Article

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Executive summary

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CoCos are a promising but underutilized financial-reform instrument. Well-designed CoCos are cost-effective. This paper considers the impact of CoCos on a bank's stakeholders: it states that the addition of CoCos to the balance sheet of systemically important financial institutions would strengthen the self-insurance of the financial system and relieve taxpayers of the burden of bail-outs.

Determinants of the interest rate premium on contingent convertible bonds (CoCos)

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Abstract
Ruling out default prior to conversion of high-trigger (going-concern) CoCos, this paper concentrates on estimating the conversion risk premium on CoCos. It does so by estimating the cost of hedging that risk with a contingent put option, exercisable only in the event of conversion, whose strike price is set at the conversion price per share (CPS). In this situation, the level of the common equity tier-1 (CET1) capital ratio at the time that the CoCos are issued plays a central role: it determines the probability of conversion during the term of the CoCos and the level of the CPS, relative to the market price per share (MPS) at the time of CoCos issuance, that must be set to stabilize the expected replacement rate, here at 80%. This replacement rate implies that CoCos holders can expect to lose 20% of the face value of CoCos in the event of conversion and are moved to exercise debt discipline. At the same time, existing shareholders derive sufficient comfort from conversion, for the losses leading up to it, not to oppose the issuance of CoCos in the first place. If the issuing companies have initial Basel III-based capital ratios that are at least 3 percentage points above the 7% going-concern trigger, covering the conversion risk should cost only a third as much as the average premium now required on equity into which, upon conversion, the CoCos would turn. By issuing such CoCos, banks can thus equip themselves with a form of contingent equity line. That line is activated automatically when triggered by adversity to rebuild their capital at a bargain without causing dilution for existing shareholders.

General introduction and motivation

This paper works through an integrated dynamic leading from a bank's issuance of CoCos, whose terms are conditioned on the strength of its initial capitalization, to their ultimate conversion and its consequences for stakeholders. It aims to provide internally consistent specifications and numerical estimates of the probability of conversion, the choice of conversion price, and expected recovery rates, to solve for the conversion-risk premium and the resulting interest rates that could make CoCos attractive for prudential and business purposes.

CoCos are debt securities that convert outside bankruptcy to common equity tier-1 (CET1) automatically when, now usually Basel III, CET1 — henceforth understood to be expressed in percent of Basel-III risk-weighted assets (RWA) – falls below a specified level. As here, this trigger level most often is 7%. CoCos provide remedial equity capital of assured loss-absorption capacity, coupled with debt relief, to a going concern automatically just when such capital is most needed and too expensive and/or dilutive to be raised directly by public offering.

CoCos thus are a promising, and as yet underutilized, financial-reform instrument. Their addition to the balance sheet, particularly of systemically important financial institutions, would strengthen the self-insurance of the financial system and relieve taxpayers from implicit bail-out obligations. Yet issuance of CoCos by banks too big to fail so far has been confined to a few European countries. They are the United Kingdom, the Netherlands, Switzerland, Cyprus (CoCos already converted) and Belgium and, most recently, for masking government deficits, Portugal and Spain. The 15 billion dollars' worth of "Enhanced Capital Notes" (ECNs) issued by a major UK bank in 2009, detailed in von Furstenberg (2011a, pp. 10-13, and 2011b, pp. 32-33), played a pioneering role in that regard. However, the skimpy conversion terms and low trigger level of ECNs have not proved exemplary, and interest rates have been into the double digits on pounds sterling and U.S. dollar issues of the series of low-rated CoCos that were offered in exchange for other debt or hybrids. The integrated analytical framework, previewed next, shows what links and choices need to be made at each step to make CoCos attractive to issuers and investors without government aid or mandates. CoCos deserve regulators' acknowledgment of their merits in shoring up capital and meeting part of regulatory capital requirements to reward private prudential innovation and self-insurance, and not as a favor to the banking industry.

An integrated trajectory from CoCos issuance to conversion: technical preview

The paper first considers whether CoCos conversion should be dilutive, non-dilutive, or the opposite of dilutive to existing shareholders so as to lower, leave unchanged, or raise book value and/or market value per share, depending on the criterion chosen for dilution. The size of the bank's $CET1_0$ capital buffer percentage above its trigger level at the time it issues CoCos (indicated by subscript 0) helps determine the probability of conversion. Its terms, in turn, affect the quality of corporate governance and the viability of issuing CoCos.

To determine the most appropriate setting of conversion terms, I estimate the empirical link between the fall in the capital ratio in the firm that would eventually lead to the trigger point and the rate of decline in the share price of its common stock. This link is needed to determine the expected recovery rate, R, which is the fraction of the principal of CoCos that may be recovered from the market value of the shares received in conversion. Next to the probability of conversion (P_c) or its complement, the probability of survival (PS) until repayment at maturity, R is crucial. It is given equivalently by the market price per share expected to prevail at the time of conversion (indicated by subscript c), MPS_c, divided by the intentionally higher conversion price per share, CPS, so that $R = MPS_c/CPS < 1$ determines the number of shares (N_c) of common stock that are to be received in conversion. This is because, by definition, N_c is equal to the principal amount of the CoCos concerted, PAC, divided by CPS, so that $N_c \equiv PAC/CPS$. Multiplying both sides of the identity by MPS_c then yields the expected market value $MPS_c(N_c) = R(PAC)$.

