1 payments were open to interpretation.

3 Risk, Uncertainty, and Asset Prices in the Literature

F.H. Knight (1921) distinguishes the profit effects of change from those of the uncertainty connected with change. One cannot profit from measurable risk because it can be eliminated by insurance or some equivalent device. Uncertainty, on the other hand, has profit potential over the short term for those who are more informed. Over the long term, profits may be elusive given evidence investors charge a significant risk premium for both information uncertainty and information asymmetry.

Epstein and Wang (1994) develop a theoretical model of intertemporal asset pricing under Knightian uncertainty. They show that uncertainty may lead to pricing equilibria that are indeterminate. The origin of this indeterminancy and the associated excess financial market volatility lies in the conjunction of agents' aversion to Knightian uncertainty and the incompleteness of information within the model.

Anderson, Ghysels, and Juergens (2009) empirically measure risk-return and uncertainty-return tradeoffs on asset prices. They use return volatility for their measure of risk and the degree of disagreement among professional forecasters for their measure of economic uncertainty. They find stronger evidence for the uncertainty-return tradeoff than for the risk-return tradeoff in their investigation of stock price movements. They also find uncertainty affects returns differently than risk. Specifically, uncertainty is highly correlated with the market excess return, but risk is not. Also, uncertainty has a very weak correlation with risk, and past uncertainty has no predictive ability of future risk or vice versa.

Empirical evidence of the effects of information asymmetry and uncertainty on corporate bond yield spreads is provided by Lu, Chen, and Liao (2010). The authors show investors charge a significant premium for both information asymmetry and uncertainty. They also show that information asymmetry and uncertainty help structural form credit models explain the yield spreads of bonds with short maturities.

While most of the literature concerns theoretical models and empirical investigations of the price effects of uncertainty in general, there are studies that look specifically at political uncertainty and its effect on asset pricing. Pastor and Veronesi (2013) develop a general equilibrium model of government policy choice in which stock prices respond to political news. The model implies that political uncertainty commands a risk premium that gets larger under weaker economic conditions. Uncertainty increases not only the political risk premium, but also the volatilities and correlations of stock returns.

Boutchkova, *et al.* (2012) examine how local and global political risks affect stock returns for various industries in various countries. They find that industries that are more dependent on trade, contract enforcement, and labor exhibit greater return volatility when local political risks are higher. Their volatility decompositions indicate that while systematic volatility is associated with domestic political uncertainty, global political risks translate into larger idiosyncratic volatility. For depository institutions, systematic volatility is higher than the average across the industries included in their study, but idiosyncratic volatility is lower.

Regulatory uncertainty is a form of Knightian uncertainty, as described in Aikman, *et al.* (2014). The authors analyze the trade-offs between simplicity and complexity in the design of bank capital requirements under the Basel I and II agreements. Using simulations, they show that the more complex determination of capital requirements under the Basel II internal-ratings based approach is less robust (underestimates the capital required) than the simpler Basel I and II standardized risk-weighting approaches when the default distribution tail is fatter, corresponding to time periods of greater uncertainty.

4 An Event Study of Contingent Convertible Bond Price Changes

Our modeling approach separates the effects of risk and uncertainty on the prices of CoCos issued by European G-SIBs other than Deutsche Bank. The purpose is to isolate the price changes associated with reevaluations of CoCo coupon and conversion or write-down risks from those associated with uncertainty over payment discretion. Changes in the value of the CoCos in our sample are modeled using the approaches discussed in Section 4.1. Changes in expected future cash flows capture changes in expectations that coupon payments could be missed or the bonds could be converted. These changes capture changes in CoCo risks. Control dummy variables capture the effects of uncertainty on CoCo prices not specifically related to CoCos; namely, the unexpected 2016 losses announced by both Deutsche Bank and Credit Suisse. These events were reported in the financial press as negative information signals about future prospects for Europe's banking industry in general. Event dummy variables capture the price effects of four press releases issued by Deutsche Bank. These press releases related specifically to Deutsche Bank's willingness and ability to make its upcoming CoCo coupon payments.

