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# Pricing Contingent Convertible Bonds - An Empirical Approach

**Saša Popović**
University of Montenegro, School of Economics, Montenegro
*sasap@ac.me*

**Ana Mugoša**
University of Montenegro, School of Economics, Montenegro
*ana.mugosa@ac.me*

*Abstract.* This article provides analysis of structuring and pricing models for contingent convertible (CoCo) bonds. Financial instability at the beginning of XXI century forced governments to make serious efforts in order to protect financial sector from consequences of future financial crisis. One of these efforts resulted in creating new regulatory framework for bank capital adequacy. In that context a special type of bonds, so-called Contingent Convertibles (CoCo) have become popular in a banking sector. The characteristic of this debt instrument is the possibility to convert into equity, or to be written off, due to the certain trigger event. In that order bonds convert to equity during financial distress. Therefore, the aim of this paper is to analyse the empirical validation of two different CoCo pricing models, equity derivatives model (EDM) and credit derivatives model (CDM), as well as to conduct their comparative analysis.
The models are applied on the CoCo's issued by The Credit Suisse Group AG bond, on the 18th June 2014 with a volume of 2.5 billion USD. This issue has perpetual maturity, mechanical capital trigger, and loss absorption mechanism is permanent principal write-down. The Black-Scholes methodology was used to price the CoCo's in EDM and CDM. The results show approximately the same trigger level, 3.95 CHF for CDM and 4.37 CHF for EDM, which contributes to the reliability of models applied.
This paper contributes to academic literature on complex convertible financial instrument such as CoCo bond by employing empirical approach to selected pricing models. Although some academics and practitioners address many criticisms against CoCo's, it is evident that these instruments record high volume of issuance and attract lot of professional attention. Black-Scholes model is widely employed in estimation of CoCo bonds price, but recent empirical evidence demonstrates that the basic model assumption of constant volatility is not reasonable, as these instruments carry a lot of fat-tail risk. Therefore, our future research will be extended to appliance of more calibrated models, meaning simulation based models.

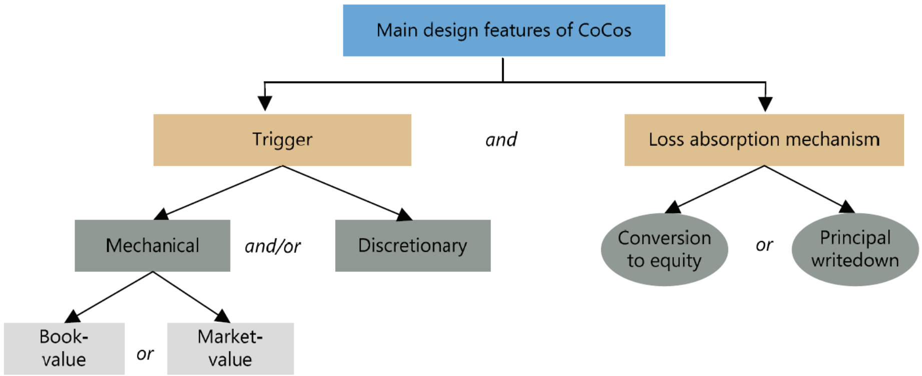
*Keywords:* contingent convertible bonds; CoCo, trigger event; loss absorption mechanism

## 1 Introduction

Many large banks suffered from deep losses of capital during the 2008 financial crisis. As catastrophic consequences confirmed later, many of them had inadequate capital levels. Such hard experience of bailing-out those who were "too big to fail" forced governments to increase level of resistance of commercial banks to external shocks as well as level of confidence in banking sector. As Pennacchi *et al.* (2014) noted with the goal of avoiding such bailouts in the future, regulators have raised banks' capital requirements and reconsidered what debt-like instruments should qualify as capital. In that context a special type of bonds, so-called Contingent Convertibles (CoCo) have become more popular to companies than issuing regular convertibles.

Unlike traditional convertibles, which have predetermined conversion date, CoCos are bonds that convert to equity, or are written off, after some triggering event such as a decline in a bank's capital below a threshold. Thus, CoCos have two main characteristics which differentiate them from traditional convertibles: the first is existence of company or market triggering event which initiate CoCos conversion, and specific terms of the payoff received by the CoCo investors at the time of conversion. Having in mind limited paper size, we are not able to comment these very specific CoCos features (Figure 1).