Further specifications are that the conversion terms are varied in response to changes in the probability of conversion that are associated with differences in $CET1_0$. The closer $CET1_0$ is to the trigger level when the CoCos are issued, the higher the probability of conversion before maturity and the lower the rate of share price decline from the already depressed level of the market price per share at the time the CoCos are issued, MPS_i, which is normalized at 1, to its level at conversion, $MPS_c < 1$. To keep the expected recovery rate, MPS_c/CPS, the same at the time of issue for all CoCos, any change in MPS_c produced by a difference in the initial capital ratios of particular CoCos issues must be compensated by an equal percentage change in CPS. The resulting conversion prices, like the probability of CoCos being converted within their 10-year term to maturity, P_c, are inversely related to $CET1_0$. They are designed to leave the losses from conversion expected by CoCos holders uniformly at about 20% of the PAC converted to facilitate standardization and focusing on differences in CoCos features other than their recovery rate.

The last step for deriving the CoCos conversion-risk premium is to price a 10-year put option whose strike price is CPS and whose market price is set equal to the expected MPS_c rather than the current MPS_0. This is done because conversion must occur before the contingent put option can be exercised.[1] Buying such on option for the number of shares to be issued at conversion, N_c, which is equal to 1/CPS when PAC is set equal to 1 as already explained, and weighting by the cumulative probability of conversion prior to maturity, P_c, because the exercise of the option is contingent on conversion, yields a rough estimate of the expected cost of the hedge against conversion risk. Put options are, therefore, used as a theoretical device for pricing the risk of losses from conversion facing CoCos investors by what it would cost to hedge this risk in perfect capital markets.[2]

The resulting schedule of premiums over the riskless interest rate, derived with conversion-contingent options coverage of the risk of losses, is then compared with the results reported in an earlier paper. That paper [von Furstenberg (2012a)] contained estimates of the cost of CDS coverage of the conversion losses for CoCos investors when conversion is treated as a default event. This comparison gives confidence that if the stand-alone credit profile (SACP) of the issuing bank and the buffer above the trigger level of the CET1 capital ratio together are adequate to support an initial investment-grade rating for CoCos, CoCos are a highly competitive contingent source of equity capital. That source is tapped automatically when it is most needed because other sources have dried up while capital ratios were shrinking. This concludes the introductory section and its technical preview.

Corporate governance and how stakeholders fare in CoCos conversion

To be motivated to exercise debt discipline, investors in CoCos should expect to be subjected to losses in the event of conversion. They could then be relied upon to exercise influence over management to avoid excessive risk taking and to keep the designated capital ratio well above the trigger point. Prompt corrective action may then follow. Certain groups of stakeholders, such as unsecured senior creditors, naturally favor adding CoCos financing as long as such financing does not displace an equal amount of common equity, because CoCos would be loss-absorbing outside bankruptcy after conversion has been triggered. On the other hand, if conversion terms are so dilutive as to make conversion harmful to existing shareholders in spite of any help in avoiding bankruptcy it could provide, it may not be possible to get CoCos issued by any firm unless there are regulatory CoCos mandates to do so. Such mandates, not further considered in this paper, have been imposed on Switzerland's two largest banks. They have also been imposed under quite different circumstances on failing banks in Spain and Portugal to precede their recapitalization through equity injections by government agencies.

CoCos can become worthless only if the stock into which they convert when triggered is expected to have no value whatsoever so that bankruptcy is at hand. However, the debt cancellation associated with conversion strengthens the balance sheet of the firm by providing for more equity and less interest-bearing debt.[3] The safety cushion that CoCos provide for firms struggling to maintain viability will then be generally appreciated, and disputes over the terms of conversion will yield to concern for what conversion can do to help the firm recover. Well away from bankruptcy and CoCos-induced changes in the dynamics of the firm's survival, however, the terms of CoCos conversion appear zero-sum, with redistribution primarily taking place between CoCos holders and existing shareholders. Relations between

1 Certain complexities are passed over here. For instance, while the cumulative probability of conversion, P_c, is later deduced from a random-walk expansion process, the survival curve of CoCos from the time of issue to maturity, other than its end point, is not made explicit, nor is the market price expected to prevail at the uncertain time of CoCos conversion discounted to the time of issue before it is used in the put option.

2 The condition that CPS > MPS_c, while holding ex-ante by design, may be violated ex-post in rare instances. Ignoring this slight upside potential makes the present estimate of the conversion risk premium a little too high and leaves the complete estimate closer to the estimate based on hedging with CDS.

3 For this restoration of value to existing shareholders to occur in a going concern, conversion would have to be into shares that would otherwise have been worthless, and not into shares of a new legal entity or successor company, established in resolution, as a recent joint paper by the Federal Deposit Insurance Corporation and Bank of England (2012) has proposed. Conversion terms are immaterial under that proposal because the holders of the highest levels of debt not written off in resolution, through conversion of that debt, would alone capitalize the shrunken successor company. The total value of the shares in this new legal entity is determined by the value of its net assets and not by the number of shares issued at conversion.

	Initially	CoCos issued	Conversion triggered	CoCos converted at CPS of:			
				0.2	0.4	0.5	1
Column:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Liabilities (U.S.$)							
CoCos		25	25				
Other liabilities	1290	1275	1275	1275	1275	1275	1275
Equity (CET1)	110	100	40	65	65	65	65
Total liabilities	1400	1400	1340	1340	1340	1340	1340
Number of shares							
pre-existing	110	100	100	100	100	100	100
from conversion				125	62.5	50	25
Total	110	100	100	225	162.5	150	125
BVS (U.S.$)	1	1	0.4	0.2889	0.4	0.4333	0.5200
Ownership %							
Pre-existing shareholders	100%	100%	100%	44.44%	61.54%	66.67%	80.00%
Former CoCos holders				55.56%	38.46%	33.33%	20.00%
Ownership (U.S.$)							
Pre-existing shareholders	110	100	40	28.89	40.00	43.33	52.00
Former CoCos holders				36.11	25.00	21.67	13.00
Memos: Risk-weighted assets are U.S.$575. CET1 ≤ U.S.$40 triggers conversion under the 7% trigger.							
BVS is calculated as the book value of CET1 divided by the total number of shares.							