4.1 Modeling CoCo Values

There are three major approaches to modeling the value of CoCos. Wilkens and Bethke (2014) provide a good comparison and empirical assessment of these approaches, which include a structural model, an equity derivatives model, and a credit derivatives model. They find an equity derivatives model most practical for the pricing and risk management of CoCos. De Spiegeleer and Schoutens (2011) provide an in-depth discussion and application of the equity derivatives modeling approach to the valuation of CoCos. We use their model for our subsample of equity-conversion CoCos. For the full sample, which includes write-down bonds as well as equity-conversion bonds, we find a probability-weighted cash flow model captures bond price changes better. For the probability-weighted cash flow approach, we follow the methodology outlined in Buergi (2013).

To simplify the analysis, the following assumptions are made in applying both modeling approaches:

- CoCos are valued to their first call date, consistent with industry practice. CoCos typically have a fixed coupon rate for the first five years, at which point the bond can be called or the coupon rate reset. Many recently issued CoCos are essentially perpetual with specified call schedules;
- A coupon payment is made on the first call date based on the original interest rate;

- The issuer will make coupon payments unless a trigger event occurs. CoCo issuers usually have complete discretion in terms of making their interest payments. However, considering the reputation risks, it is assumed that no issuer will choose not to make a coupon payment;
- To simplify the modeling, if a bond is converted or written down, we assume it is done so completely. For both equity-conversion and write-down CoCos, it is possible the issuer will only partially convert or write down the principal of the bond, resulting in a potential partial bond redemption at maturity/call;
- If a bond is converted or written down, it is assumed to be permanent. In reality, write-down CoCos can have a write-up/write-back feature that provides the issuer flexibility to write up the instrument after a trigger event occurs; and
- A zero percent discount rate is used to calculate the present value of future cash flows. A risk-free discount rate is appropriate given that default risk is accounted for in the numerator. While European Central Bank policy rates were negative and declining during the time period of investigation, it may be that negative interest rate environments induce unexpected changes in investors' required returns.

An Equity Derivatives Approach. The De Spiegeleer and Schoutens (2011) equity derivatives model has a closed-form solution (see **Appendix**). A CoCo bond is priced as a standard corporate coupon bond with two types of options: 1) a knock-in forward to calculate the equity-conversion value should a trigger event occur, and 2) binary down-in options to account for the lost coupon bond payments if a trigger event occurs. The knock-in forward represents a long position in a knock-in call and a short position in a knock-in put (both options share the same strike price and barrier). The knock-in forward represents the situation in which the investor receives forwards (warrants) in the case of a trigger event, which is different than receiving shares. Receiving shares implies voting rights.

A Probability-Weighted Cash Flow Model. The value of the bond is the sum of the expected future coupon and principal payments up to and including the first call date. The discount rate used to find the present value of each future payment is zero. We use a Monte Carlo simulation with 10,000 iterations at each pricing date. To model the triggering of an event, five-year senior CDS spreads were obtained from Bloomberg for each pricing date and a probability of default (pd) is calculated using the formula (Chan-Lau, 2006):

$$pd = \frac{CDS \times (1 + r)}{1 - rr}$$

r = the risk-free rate = 0;

rr = recovery rate = 0.14.[2]

