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Contingent convertible bonds with the default risk premium

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ABSTRACT

Contingent convertible bonds (CoCos) are hybrid instruments characterized by both debt and equity. CoCos are automatically converted into equity or written down when a predefined trigger event occurs. The present study quantifies the issuing bank's default risk that only manifests in the post-conversion period for pricing CoCos depending on a loss-absorbing method. This work aims to reflect the distinct features of equity-conversion CoCos - in contrast to a write-down CoCos - in a valuation framework. Accordingly, we propose a model to compute the ratio of common equity Tier 1 (CET1), which is composed of core capital and risky assets, by employing a geometric Brownian motion and a random variable. Then, we formulate the post-conversion risk premium by measuring the probability with which the bank's CET1 ratio breaches a regulatory default threshold after conversion. Finally, we empirically examine a positive value of the post-conversion risk premium embedded in the market prices of equity-conversion CoCos.

1. Introduction

During the global financial crisis of 2007–2008, many financial institutions were left severely under-capitalized. Some major banks were bailed out by taxpayers rather than bailed in by creditors because the old-style subordinated debts had failed to act as a buffer against losses during times of distress. Substantial government intervention and financial support were necessary to prevent many banks from becoming insolvent, resulting in a need for stronger regulation of the banking system. As a part of the revised banking regulation, Basel III has implemented strict capital requirements to enhance banks' financial stability and reduce systemic risk (Basel Committee on Banking Supervision, 2011). The major changes in Basel III place more weight on core capital, i.e. common equity Tier 1 (CET1). The minimum requirement level for CET1 capital, a newly established category for banks' capital structure, was gradually phased in up to 4.5% of total risk-weighted assets (RWA) until 2015.

One remarkable evolution in the capitalization of banks under this new regulation is the emergence of a new hybrid asset class called *contingent convertible bonds* or CoCos for short. CoCos are a type of bond that is automatically converted into equity or written down when the issuer's capital-ratio falls below a specified level. This automatic conversion characteristic means that CoCos are expected to reduce the economic costs of bankruptcy for the benefit of all debt and equity holders. According to Basel III, CoCos are eligible capital instruments for meeting buffers (see European Banking Authority, 2011) because they may help reduce bank vulnerability and provide greater countercyclical resilience. The combination of the regulatory environment and the pressure on banks to recapitalize has led rapid growth of the CoCo market over the past decade. The global issuance of CoCos was estimated to be USD 360 billion until 2015 since the first issue by the Lloyds Banking Group in 2009 (Fig. A.4).

Despite high demand for CoCos in the financial industry, modelling and pricing CoCos are still challenging issues because the equity and credit risk are incorporated into a single product. For the design of CoCos, Flannery (2005, 2009) and Pennacchi, Vermaelen, and Wolff (2014) introduce 'reverse convertible debentures' and 'call option enhanced reverse convertibles', respectively, as examples of the structure of early CoCo proposals. McDonald (2013) suggests that CoCos with a dual-trigger that depends on the situation of both the individual firm and the whole banking system. Sundaresan and Wang (2015) discuss on stock price trigger CoCos and the nonexistence of a unique equilibrium in their prices.

On the valuation of CoCos, one strand of the literature is based on structural bond pricing models (e.g. Leland, 1994). The value of CoCos can be derived as an optimal level when firms' capital structure is composed of equity, subordinated debt, and CoCos (Pennacchi, 2011; Glasserman & Nouri, 2012; Brigo, Carcia, & Pede, 2015; Albul, Jaffee, &

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Tchistyi, 2015; Yang & Zhao, 2015; Chen, Glasserman, Nouri, & Pelger, 2017). The other strand of literature on the valuation of CoCos uses the pricing techniques of financial derivatives from two viewpoints, that of equity and fixed-income derivatives, as proposed by De Spiegeleer and Schoutens (2010, 2012). Cheridito and Xu (2015) apply a reduced-form approach, and Corcuera et al. (2013) employ a Lévy process to model CoCos. Chung and Kwok (2016) evaluate capital-ratio trigger CoCos including a discretionary conversion based on two-dimensional stochastic processes. Corcuera et al. (2014) derive a closed-form formula of coupon-cancellable CoCos, a new type of CoCo where coupon can be cancelled during the contract. Among empirical approaches, De Spiegeleer, Hocht, Marquet, and Schoutens (2017) estimate the implied volatility of the CET1 ratio by using the market prices of issued CoCos, and Wilkens and Bethke (2014) conduct a comparative analysis via a hedging simulation to assess the best-fitting model in practice.

In this study, we propose a novel model of the CET1 ratio, which is defined as the ratio of a bank's equity value to its RWA value for an in-depth analysis in CoCos by building a hidden random threshold. In our setup, we assume that the equity price follows a geometric Brownian motion and that bank's RWA is unknown on the evaluation date, but only its distribution is given. Although the true value of a bank's RWA is revealed at the time of conversion, it can be progressively estimated by using available balance sheet information at issuance. Under this model, we then derive the theoretical prices of CoCos with a CET1 ratio trigger and their expected recovery rates in an analytic form.

In addition, we develop a valuation framework to examine the difference between CoCos with two loss-absorbing mechanisms: equity-conversion (EC) and write-down (WD). To address distinctive risk that can exist only in EC CoCos, we introduce two new concepts: *regulatory default* and *post-conversion risk*. We define regulatory default as the likelihood that an issuing bank fails to retain the minimum capital requirement set by regulators and post-conversion risk as the likelihood that regulatory default occurs in the ex-post conversion situation. We derive the premium caused by post-conversion risk that only manifests after conversion by computing the price difference between two CoCos with/without post-conversion risk.