Table 1: Gains and losses of shareholders and CoCos holders from CoCos conversion at selected values of the conversion price per share (CPS)

the conversion price (CPS), book value (BVS), and market price (MPS), all per share (S), are crucial to which group gains and which loses from conversion and when conversion produces theoretical stock-value and earnings-per-share dilution or its opposite. After explaining the metric of dilution, a sequence of accounting snapshots in Table 1 – from CoCos issuance through conversion – applies this metric to show which group gains and which loses from conversion. The distributions that result depend on the alternative values of CPS specified in Table 1 and hence on the number of shares issued to the CoCos holders in conversion. One such distribution key may dominate the others by containing adequate incentives to get CoCos issued while also providing CoCos debt discipline to discourage excessive risk-taking.

Defining and measuring dilution from conversion, and its opposite

Equating CoCos conversion automatically with dilution and regarding only write-down CoCos that do not convert to equity when triggered as non-dilutive for existing shareholders is commonplace in financial reporting and commentaries [see Durand (2011) for a case in point]. In fact, however, write-down-only CoCos that convert into thin air and not shares are not just non-dilutive but strongly anti-dilutive, making a gift of CoCos debt write-off to existing shareholders.[4] Although partial write-down, or complete permanent write-off "cliff" CoCos have been issued by at least four banks in recent years, the market for such contingently canceled debt claims is likely to remain very small. When triggered, their holders would be worse off than under regular bankruptcy, where subordinated debt holders would not be first to absorb losses, ahead of stockholders, and their losses might not be total. Write-off CoCos have been likened to regular CoCos with a CPS of infinity so that $N_c \equiv PAC/CPS = 0$. There is no need to go to such an extreme value for CPS to satisfy the no-dilution condition for existing shareholders, $CPS \geq MPS_c$.

Some prominent groups of academics have taken the opposite, equally extreme, position of wanting the terms of conversion to be made ruinous for existing shareholders rather than CoCos holders. Specifically, von Furstenberg (2011b, p. 5) references the Interim Report of the (U.K.) Independent Commission on Banking [ICB (2011, p. 182)], Goodhart (2011, p. 117), Calomiris and Herring (2011, p. 18), Flannery and Perotti (2011, p. 4), and

4 Write-down CoCos that provide for partial or full reinstatement of the debt claim after the firm has recovered to a specified degree have so many debilities, including the creation of an ugly debt overhang problem and regulatory uncertainty, as to be left out of account here.

the (U.S.) Shadow Financial Regulatory Committee [SFRC (2010)] as having favored CoCos with conversion terms that hold out the prospect of "death by dilution" or at least "severe" dilution. These authors expected such confiscatory terms of conversion to compel existing shareholders to impress upon management to keep the institution's capital ratio well above the trigger level by all means at its disposal. Should conversion ever be triggered nonetheless, it would decimate the stake of existing shareholders while the former CoCos holders would end up with the great majority of shares and seize control. What tying such deadly threats to CoCos conversion ignores is that existing shareholders would be ill-advised to consent to the issuance of "Damocles" CoCos in the first place.

Hence extreme arrangements, where either CoCos holders or existing shareholders are set up to lose everything in conversion, are likely to succeed only in discouraging CoCos from being issued. Such arrangements boost, typically underpriced, tail risks by making rare events devastating to one group or the other, should they occur, with adverse ripple effects on counterparties. Thus there will be no chance for these ill-designed CoCos to make a contribution to financial stability through greater self-insurance and provisioning of financial institutions. In between these extremes there is a continuum of outcomes that can be reached by varying the conversion price per share, CPS.

The treatment that follows assumes that CoCos remain at their principal or face amount, PAC, on the balance sheet until converted[5] and that the number of shares issued in conversion, N_c, is always equal to PAC/CPS and hence $CPS = PAC/N_c$. PAC is known from the time of CoCos issuance. N_c and CPS are generally known from the time of issue as well, as knowing one allows solving for the other. This advance knowledge facilitates the pricing and hedging of CoCos in financial markets and is indispensable to their success.

One method of conversion that has been used simply sets CPS equal to MPS around the time of CoCos issuance, MPS0. Another determines CPS, subject to a minimum, from stock price data around the time of CoCos conversion rather than issuance. Then CPS equals the actual MPS_c known only at conversion, provided it lies above a specified minimum value. In practice, as documented in von Furstenberg (2012a, pp. 59-62), the minimum value set on CPS when CoCos are issued by initially well-capitalized banks has tended to be around $0.5MPS_0$ while MPS_c is expected to be around $0.4MPS_0$ for these banks. Assuming that the minimum will in fact be binding, the number of shares to be issued in conversion is thus known already at the time of CoCos issuance as it is when CPS is set equal to the MPS_0.

The two groups most directly affected by conversion are CoCos holders and existing shareholders. In the comparative-static setting of a going concern, losses to one of these two groups imply gains for the other since conversion, viewed as an accounting operation, cannot create net wealth. CoCos holders would be subject to losses from conversion on the principal amount of their claim if the market value of the shares obtained through conversion is less than PAC. This will happen when $MPS_c < CPS$ and hence $MPS_c(N_c) < PAC$. Existing shareholders would then end up with net gains from the debt cancellation accompanying conversion even though the number of shares outstanding has increased. Conversely, if CoCos holders can expect to get value exceeding PAC from the shares obtained through conversion because $MPS_c > CPS$, pre-existing shareholders stand to lose from conversion and oppose the issuance of CoCos by the firm.[6]

CoCos issuance to conversion: a process with alternative endings, depending on CPS

The numerical account in Table 1 lays out balance sheet modifications from CoCos issuance to conversions, which are conducted on alternative terms. In the table, the initial composition of a financial institution's liabilities in column (1) is affected by the $25 CoCos issued in column 2. Of this $10 (40%) is used for stock buyback and $15 (60%) as a substitute for other debt. Total liabilities and book value per share (BVS) so far do not change. The capital position of the firm then deteriorates drastically: column (3) shows the book value of equity falling from

5 If CoCos liabilities had been marked to market, the boost to book equity from write-off of PAC at conversion is less by the amount of the prior markdown. Because that markdown anticipates some of the benefits of complete write-off should it occur, it could be added back to estimate the total benefit of the debt write-off at conversion.