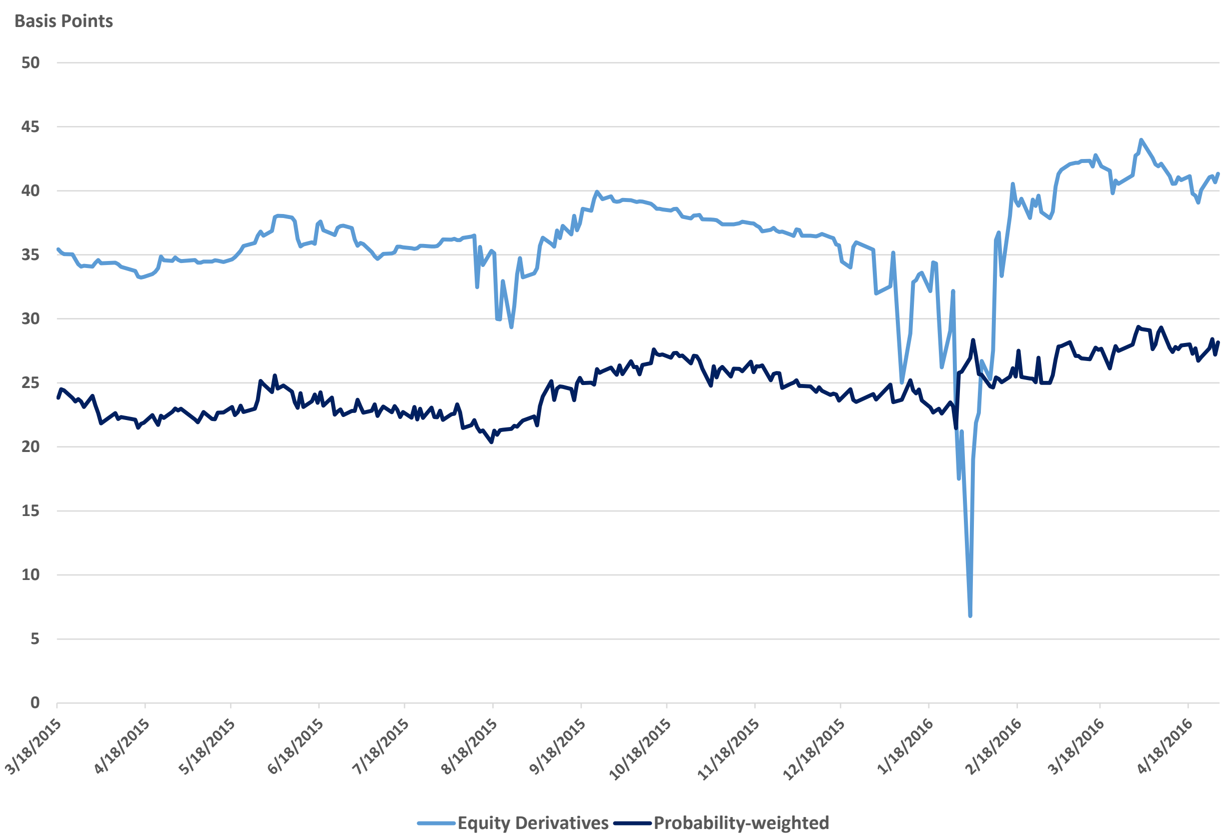
With the calculated probability of default, and assuming a standard normal distribution, default thresholds are determined using the normal inverse cumulative distribution function. Then, for each pricing date, 10,000 randomly generated values are drawn from a standard normal distribution for each coupon date from the first coupon payment to the last coupon date at the first call date. If the randomly generated value at a coupon payment date is less than the default threshold, then this is assumed to be a trigger event (issuer goes below CET1 trigger threshold or supervisor activates a discretionary trigger). The bond is written down 100 percent and all coupon payments from that point forward are assumed to be zero and the bond redemption value is zero. All calculated cash

[2] The recovery rate is fixed ((see Moody's Investors Service, 2016).

flows (whether zero or not) are then summed to get a total bond price for that iteration and then averaged over all iterations to get a price representative for that pricing date.

Comparing the Results of the Two Modeling Approaches. Daily spreads between modeled values and market quoted prices of an equity-conversion CoCo issued by HSBC are shown in **Figure 4**. These spreads are representative of those for other equity-conversion CoCos in the sample. The equity derivatives modeled values had larger spreads relative to prices than the probability-weighted cash flow modeled values before and after the February 2016 event window. However, during Feb. 4-8, the equity derivatives modeled values had lower spreads than the probability-weighted cash flow modeled values. This suggests the equity derivatives model captured more of the price volatility associated with Deutsche Bank's first press release on Feb. 8 in revised estimates of default risk than did the probability-weighted cash flow model. There is a significant price discount neither model accounts for over the time period of investigation.

Figure 4. Spread of Modeled Values Over Prices for HSBC's CoCo Over Time Period of Investigation



Sources: Bloomberg Finance L.P., authors' analysis

4.2 Sample Selection

Eleven European G-SIBs and one former G-SIB had euro-denominated CoCos outstanding as of January 2016. Bonds issued after March 2015 are excluded to ensure there are at least 200 trading days before the start of the Feb. 8, 2016, event window.[3] Due to liquidity and pricing concerns, trading days when 10 or more markets were closed across Europe were excluded. Bonds issued by

[3] We followed the approach used in Brown and Warner (1985), except we reduced the number of trading days before the start of the event window from 244 to 200 as a compromise between our goals of maximizing sample size and maintaining our appeal to the central limit theorem.