Figure 1: Structure of CoCo's




Adapted from Avdjiev *et. al*. (2013, 45)

Smidth and Azarmi (2015) recall that this instrument behaves like a straight bond in times of economic wellbeing of the issuer. However, once the issuing bank's capital ratio falls below a certain threshold, the bond is converted into common stock. The resulting decrease in the bank's debt-equity ratio can lead to a considerable reduction of the bank's default probability. Also, upon conversion, the bank recapitalizes automatically and therefore bankruptcy costs that would arise otherwise are circumvented. CoCos are thus a valuable instrument to reduce the probability of bank default, costs, and to make the owners of a bank internalize the outcomes of poor performance. This makes CoCos publicly, economically and politically interesting.

At the very beginning, the CoCo market was relatively small, but it continue growing. Banks have issued approximately $70 billion USD worth of CoCos since 2009. CoCo issuance volumes have increased to grow with issuance in 2014 projected to be in the range of $75 billion to $100 billion. According to Moody's Investors Service[1] CoCo issuance peaked in 2014. Some expert expect issuance for the full year 2015 would total about $106 billion on an annualized basis, compared with USD175 billion the previous year.

According to the Basel III regulations CoCos are initially counted towards the lower tier 2 capital. However, once a conversion takes place, coupon payments are discontinued and the initial CoCo principal is classified as core tier 1 capital. Figure 2 shows CoCos' position in Basel III capital requirements.

[1] https://www.moodys.com/research/Moodys-Global-issuance-of-contingent-capital-instruments-drops-by-44--PR_335214 accessed on 18th January 2016, 8:08 PM.

Figure 2: CoCos position in Basel III capital requirements

| | |
|---|---|
| Tier 2 (T2)<br>• Non-CoCo subordinated debt<br>• Low trigger CoCos | CET1+ AT1+T2 ≥8% RWA |
| Additional Tier 1 (AT1)<br>• Preferred shares<br>• High trigger CoCos | CET1+ AT1 ≥6% RWA |
| Core Equity Tier 1 (CET1)<br>• common shares<br>• retained earnings | CET1 ≥4,5% RWA |

Adapted from Avdjiev *et al.* (2013, 47)

Wilkens and Bethe (2014) review CoCo bonds valuation models and their grouping into three main categories, simultaneously citing main sources of empirical research for every group:

- structural models (SM) - explicitly capture the typical trigger event and the purpose of CoCo bonds as a deleveraging tool. (see, e.g., Pennacchi *et al*. 2014; Albul *et al*. 2012; Glasserman and Nouri 2012),
- equity derivatives models (EDM) - mainly reflect the dependence on share price as an indicator of both the financial health of a company and the value transfer at conversion. (see De Spiegeleer and Schoutens 2012), and
- credit derivatives models (CDM) - encapsulate the fact that CoCo bonds are credit-risky debt, paying coupons until maturity or until trigger or default. (see De Spiegeleer and Schoutens 2012).

Last two valuation models: equity derivatives models (EDM), and credit derivatives models (CDM) are employed in our empirical research.

The remainder of the paper is as follows: Section 2 briefly reviews relevant literature on CoCo bonds. Section 3 presents data description and their required adjustment so that they can be used as inputs for CoCo pricing models employed. Section 4 discusses methodology used and valuation models for CoCo bonds. In Section 5 we present empirical results of the research, and final section offers concluding remarks.

porta tellus eget, pretium mauris. Integer elementum condimentum semper. Maecenas dapibus tincidunt augue, non commodo eros sodales vehicula.

**2 Literature review**

First insight in CoCos, according to Zombirt (2015), could be found in the paper of Leland (1994), who tries to shape an optimal capital structure and for the first time mentions "triggers" as the early warning mechanisms that could prompt supervisory authorities to undertake remedial action. Then Raviv (2004) proposes a debt-for-equity swap that is triggered when the bank's regulatory capital ratio drops below a pre-specified level. Many authors consider early work of Flannery (2005) as a pioneering work whose proposals made significant contribution to the regulators in promoting CoCos. He proposes contingent capital instrument, with market-based trigger, i.e. the bank's equity falling below a pre-specified level whereby the conversion price would be the market price at conversion.