6 The combination of inequalities $CPS < BVS_c$ and $CPS > MPS_c$ may be encountered so that conversion can reduce BVS_c, because CoCos holders are overcompensated at conversion by the BVS criterion, while at the same time increasing MPS_c, because CoCos holders are not fully compensated by the MPS criterion. Hence which criterion for dilution is chosen can make a difference.

100 to 40, and BVS from $1 to $0.40 on the 100 shares held by existing shareholders. RWA is calculated with a weighted-average risk weight of 42.91% applied to total assets of $1,340 in this illustration. CoCos conversion is triggered because CET1/RWA now falls below 7% as explained in the memo to the table.

How many shares are issued to the former CoCos holders depends on the conversion price per share that is specified in the CoCos covenant. CPS values shown range from $0.2 to $1 in columns (4) to (7) of Table 1. The first major recent CoCos issue, made in the U.K. in 2009, specified a CPS equal to the MPS_0. For financial firms, BVS and MPS0 are often close during relatively good times which are most suitable for issuing CoCos. However, BVS tends to be appreciably greater than MPS_c when capital ratios have deteriorated toward the trigger point of CoCos. If CPS is $1 but BVS has fallen from $1 to $0.4, the last column of Table 1 shows that conversion at that CPS would transfer an amount equal to $52 – $40 = $12 from the former CoCos holders to pre-existing shareholders. For them, the result of conversion at such a high CPS thus would be strongly anti-dilutive.

Almost the precise opposite would happen in this comparative-static setting if CPS had been as low as $0.2. In that case, CoCos holders (unless legally entitled to no more value than PAC) would get about $36.11 – $25 = $11.11 more than the PAC of $25 in shares, while the original shareholders are left that much short of $40, which is the value of their equity prior to conversion shown in column (3).

The logic underlying these results is this: in the example just given, CoCos debt cancellation contributes 25/65, or 38.46%, of the equity of $65 outstanding after conversion when CPS = BVS_c = 0.4. If the former CoCos holders were to end up with a larger share in the total number of shares outstanding after conversion, as in column (4), they would benefit at the expense of pre-existing shareholders. Conversely, if their part of the total number of shares is less than 38.46%, as in columns (6) and (7), pre-existing shareholders benefit from conversion on these terms at the expense of the former CoCos holders. Only when CPS = BVSc (= $0.4 in column(5)) is there no redistribution judging by book values. Under the latter terms, the former CoCos holders obtain the full value of PAC = $25 in shares, while pre-existing shareholders suffer neither dilution nor anti-dilution of their prior stake of $40. Judging by market rather than book values, the same results would be obtained if CPS would be equal to the expected future value, MPS_c. However, such a distributionally neutral outcome can only be intended, not guaranteed, by fixing CPS, or equivalently the number of shares to be issued in conversion. Furthermore, as next argued, aiming for such a "fair" outcome would not yield the optimal structure of incentives.

Reflecting on the appropriateness of the distribution of gains and losses from conversion for CoCos and existing shareholders, it appears that when BVS_c and/or MPS_c is expected to be around $0.4 at conversion, CPS = $0.5 is the best choice. As shown in column (5), existing shareholders then would receive some comfort from conversion for the large losses already suffered as their stake would be raised from $40, down from $100, to $43.33. Thus, existing shareholders would remain exposed to large losses of capital that would make them averse to venturing onto the road to conversion even though the act of conversion itself would provide a measure of relief.

At the same time, CoCos holders get to collect only $21.67 on the PAC of $25 from the shares issued in conversion. Even though the number of shares obtained from conversion is 20% less (50 compared with 62.5) at a CPS of 0.5 rather than 0.4, the recovery rate from Table 1 would be 21.67/25.00 and thus over 80% (86.7%, to be exact). The reason is that BVS and MPS rise in the process of shifting to the higher value of CPS because the number of shares outstanding declines (from 162.5 to 150). Such an effect would become immaterial if CoCos were a much smaller percentage of total liabilities than assumed in Table 1. Hence the uniform R adopted in the next part of the paper is much closer to 80% than the R deduced above. CoCos holders would thus suffer significant losses from conversion and oppose any course of action by the firm that would predictably carry an appreciable risk of ending in decapitalization to the trigger point. Goodhart's recommendation that CoCos holders should have governance representation on the board of directors and relevant committees of the bank [see von Furstenberg (2013, p.101)] may have to be adopted to strengthen not only these holders' incentive, but also their ability, to exercise CoCos *debt discipline* over management.[7]

7 This recommendation runs counter to the earlier support for severely penalizing existing shareholders in Goodhart (2010) because it implies, correctly in my view, that CoCos holders, not pre-existing shareholders, should suffer losses at conversion and be empowered to better guard against management's actions that could lead to conversion.