BNP Paribas, ING, and the Royal Bank of Scotland were issued in April 2015 or later, and so are not included in the sample. Excluding Deutsche Bank, this leaves eight bonds in the final peer group sample. For G-SIBs with more than one euro-denominated CoCo issue meeting our criteria, we chose the issue with the fewest unchanged quotes from one day to the next.[4] The sample is a balanced mix of equity-conversion and write-down types. Most of the bonds have CET1 triggers of 5.125 percent, the minimum level required for a CoCo to qualify as AT1 capital under Basel III (see Avdjiev, Kartasheva, and Bogdanova, 2003). The median coupon rate is 6.5 percent, while the median first call date is 5.5 years after Feb. 1, 2016 (authors' analysis of CreditSights, 2016).

Summary statistics of the probability-weighted cash flow modeled values and quoted market prices of the CoCos in the final sample are shown in **Figure 5**. Changes in bond prices and values are calculated by taking the natural logarithm of the current trading day value divided by the previous trading day value. Modeled value changes under-predict price changes in some cases, but over-predict price changes in others. There does not appear to be a pattern of over- or under-prediction in relation to the bonds' characteristics.

[4] Less liquid bond issues exhibited more unchanged or "stale" quotes suggesting the bonds traded less frequently. In our final sample of eight bonds, four bonds had no unchanged daily quotes, three bonds had one unchanged daily quote, and one bond had two unchanged daily quotes.

Figure 5. Summary Statistics for Changes in Sample Bond Prices and Modeled Values

G-SIB	BBVA		Barclays		Credit Agricole		HSBC	
Change	Price	Modeled Value	Price	Modeled Value	Price	Modeled Value	Price	Modeled Value
Median	-0.038	-0.075	-0.041	-0.025	-0.003	-0.058	-0.033	-0.008
Mean	-0.054	-0.038	-0.047	-0.050	-0.032	-0.029	-0.054	-0.029
Std Dev	0.903	1.019	0.747	0.793	0.676	1.029	0.678	0.680
G-SIB	Santander		Societe Generale		UBS		Unicredit	
Change	Price	Modeled Value	Price	Modeled Value	Price	Modeled Value	Price	Modeled Value
Median	-0.051	-0.090	-0.003	-0.054	0.006	-0.025	-0.081	-0.081
Mean	-0.065	-0.057	-0.026	-0.014	-0.017	-0.021	-0.088	-0.045
Std Dev	0.858	1.384	0.646	0.653	0.529	0.304	1.227	0.903

Note: Change measured as one hundred times the natural log of the current trading day value over the previous trading day value. Each bond has 269 observations.

Sources: Bloomberg Finance L.P., authors' analysis

4.3 Panel Regression Model and Hypotheses

The regression model is specified as follows:

$$\ln \frac{quote_{i,t}}{quote_{i,t-1}} = \ln \frac{modeled_{i,t}}{modeled_{i,t-1}} + C1_t + C2_t + C3_t + D1_t + D2_t + D3_t + D4_t.$$

Daily CoCo quoted price changes are modeled as a function of changes in their probability-weighted cash flows. For the equity-conversion subsample, we also run the panel regressions substituting modeled changes computed using the equity derivatives approach for the probability-weighted cash flow approach. The bonds are equally weighted in the peer group portfolio. There are 269 observations per bond, so the panel is balanced.

We expect a positive relationship between CoCo quoted price changes and modeled value changes. These changes reflect changes in default risk captured by CDS spreads. CDS spreads, in turn, capture changes in bank default risk including, but not limited to, reevaluations of CoCo bond coupon and write-down risks. This variable captures the CoCo bond coupon and write-down risks that can be readily quantified by valuation models. We do not expect a one-to-one relationship since the model does not account for interest rate changes.

Controls. Given the large stock and bond market impacts of the Deutsche Bank and Credit Suisse 2015 earnings releases, control dummy variables are included for those events in some model specifications. We include both the preliminary and final 2015 earnings releases by Deutsche Bank since both contained new information relevant to expected CoCo payouts. We expect a negative relationship given the unexpectedly large losses reported. These losses potentially signaled poor prospects for Europe's banking industry and future cash flows to all CoCo investors.