The main contributions of this study are twofold. First, we introduce a methodology for pricing EC CoCos that are distinguished from the WD type by using a new CET1 ratio model. Many studies discuss whether issuing CoCos can improve financial stability and, if so, the extent to which this can reduce systemic risk in the entire banking system (see Jaworski, Liberadzki, & Liberadzki, 2017; Hilscher & Raviv, 2014). However, studies of the difference between the loss-absorbing methods of CoCos are scant - in the context of banks' incentive to issue (or investors' risk to take) EC CoCos in contrast to WD CoCos. Among this limited literature, Avdjiev, Bolton, Jiang, Kartasheva, and Bogdanova (2015) empirically examine how the issue announcement affects each type of CoCo, while Martynova and Perotti (2018) present a theoretical approach for different risk-taking incentives in a discrete time setup. Meanwhile, the present study provides theoretical and empirical frameworks that differentiate between the method of valuation for EC and WD CoCos over a continuous time period by quantifying post-conversion risk. Second, we present empirical evidence that the post-conversion risk premium is constantly reflected in the real market prices of EC CoCos. By adopting a rigorous procedure for our empirical tests, we estimate a post-conversion risk premium of around 2% charged on the EC CoCos issued by Credit Suisse. This result bridges the gap between our theoretical proposal and the ongoing market perception of the loss-absorbing functions of CoCos.

The rest of the paper is organized as follows. Section 2 proposes a model for CoCos with a CET1 ratio trigger with several types of conversion and loss-absorbing methods in a single formula. Section 3 derives the closed-form formulae of CoCos with a CET1 ratio trigger and their expected recovery rates. Section 4 presents a model for post-conversion risk and shows a method of quantifying the post-conversion risk premium by employing a compound barrier option pricing idea. Section 5 estimates the post-conversion risk premium from the real market prices of CoCos. Section 6 concludes. The appendix includes the technical proofs, additional numerical tests, and figures and tables.

2. Model for contingent convertibles

The CoCo conversion process is activated when a certain identifier breaches a specified level. CoCos have two defining characteristics: (i) a trigger that activates conversion and (ii) a loss-absorbing mechanism that specifies how losses are absorbed at conversion.

Two types of triggers are mainly employed in practice: the capital-ratio trigger and regulatory trigger. The capital-ratio trigger is set based on accounting values in balance sheets such as equities and liabilities which makes it easy to show the overall capital sufficiency of banks with the one drawback that information on capital-ratios is not continuously available because of infrequent updates. The regulatory trigger is implemented based on a regulator's judgement on the solvency prospects of issuing banks. This trigger is controlled by authorities, which makes it difficult to quantify the probability of conversion. Once conversion is activated under the defined trigger, a loss-absorbing process is automatically enforced in two directions: a bond principal is either converted into common equity (EC-type) or written off (WD-type).

In this study, we focus on a CET1 ratio trigger. Let $(\Omega, \mathscr{F}, \mathbb{P})$ be a probability space, and $(\mathscr{F}_t)_{t\geq 0}$ be a natural filtration generated by a Brownian motion $(W_t)_{t\geq 0}$. Assume that an equity price process S_t, under an equivalent risk-neutral martingale measure $\mathbb{Q}$, satisfies

$$dS_t = rS_t dt + \sigma S_t d\widetilde{W}_t, \tag{1}$$

where $\widetilde{W}_t$ is a $\mathbb{Q}$-Brownian motion, r is the risk-free interest rate, and σ is the volatility of equity price S_t.

The CET1 ratio is formulated to a ratio of the bank's CET1 capital to its total RWA amount. Under Basel III, a bank's capital is categorized into three levels: CET1, Additional Tier 1, and Tier 2 capital. Among them, CET1 capital includes common shares issued by a bank, stock surplus, and retained earnings.[1] Meanwhile, total RWA is calculated as the weighted sum of the risk exposures of credit, market, and operational risky assets. To assess each risk position, either a linear weighting scheme or a value-at-risk approach is used. A linear weighting scheme assigns different weights depending on the level of risk. A value-at-risk approach computes the expected losses within a time horizon under a certain confidence level.[2] According to Le Leslé and Avramova (2012), credit risk is the largest component of total RWA, representing 86% on average, while market and operational risks account for 6.5% and 7.5%, respectively.

By the definition of each portion, the CET1 ratio is set as follows:

$$\text{CET1 ratio} = \frac{\text{CET1 capital}}{\text{Total RWA}} \approx \frac{S_t \times M}{\text{Total RWA}} = \frac{S_t}{\text{Total RWA}/M}, \tag{2}$$

where M is the total number of shares issued by a bank and S_t is the share price at time t, as defined in Eq. (1).

Let us define L as the RWA-per-share value of a CoCo-issuing bank, which is the total RWA amount divided by the number of shares that a bank issued, i.e. Total RWA/M. We assume that L is a non-negative random variable with distribution F, which is independent of filtration $(\mathscr{F}_t)_{t\geq 0}$, and $(\mathscr{G}_t)_{t\geq 0}$ is an enlarged filtration, defined by $\mathscr{G}_t = \mathscr{F}_t \vee \sigma(L)$.

According to the definition of the CET1 ratio, conversion time τ_B can be represented as the first time when S_t/L falls below a threshold value α_0:

[1] Additional Tier 1 capital consists of non-cumulative preferred stock, and Tier 2 capital includes debt subordinated to depositors with an original maturity of five years.

[2] A one-year 99.9% confidence interval is given for credit risk and a 10-day 99% confidence interval is given for market risk.