Pricing the conversion risk of CoCos with CDS spreads or contingent put options

My first simplified approach to pricing CoCos, exposited in a previous paper [von Furstenberg (2013)], followed Zhu (2004) in applying an arbitrage theorem that involved Credit Default Swaps (CDS). That approach showed that CDS spreads (annualized quarterly premium payments in percent of notional, N), ρ, should be approximately equal to the credit spreads (yield rates minus riskless rate), c-r. Zhu showed that, in complete markets, the fundamental equilibrium relation would be ρ = c-r because there would be arbitrage profits to be made otherwise. For instance, if ρ > (c-r) or equally (ρ+r) > c, an investor can sell the CDS in the derivatives market (earning ρ), buy a risk-free bond (earning r), short the corporate bond in the cash market (owing c), and make profits until ρ has declined and/or c has risen to restore the equality of ρ and (c-r). If the bond defaults, the profit on the short matches the payout on the CDS, [(1-R)N]. The problem of pricing the credit spread on CoCos was thus handled by pricing a CDS with specified survival and recovery rates and treating CoCos conversion as a default event.

A second, equally simplified, approach to estimating the conversion risk premium commanded by CoCos, over the interest rate on risk-free debt of equal maturity, prices contingent put options rather than CDS. This is the approach explored here. Results using both approaches are compared at the end of this part.

Contingent put options may be exercised just like regular options but only if and when the underlying CoCos have been converted during their term-to-maturity, assumed to be 10 years. The price of such options thus is equal to that of regular options — with the current market price, the strike price, the risk-free interest rate, the annualized volatility, and contract maturity specified — times the probability that the CoCos are triggered and duly converted into common equity rather than being paid off in full at maturity.

The probability of CoCos being converted rather than paid off depends on how far the issuer's $CET1_0$ capital ratio was above the trigger point when the CoCos were issued, and how much time has elapsed since then, up to maturity. When one analyzes the data for common equity tier 1 (CET1) Basel-III-based capital ratios of the largest U.S. banks, obtained from 10-Q and 10-K reports filed with the SEC, one finds that the average capital ratio reported rose from 7.15% to almost 9% between 2010 and 2012. The standard

$CET1_0$	P_c
12%	4.46%
11%	8.69%
10%	15.39%
9%	24.83%
8%	36.69%

Table 2: Relationship between $CET1_0$ and P_c

deviation of the changes in CET1, $\Delta CET1_t$, to the end of one quarter (t) from that of the previous quarter (t-1) through 2012-Q3 is 0.465 or 0.93 at an annual rate and 2.94 over 40 quarters when a random-walk diffusion process applies. Then if the CET1 ratio is 5 percentage points above its 7% trigger level to start with, so that $CET1_0 = 12\%$, there would be a 4.46% probability (P_c) that conversion would be triggered within 10 years since the z-score on a standard normal distribution would have to be $-5/2.94 = -1.7$ or less for the trigger event to occur. Table 2 shows that P_c rises to almost 37% if CET_0 is only about 1% above the trigger level of 7% to start with, as still is the case for a few of the banks analyzed. The cumulative probability of conversion thus falls strongly, ceteris paribus, with the rise in the initial capital buffer above 7%. This percentage, with the 2.5% conservation buffer included, may soon be the lowest of the minimum regulatory Basel III CET1 capital ratios that have to be maintained by any class of internationally active banks.

Implementing the contingent-options approach for pricing the CoCos conversion risk

To implement the contingent options approach to CoCos pricing it is further necessary to associate the decline in $CET1_c$ to the trigger level with the expected fall in the market price of the company's shares of common equity. In estimating this relationship with data for the largest U.S. banking institutions for $\Delta CET1_t = CET1_t - CET1_{t-1}$ and from Yahoo Finance for the rate of change in adjusted stock prices at the close of trading between ends of quarters, $\ln(MPS_t/MPS_{t-1})$, intertemporal relations are important. Though dealing with 10-K annual, rather than 10-Q quarterly report filings with the SEC, the following quote may lead us into the issue: [I]nvestors' reaction to information in 10-K appears sluggish in that future stock prices continue to drift in the same direction as the immediate market response to the information… [F]or every 1% of immediate market reaction to 10-K, there is a delayed response [over the 12 month period after the annual report filing] of about 0.7% [You and Zhang (2007)].

b_1	0.0399 (0.0582)
b_2	0.0734 (0.0573)
b_3	-0.0805 (0.0599)

Table 3: Estimates of regression coefficient

"Large accelerated filers" must submit their reports to the SEC and release them to the public within 40 (10-Q) and 60 (10-K) days from the close of the respective quarter or year. Hence You and Zhang (2007) would expect the market's reaction to the change in the capital ratio to occur when the data to calculate that change is reported and shortly thereafter, and not in the earlier quarter for which it is reported. This leads to the specification $\ln(MPS_{t+1}/MPS_t) = b_1 \Delta CET_t$.[8] However, the estimate of the regression coefficient b_1 obtained with the 40 $\Delta CET1_t$ observations that can be constructed for the banks through 2012:Q3[9] was weak, as Table 3 shows with standard errors of estimate in parentheses.

The simultaneous relation, $\ln(MPS_t/MPS_{t-1}) = b_2 \Delta CET1_t$, was slightly more successful. This specification is also quite plausible because large companies tend to provide earnings and dividend guidance and announce planned major reserve set-asides that could affect CET1 during any quarter while that quarter is still unfolding. Finally, there is the idea that markets unaccountably know quite well what is going to happen to CET1 before the accountants are able to tell. In that case the market is two quarters ahead of the quarterly release date of the latest report needed to construct $\Delta CET1_t$ and one quarter ahead of the end-of-quarter to which that report would apply. However, the specification $\ln(MPS_{t-1}/MPS_{t-2}) = b_3 \Delta CET1_t$ received no empirical support as b_3 unexpectedly turned out to be negative.