Differences between the equity-conversion and write-down bond types in the full sample are tested using a control dummy variable that takes on a value of one if the bond is the write-down type. We do not attempt to distinguish any potential pricing differences between temporary partial write-down and permanent full write-down bond types.

Event Windows. One-day and two-day event windows capture the information effects of the four Deutsche Bank press releases relevant to their CoCo coupon payment risk. The press event dummy variables are expected to capture CoCo-specific Knightian uncertainty as opposed to reassessments of default risk priced via changes in CDS spreads captured by the cash flow models. Two-day windows are used to account for the possibility the timing of the press release did not allow for the information to be fully incorporated into quoted market prices that same day.

Hypotheses. Deutsche Bank's press releases could be expected to reduce its own CoCo bondholders' uncertainty about future cash flow risks, but they could not necessarily be expected to influence the peer group bondholders' uncertainty. In the case of Press 1, none of these other G-SIBs are subject to uncertainty regarding the application of German GAAP to the determination of

ADI. For Press 2-4, Deutsche Bank's reduction of its debt payment obligations would not affect the peer group's expected CoCo cash flows. For the four events, our null hypotheses are:

Press 1 H_0: There is no relationship between the peer group's CoCo price changes and Deutsche Bank's clarification of its AT1 payment capacity.

Press 2 H_0: There is no relationship between the peer group's CoCo price changes and Deutsche Bank's announcement of a tender offer to buy back euro-denominated and U.S. dollar-denominated debt.

Press 3 H_0: There is no relationship between the peer group's CoCo price changes and Deutsche Bank's announcement of the preliminary results of its tender offer to buy back euro-denominated debt.

Press 4 H_0: There is no relationship between the peer group's CoCo price changes and Deutsche Bank's announcement of the preliminary results of its tender offer to buy back U.S. dollar-denominated debt.

A statistically significant positive or negative relationship would provide evidence of uncertainty effects for other European G-SIBs.

Positive effects could result from Press 1 if it was perceived as heralding more information disclosure by other European G-SIB CoCo issuers about their willingness and ability to make future coupon payments. Positive effects could similarly result from Press 2 if CoCo investors thought Deutsche Bank's tender offer would potentially be emulated by other CoCo issuers should their coupon payments be called into question. Press 3-4 could have positive effects if the preliminary results of the debt buy backs signaled investor confidence in the CoCo market or a greater likelihood of successful tender offers by other European G-SIBs.

Negative effects from Deutsche Bank's efforts to signal its willingness and ability to make CoCo coupon payments could result from a rise in investor uncertainty or risk aversion. Although the first press release was meant to clear up some of the investor confusion over Deutsche Bank's ADI, it may have also raised concerns among other banks' CoCo investors that there were CoCo risks they did not fully understand or account for.

5 Findings

The event study results for the full sample using the probability-weighted cash flow valuation method are shown in **Figure 6**. More than 40 percent of changes in quoted CoCo prices can be explained by changes in their probability-weighted cash flow values at a 95-percent confidence level. There appears to be no difference between the equity-conversion and write-down bonds within the sample based on the economically and statistically insignificant coefficient on the write-down dummy variable.

Figure 6. Event Study Results for Full Sample of European G-SIB CoCos

Panel Regression Technique	Event Window	Adj. R^2	Modeled Change	Stock Index Change	Write Down	Earnings 1	Earnings 2	Earnings 3	Press 1	Press 2	Press 3	Press 4
Pooling	1-day	0.314	**0.473**		0.000				**-1.432**	**-0.272**	**-0.844**	0.100
			(8.628)		(0.380)				(8.978)	(2.858)	(24.914)	(2.351)
Pooling	2-day	0.395	**0.429**		0.000				**-2.466**	1.029	**-1.209**	0.345
			(7.801)		(0.448)				(3.851)	(1.161)	(4.851)	(1.873)
Fixed	2-day	0.392	**0.429**						**-2.466**	1.029	**-1.209**	0.345
			(7.801)						(3.851)	(1.161)	(4.852)	(1.874)
Pooling	2-day	0.410	**0.418**			-0.664	0.070	**-1.028**	**-2.495**	1.034	**-1.228**	0.342
			(7.553)			(1.173)	(0.693)	(5.107)	(3.961)	(1.164)	(4.855)	(1.811)
Pooling	2-day	0.492	**0.295**	**0.144**					**-2.004**	0.593	**-0.955**	0.323
			(6.145)	(5.451)					(3.361)	(0.585)	(3.717)	(1.404)

Note: For all models, the F-test did not reject null of OLS pooling versus fixed effects for peer models; the Breusch-Pagan Lagrange multiplier test did not reject null of OLS pooling versus random effects; intercept terms (not shown) are insignificant; fixed effects (not shown) are insignificant; Student's t-statistics shown are based on standard errors corrected for heteroskedasticity, serial correlation, and cross-sectional dependence. Modeled change and stock price change are measured as the natural logorithm of the current value divided by the previous value. Earnings 1 is a dummy variable that takes on a value of 1 on the date of Deutsche Bank's preliminary 2015 earnings release, and is zero otherwise. Earnings 2 is the dummy variable for Deutsche Bank's final 2015 earnings release. Earnings 3 is the dummy variable for Credit Suisse's 2015 earnings release. Press 1-4 are the dummy variables corresponding to the dates of Deutsche Bank's press releases described in Figure 6. Coefficients on control and press dummy variables are transformed using the equation 100[exp(coefficient) - 1]. Coefficients in boldface type are statistically significant at the 5% level using a two-tailed test, all others are insignificant at a 5% level. Balanced panels of 269 observations per bond; eight bonds in full sample.

Sources: Bloomberg Finance L.P., authors' analysis

Comparing the results for the one-day and two-day event windows shows that it took two days for the effects of Press 1 to be fully incorporated into CoCo prices. The peer group panel of CoCo prices declined by a statistically significant 1.4 percent over one day and 2.5 percent over two days at a five percent level. As a result, we reject the null hypothesis that Deutsche Bank's announcement of its AT1 payment capacity had no effect on other European G-SIBs' AT1-qualifying CoCos. The announcement had a small, but significant negative effect on the prices of European G-SIB CoCos consistent with the presence of Knightian uncertainty that was not abated by Deutsche Bank's announcement.

As a check on our results, we also include the change in the European Bank Stoxx Index as a control variable in one OLS pooling model specification. This control variable diminishes the explanatory value of our modeled CoCo value changes, but together with the modeled changes, explains 43.9 percent of the price changes. This version of the model suggests a lower bound of -2.0 percent for the Press 1 effect on the peer group's CoCo bond prices.

For Press 2, there is a statistically significant 0.3 percent decline in the peer group's CoCo prices on the release date, but no significant price change over two days. One possible explanation is that market participants viewed Deutsche Bank's tender offer to repurchase some of its outstanding debt as a negative signal of the future value of CoCo bonds in general, but the effect was ephemeral. Therefore, we do not reject the null hypothesis that Deutsche Bank's debt buyback offer had no effect on the CoCo prices of the other European G-SIBs.

Press 3 and Press 4 had very different reactions. Press 3 is associated with the preliminary results of the tender offer to buy back euro-denominated debt. Although participation was weak, Deutsche Bank did not accept all the bonds tendered. This produced a statistically significant price decline of 1.0-1.2 percent over two days. As a result, we reject the null hypothesis of no relationship between the peer group's CoCo price changes and Deutsche Bank's announcement of the preliminary results of its tender offer to buy back euro-denominated debt.

The U.S. dollar-denominated debt buyback also had weak participation, but all the bonds tendered were accepted by Deutsche Bank. There was no significant market reaction to this Press 4 event. As a result, we do not reject the null hypothesis of no relationship between the peer group's

CoCo price changes and Deutsche Bank's announcement of the preliminary results of its tender offer to buy back U.S. dollar-denominated debt.

There are a couple of possible explanations for the difference in results for Press 3 and Press 4. Deutsche Bank's fourth press release stated, "The relatively low investor participation in the public tender offers for both the euro- and U.S. dollar-denominated securities tendered reflects improved market sentiment and an investor preference to retain exposure to Deutsche Bank." However, in combination with the negative market reaction to Press 3, the bank's failure to accept all the euro-denominated securities tendered (see details in **Figure 1**) undercuts that assertion. It is also the case our sample includes only euro-denominated bonds.