On balance, the best estimate appears to be that the response of stock prices to changes in a company's CET1 ratio is simultaneous in quarterly data and presumably co-integrated but anemic. The signal-to-noise ratio in $\Delta CET1$ may have been raised by the Federal Reserve's declining to require and supervise the adoption of Basel III standards for reporting tier-1 common equity and RWA. The Fed did not provide adequate and uniform guidance even to the largest U.S. banks in that regard. Thus self-selection in choosing to initiate reporting of Basel III-based capital ratios may have led to varying degrees of upward bias. In addition, errors may well arise in CET1, and likely also in $\Delta CET1$, from measurement inconsistencies across time and companies. Raising the preferred regression coefficient, b_2, by 2.326 times its estimated standard error from 0.0734 to 0.2067 implies choosing a coefficient on $\Delta CET1$ so high as to allow only a 1% chance that the true coefficient is even higher. Such an adjustment may provide adequately for the jump in the sensitivity of stock prices to evidence of decapitalization that is to be expected in a financial crisis. The equation used to predict the rate of change in the stock price from its initial position at $CET1_0$ to its level at CoCos conversion – when CET1 has declined to the trigger level of 7% – is therefore:

$$\ln(MPS_c/MPS_0) = 0.2067 \Delta CET1_c. \qquad (1)$$

To give an example of how this equation is used, if $CET1_0$ were 12%, it would take a 5 percentage point decline to trigger CoCos. Hence substituting -5 for $\Delta CET1_c$ in the equation above yields $\ln(MPS_c/MPS_0) = -1.0335$ and, taking antilogs, $MPS_c = 0.3558 MPS_0$. By the time of CoCos conversion the market price of the company's common shares thus would be expected to have fallen to 35.58% of its initial level.

If, at the lower end, $CET1_0$ would be only 8%, just 1 percentage point above the trigger level, the probability of conversion, P_c, prior to the assumed maturity of 10 years, would be much higher and already factored into the market price per common share at the time the CoCos are issued. As shown in the Table 4, that expected price at conversion, MPS_c, would then be down only to 81.33% of its level at the time of CoCos issuance, rather than down to 0.81335 = 35.58% as in the earlier example. Hence if the conversion price, CPS, were set equal to the market price per common share at the time of CoCos issuance, MPS_0, unhedged CoCos holders would expect to lose on account of conversion an amount equal to about 20% (18.67%) of the face value of CoCos issued at $CET1_0$ of 8%.

8 The constant term was dropped after its estimate turned out to be minute and statistically insignificant.

9 The closing stock price at the end of March 2013, past this paper's deadline for submission, is needed to implement this specification with $\Delta CET1_t$ through 2012:Q4. Hence the quarterly change in CET1 during the fourth quarter that could be calculated with year-end 2012 data available by 1 March 2013 could not be used in any of the three regressions to allow their results to be comparable.

$CET1_0$	MPS_c/MPS_0	CPS/MPS_0
12%	0.3558	0.4375
11%	0.4375	0.5380
10%	0.5380	0.6615
9%	0.6615	0.8133
8%	0.8133	1

Table 4: MPS expected at conversion and CPS, both relative to MPS at the time of CoCos issue, as a function of the capital ratios at that time

This same expected loss rate is preserved for all starting values of the CET1 percentage as MPS_c/CPS is 0.8133 for all values of $CET1_0$ in Table 4. The higher $CET1_0$, the more severe the reversal of a company's fortunes and capitalization would have to be to bring on CoCos conversion. Hence to keep CoCos holders' losses from conversion to the same percentage, the number of common shares issued in conversion, N_c, per face value of CoCos, would also have to be higher, and CPS correspondingly lower, the greater $CET1_0$. Only if the company is initially very well capitalized, with a $CET1_0$ of 11% -12%, could the conversion price be set as low as half of MPS_0 according to Table 4 and still remain well above MPS_c.[10]

Making the contingent-put-option approach to hedging conversion risk operational

The risk of loss from conversion arises from the expected market price per common share issued at conversion, MPS_c, being less than the conversion price, CPS. The product of CPS and N_c is required to be equal to the face value of CoCos, PAC, but MPS_cN_c will be less than PAC, if $CPS > MPS_c$ as here intended by the choice of CPS. To hedge against this risk of losses from conversion, investors could, notionally if not realistically, purchase a 10-year American contingent put option on the number of shares received in conversion. Analogous to a barrier option, this "contingent" put option, absent conversion, would not be exercisable, however, even if it were in the money otherwise. The value of the shares received in conversion thus would equal PAC if the shares could be put at a strike price of CPS once CoCos conversion has been triggered. Hence the expected market price at conversion, MPS_c, is the then relevant spot price used in calculating the value of the contingent put option whose contingency clause has been satisfied. Finally, MPS_c equals MPS_c/MPS_0 (see above) because MPS_0 functions as numeraire.

Additional parameter values are required to price the contingent put option. Assuming a random walk in stock prices co-integrated with CET1, the quarterly volatility of 0.1924, equal to the standard deviation of the 41 observations on $\ln MPS_t/MPS_{t-1}$ introduced earlier, translates into an annual volatility of 0.3848. The U.S. Treasury rate on a 10-year issue is taken to be either at a low of 2% or at a more normal level of 4%, with both percentages equally split between real interest and inflation premium. With these alternative riskless interest rates and an expected share price conditional on conversion of MPS_c, potential investors in CoCos can determine the expected cost of a 10-year put option with a strike price of CPS. Buying such an option for the number of shares to be issued in conversion, which is CPS^{-1} times the face amount of CoCos, and multiplying by the probability of conversion, P_c, would yield a rough approximation to the expected cost of the hedge in perfect capital markets. Arbitrage would then ensure that investors would be compensated fully through a premium over the riskless rate, later represented as AAA/Aaa corporate bond yield, for the up-front costs they would have to incur if they hedged against conversion risk and the resulting loss in the manner here described.[11]

Comparing results from the CDS and contingent-put approaches to pricing CoCos

Results derived with the first approach to pricing CoCos are laid out in von Furstenberg (2012, p. 71). They show the annualized fixed premium leg in percent of notional for a par value CDS for (i) CoCos survival curves with different 10-year terminal probabilities of survival (PS) to maturity, and (ii) different recovery rates, R, from the shares of common stock obtained through conversion.