A comparison of the equity-conversion subsample results using the cash flow modeled changes to the equity derivatives modeled changes shows that the cash flow model provides more explanatory power than the equity derivatives model (see **Figure 7**). This can be seen in a comparison of the adjusted R-squared values for the two types of models. The pooled OLS regressions using the cash flow modeled CoCo value changes explain 31.3-41.7 percent of CoCo price changes, similar to the regressions for the full sample. The pooled OLS regressions using the equity derivatives modeled changes explain a lesser 16.3-28.0 percent of CoCo price changes. Equity derivatives modeled values explain only 8.4-11.2 percent of changes in quoted CoCo prices, while the cash flow modeled values explain 38.5-44.6 percent.

Figure 7. Event Study Results for European G-SIB Equity-Conversion Subsample

Model	Event Window	Adj. R^2	Modeled Change	Press 1	Press 2	Press 3	Press 4
Equity derivative		0.163	**0.112**				
			(5.753)				
Cash flow		0.313	**0.446**				
			(8.978)				
Equity derivative	1-day	0.194	**0.107**	**-2.018**	**-0.708**	**-0.935**	-0.036
			(5.296)	(12.974)	(3.827)	(19.328)	(0.516)
Equity derivative	2-day	0.280	**0.084**	**-2.566**	1.084	**-1.618**	0.744
			(4.602)	(8.853)	(0.953)	(3.544)	(1.443)
Cash flow	1-day	0.325	**0.429**	**-1.174**	**-0.421**	**-0.907**	**0.002**
			(8.221)	(6.009)	(4.379)	(24.993)	(5.638)
Cash flow	2-day	0.417	**0.385**	**-2.514**	0.916	**-1.441**	0.458
			(7.305)	(3.031)	(0.999)	(4.020)	(2.365)

For all models: the F-test did not reject null of OLS pooling versus fixed effects for peer models; Breusch-Pagan Lagrange multiplier test did not reject null of OLS pooling versus random effects; intercept terms (not shown) are insignificant; Student's t-statistics shown are based on standard errors corrected for heteroskedasticity, serial correlation, and cross-sectional dependence. Modeled change is measured as the natural logorithm of the current value divided by the previous value. Events 1-4 are the dummy variables corresponding to the events described in Figure 6. Coefficients on the event dummy variables are transformed using the equation 100[exp(coefficient) - 1]. Coefficients in boldface type are statistically significant at the 5% level using a two-tailed test, all others are insignificant at a 5% level. Balanced panels of 269 observations per bond; four bonds in equity conversion subsample.

Sources: Bloomberg Finance L.P., authors' analysis

Press 1-4 effects for the subsample over the one-day and two-day event windows are very similar to those for the full sample. Press 1 has a statistically significant negative 2.5 percent effect on the peer group's CoCo prices over two days. Press 2 has only an ephemeral effect on the equity-conversion subsample's prices. Press 3 resulted in about a 1.5 percent decline in equity-conversion CoCo prices over two days. The Press 4 results are slightly different. There is a very small, but statistically significant decline over one day using the cash flow modeled values. However, the effect is insignificant over the two-day window. Overall, there does not appear to be evidence of different effects for equity-conversion versus write-down types of CoCos.

6 Possible U.S. Policy Implications

Under a Federal Reserve rule, U.S. G-SIBs will be required to maintain a significant portion of their total loss-absorbing capacity (TLAC) in the form of long-term unsecured debt that would be used to absorb losses in the event the company enters resolution under Orderly Liquidation Authority in Title II of the Dodd-Frank Act (Federal Reserve, 2016). This debt's potential use as loss-absorbing capacity in the United States is subject to regulatory discretion; specifically, a complex process involving the judgment of regulators and government officials (see 12 U.S.C. § 5383).

Otherwise, TLAC-eligible long-term debt under the final U.S. rule presents fewer opportunities for Knightian uncertainty effects in comparison to CoCos. TLAC-eligible long-term debt in the United States will not be subject to the CoCo coupon risks discussed in this study. TLAC-eligible debt instruments will also be a much simpler and more homogeneous group than CoCos because regulation requires TLAC debt to be "plain vanilla" and issued by the bank holding company, which must itself have a "clean balance sheet." Additionally, the United States uses a single system of public accounting.