The second approach, applied here, links the probability of CoCos conversion explicitly to the degree to which a company's $CET1_0$ is above the 7% trigger level when its CoCos are issued. PS under

10 This finding contradicts some of my earlier design suggestions for CoCos, as for instance in von Furstenberg (2013, p. 101), that did not take differences in $CET1_0$, and their implications for the expected level of MPS_c/MPS_0, into account and did not seek to hold the expected recovery rate constant at a value well below 100% to generate appropriate incentives for corporate governance and CoCos issuance.

11 As for the CDS, the arbitrage condition can again be represented as $c = r + \rho$, where c is the yield rate on PAC=1, r is the riskless interest rate, and ρ the annualized interest rate premium corresponding to the up-front cost of the contingent put of PAC/CPS shares. For instance, if $c > r + \rho$, the investor can make an assured arbitrage profit by buying CoCos (earning c), going short on the risk-free bond (owing r) and buying the put (owing ρ).

$CET1_0$	P_c	CPS	Put (r = 2%)	Put (r = 4%)	{Up-front cost} and Interest rate premium for hedge[a] (r = 2%)	{Up-front cost} and interest rate premium for hedge[a] (r = 4%)
12%	0.0446	0.4375	0.1640	0.1184	{0.0167} 0.20%	{0.0121} 0.19%
11%	0.0869	0.5380	0.2023	0.1461	{0.0327} 0.38%	{0.0236} 0.33%
10%	0.1539	0.6615	0.2482	0.1793	{0.0577} 0.66%	{0.0417} 0.56%
9%	0.2483	0.8133	0.3055	0.2206	{0.0933} 1.16%	{0.0673} 0.88%
8%	0.3669	1	0.3758	0.2714	{0.1379} 1.56%	{0.0996} 1.29%

Table 5: Cost of hedging the CoCos conversion risk through contingent put options as a function of the initial capital ratio CET1 and associated values of the probability of conversion and the conversion price per share

[a] The up-front cost is Pc/CPS times the cost of the put. The latter was obtained with the riskless rate r = 2% or 4% using the calculator at http://www.erieri.com/BlackScholes. Like the Black-Scholes theorem, this calculator was developed for European options and stocks that do not pay dividends. The compensation for that up-front cost is calculated in terms of a higher annual rate on coupons paid semiannually to investors in 10-year CoCos.

the first approach is the same as 1-P_c under the second. However, the expected recovery rate is made independent of $CET1_0$ by varying the conversion price CPS, and hence the number of shares to be issued at CoCos conversion, in such a way that the expected recovery rate is always just above 80% (81.33%). With regard to the choice of interest rates, the first approach uses the discount-factor curve of 1 February 2012 when the rate on Treasuries with a constant maturity of 10 years was 1.87%. The second applies alternative risk-free rates of 2% or 4% per annum in option valuation. These rates are also used to translate up-front costs of buying contingent put options into equivalent annualized interest rate premiums. These premiums, like the CDS premiums, are treated as add-ons to the yield on AAA/Aaa-rated corporate bonds.

When compared at approximately matching values of the probability of survival (PS) and of not being converted (1 – P_c), the estimated percentage premiums under the CDS approach are appreciably less than under the contingent-put approach. A 2% riskless discount rate is most compatible with a CDS calculated with the interest rate level of February 1, 2012. Then the difference is over 50% and greatest for the highest PS values in the Table 6. No exact agreement could have been expected since the two elementary approaches employ different simplifying assumptions, though both are compared at a recovery rate of about 80%. Inconsistencies in the selectively reported Basel III CET1 variable reported by the largest U.S. banks and unresolved timing issues in valuation weaken the application of the contingent put option approach in particular. Nevertheless, these estimates provide useful information about the range in which the conversion premium for any PS may lie and how the premiums rise as the probability of CoCos conversion increases.

For instance, the three columns of premium estimates in Table 6 agree that, at a PS (and 1-P_c) of about 0.6 on the last line, the premium should be 4 to 5 times as high as at a PS of about 0.9 on line 2.

Interpretation of results

Table 6 shows that under the worst of circumstances considered, when the CET1 buffer is only 1 percentage point above the 7% trigger level and the probability of CoCos surviving until maturity is down to about 60%, the CoCos conversion premium over the nearly riskless rate is just over 1% when its size is estimated with the CDS approach. When estimated with the contingent-put approach this premium is a little over 1-1/2% if the riskless rate on 10-year Treasury notes is 2%, as it was in February 2013. The premium is only about 1-1/4% if the riskless rate is represented by the 4% yield required in the same month on Moody's Aaa-rated bonds, whose effective maturity is about 10 years. Because CoCos are corporate bonds with the risk of conversion added it is attractive to think of that premium as an add-on to the Aaa rate for pricing purposes.

Conversion risk includes the probability of conversion and the losses expected on the shares received in conversion, which are measured by the cost of hedging against these losses either with CDS or, as in this paper, with contingent-put options. The question then is whether CoCos may be expected to be cheaper to issue than equity into which some of them ultimately may turn. The literature on the "equity premium puzzle," ably reviewed and extended by Benartzi and Thaler (1993), implicitly cautions against comparing a model-deduced premium on one type of instrument with the actual risk premium observed on another. The reason for the caution is that the actual premium may be

Approach: Recovery rate ≈ 80%	**CDS**[a] $PS_{40\text{-quarters}}$	**CDS**[a] premium	**Contingent put** $1 - P_c$	**Contingent put** premium with (r = 2%)	**Contingent put** premium with (r = 4%)
			0.9554	0.20%	0.19%
	0.9	0.21%	0.9131	0.38%	0.33%
	0.8	0.45%	0.8461	0.66%	0.56%
	0.7	0.72%	0.7517	1.16%	0.88%
	0.6	1.03%	0.6331	1.56%	1.29%

Table 6: CDS and contingent put premiums compared as estimators of the CoCos conversion risk premium at specified survival rates

[a] Source for CDS results: von Furstenberg (2012a, p. 71). The probability of survival, PS, for 40 quarters under the CDS approach is conceptually the same as the complement of the probability of CoCos being converted, Pc, rather than repaid at their 10-year maturity, under the contingent-put approach.

much higher than what accepted valuation models would yield with plausible calibration of central parameters, such as the degree of risk aversion. Hence there is the possibility that CoCos would pose a premium puzzle like stocks, requiring an actual rate premium over the Aaa rate on corporates that is much greater – as research referenced just below suggests, twice as high – than plain models would predict.

If CoCos were priced like equity from the start, I would accept the highly informed judgment of Fernandez (2012) that the incremental return of a diversified portfolio (the market) over the risk-free rate — traditionally the return on Treasury securities, now sometimes trumped by Aaa-rated corporate bonds — required by an investor is about 4% so far this century. Furthermore, I infer from Benartzi and Thaler (1993) that the model-deduced premium over a time horizon coinciding with the 10-year term to maturity of the CoCos here considered is around 2%. This would leave the remaining difference of (4 – 2)% = 2% unexplained by a standard valuation model with plausible calibration.

CoCos issues have been few, and conversions so far have occurred only once (in Cyprus) though, more will occur on the Iberian Peninsula by prior arrangement in the next five years. This means that CoCos still bear innovation, non-standardization, and illiquidity risks. In addition they are subject to intense regulatory scrutiny and exposed to regulatory interference with their terms. For all these reasons it is difficult to parse the actual returns required on CoCos and to predict how much their required return would fall once volume builds and their market deepens. Hence the only valid, apples-to-apples comparison that can be struck is to compare the model range of premium estimates in the last text table for specified levels of the probability of CoCos survival, $PS_{40\text{-quarters}}$, with a model-deduced stock market premium of 2% for a 10-year horizon. By that standard, the cost savings from CoCos are modest, being under 100 bps for PS = 0.6 and around 100 bps for PS = 0.7. They are impressive only for higher values of PS of 0.8 and over, which are associated with initial levels of capitalization, $CET1_0$, 3 or more percentage points above the trigger level of 7%. As von Furstenberg (2013, p. 99) shows, such strong capital buffers when combined with no less than a stand-alone credit profile (SACP) rating of a-, that is commanded by most global systemically important banks, would allow these institutions to issue investment-grade CoCos.

Conclusion

To be incentive-compatible, CoCos investors must have reason to expect to lose from conversion. For existing shareholders to support CoCos issuance, they must expect to get some consolation from conversion for the losses of equity already suffered in the process of the company's decapitalization to the trigger point. Aiming for a uniform recovery rate of just over 80% from CoCos in setting conversion terms under different initial conditions meets these distributional objectives. It turns out that CoCos with such a high recovery rate and a probability of survival until maturity of 85% would warrant a conversion risk premium of 66 bps or less if they are rated investment grade. To merit such an initial rating, the CET1/RWA capital ratio of the issuer has to be at least 10%, three percentage points above the trigger level of 7%. (At year-end 2012, the vast majority of the largest banks in the U.S. had Basel-III CET1/RWA ratios that still fell 1 or 2 percentage points short of that level.) Results obtained with the CDS approach to hedging in my previous work [von Furstenberg (2012a)] indicated a premium that would be even smaller. Hence high-grade, high-recovery CoCos may be expected to command only a small fraction of the premium (over AAA/Aaa-rated corporates) required on the equity into which, upon conversion, they would turn.

Even before considering the likely deductibility from taxable income of interest paid on high-trigger CoCos,[12] this makes CoCos deliver contingent capital at a bargain relative to issuing more equity, but only after the CET1/RWA capital ratio of the issuer has been built up to 10% or more. This could make the firm's capital buffer high enough to issue investment-grade CoCos with a 7% trigger. Under these conditions the model-deduced CoCos conversion risk premium turns out to be equal to one-third of the model-deduced equity premium and equal to only one-sixth of the actual equity premium.

For estimating the effect of adding CoCos on the cost of capital overall, the conclusion, that well-designed CoCos are a cost-effective instrument innovation, is based on the assumption that CoCos issuance does not increase leverage in a way that would raise the required rate of return on equity along Modigliani-Miller lines. The reasoning why it should not be expected to do so is that the additional debt is a hybrid that, in a pinch, is loss-absorbing by turning automatically into equity. Furthermore, the leverage that CoCos provide when issued is automatically reversed in conversion that boosts equity just when the need is great because the capital ratio has fallen to the trigger point. CoCos thus do the work of common equity at the interest cost of high-grade debt with compensation for the conversion risk premium added.

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12 In von Furstenberg (2012a, pp. 66-67) and (2012b, pp. 1-2) I have provided an assessment of the U.S. tax treatment of CoCos in this regard.

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