7 Conclusions

In early 2016, two things happened in the European CoCo market: investor perceptions of prospects for Europe's banking sector deteriorated following disappointing earnings announcements by Deutsche Bank and Credit Suisse; and investors became concerned Deutsche Bank might suspend its CoCo coupon payments. Not surprisingly, Deutsche Bank's CoCo prices fell. However, against a background of investor concerns about the European banking sector as a whole, CoCo prices for other European banks also declined.

There was considerable uncertainty surrounding coupon, and perhaps, conversion risks. The negative reaction to Deutsche Bank's information disclosures is not surprising given that CoCo coupon payments and conversions remained discretionary afterwards. If anything, the events of February 2016 only heightened CoCo investors' awareness of the risks attached to discretionary terms in CoCo indentures.

Regulatory discretion can be viewed as a form of Knightian uncertainty, and uncertainty in regulations intended to promote safety and soundness can have unintended consequences for financial institutions and markets. Knightian uncertainty can be destabilizing through the introduction of excess volatility into financial instrument pricing. This uncertainty can arise directly from the regulation itself, or indirectly via interactions with, for example, accounting standards and financial innovations.

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Appendix: Equity Derivatives Model

We use the model of De Spiegeleer and Schoutens (2011). The model components include:

A. A standard corporate bond pricing model to value the coupon and principal values of the bond if no equity-conversion trigger event occurs;

B. A knock-in forward option to calculate the terminal value of the CoCo if a trigger event occurs. The assumption is that an investor receives forwards (warrants) rather than shares; and

C. Binary down-in options to calculate the value of lost coupon payments if a trigger event occurs.

$P_t = A + B + C$, where

$$A = Nexp(-rT) + \sum_{i=1}^{k} c_i \exp(-rt_i)\,;$$

$$B = C_r \times \Big[Sexp(-qT) \left(\frac{S^*}{S}\right)^{2\lambda} N(y_1) - Kexp(-rT) \left(\frac{S^*}{S}\right)^{2\lambda-2} N\big(y_1 - \sigma\sqrt{T}\big) -$$

$$Kexp(-rT)N\big(-x_1 + \sigma\sqrt{T}\big) + Sexp(-qT)N(-x_1)\Big]; \text{ and}$$

$$C = -\sum_{i=1}^{k} c_i \exp(-rt_i) \left[N\big(-x_{1i} + \sigma\sqrt{t_i}\,\big) + (\tfrac{S^*}{S})^{2\lambda-2} N(y_{1i} - \sigma\sqrt{t_i} \right].$$

with

$$K = C_p$$

$$C_r = \frac{N}{C_p}$$

$$x_1 = \frac{\log(\frac{S}{S^*})}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T}$$

$$y_1 = \frac{\log(\frac{S^*}{S})}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T}$$

$$x_{1i} = \frac{\log(\frac{S}{S^*})}{\sigma\sqrt{t_i}} + \lambda\sigma\sqrt{t_i}$$

$$y_{1i} = \frac{\log(\frac{S^*}{S})}{\sigma\sqrt{t_i}} + \lambda\sigma\sqrt{t_i}$$

$$\lambda = \frac{r - q + \sigma^2/2}{\sigma^2}$$

Our variable definitions and assumptions include:

- A bond maturity T equal to the first call date (5-8 years from issue);
- A conversion price C_p as specified in the bond indenture, from which a conversion ratio C_r is calculated based on the number of shares received N;
- A constant risk-free rate *r* and volatility σ when calculating the binary down-in options at future coupon dates and knock-in forward option;
- A dividend yield $q = 0$ if a trigger event occurs; and
- A CET1 breach trigger event. We do not attempt to model a regulatory accounting trigger event. Our model uses a share price trigger S^* as a proxy for a CET1 breach trigger, consistent with the approach taken by De Spiegeleer and Schoutens (2011) and others. We estimate S*, also based on De Spiegeleer and Schoutens (2011), where the recovery rate is based on the ratio of the share price trigger to the conversion price. In our analysis, the recovery rate and conversion price are given and therefore a trigger share price could be estimated.

To calculate the knock-in forward and binary down-in options, we use implied volatility data obtained from Bloomberg (the HIST_CALL_IMP_VOL field). Specifically, we use the at-the-money call implied volatility of the first listed expiry that is at least 20 business days out, based on the Listed Implied Volatility Engine (LIVE) calculator.