Capital insurance whereby the insurer receives a premium for agreeing to provide an amount of capital to the bank in case of a systemic crisis is propose by Kashyap *et al.* (2008). The insurer would be required to hold the full insured amount. The trigger would be some measure of aggregate write-offs of major financial institutions over a year-long period. Caballero and Kurlat (2009) propose tradable insurance credits issued by the central bank, allowing the holders to attach a central bank guarantee to assets on their balance sheet during a systemic crisis. A trigger for systemic crisis would be determined by the central bank. Admati and Pfleiderer (2010) argue for increasing the liability of equity holders and find that such a structure will mitigate the conflicts of interest between equity and debt holders and may reduce the need for bail outs. Later, Maes and Schoutens (2012) discuss counterparty risk, effectiveness, moral hazard, contagion and systemic risk, as well as death-spiral issues arising from the hedging strategies of the investors. They conclude by raising concerns about the pricing of the instruments by highlighting the similarities between CoCos and equity barrier options and CDSs.

We close this brief literature review by putting stress on Nordal and Stefano (2014) who summarize the CoCo issuing activity of European banks and review characteristics of these securities for the time period January 2009-June 2014

**3. Data description**

In this paper we analyse Credit Suisse Group AG CoCo bond issued on 18th June 2014 (ISIN XS1076957700). Issue volume is 2.5 billion USD, with a bond nominal value of 1000 USD, and regular biannual coupon payment by coupon rate of 6.250%. Biannually means one coupon payment in two years, so the first payment date is 18th June 2016. Cancellation possible date is 18 December 2024 and would be the first maturity date of the bond where investors would be receiving the full par amount. Initial data on this issue are presented in Table 1.

Table 1: Fundamental data on Credit Suisse Group AG bond issue

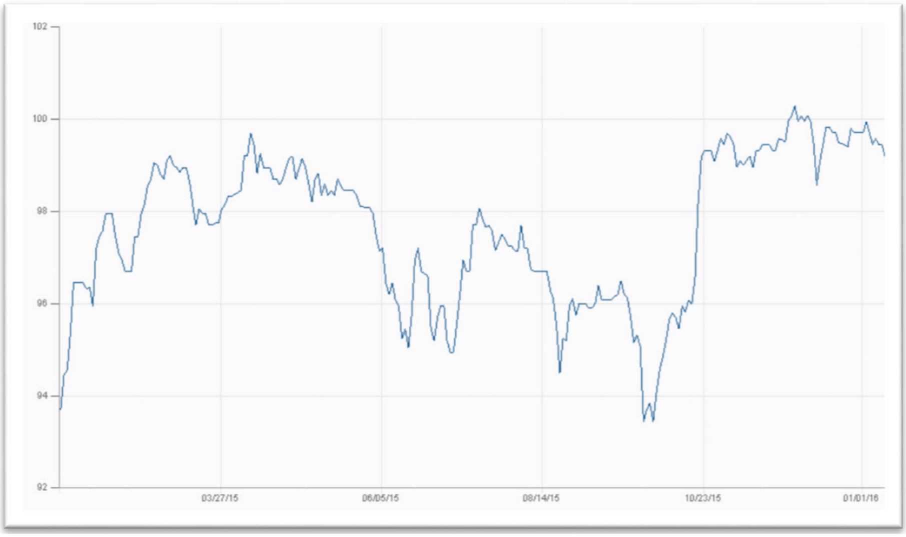
| | |
|---|---|
| **Fundamental** | |
| ISIN | XS1076957700 |
| Issuer | Credit Suisse Group AG |
| Country | Switzerland |
| **Issuance** | |
| Issuer | Credit Suisse Group AG |
| Bond Type | Corporate USA and World |
| Issue Volume | 2,500,000,000 |
| Currency | USD |
| Issue Price | 100.00 |
| Issue Date | 6/18/2014 |
| **Coupon** | |
| Coupon | 6.250% |
| Denomination | 1000 |
| Quotation Type | |
| Payment Type | regular interest |
| Special Coupon Type | fixed coupon now, later variable |
| Maturity Date | |
| Coupon Payment Date | 6/18/2016 |
| Payment Frequency | biannual |
| No. of Payments per Year | 2,0 |

| | |
|---|---|
| Coupon Start Date | 12/18/2014 |
| Final Coupon Date | |
| Floater? | No |
| **Cancellation** | |
| Issuer Callable | No |
| Cancellation Type | without constraint |
| Cancellation Possible Date | 12/18/2024 |
| Cancellation Redemption Price | 100 |

Source: *http://www.quotenet.com/bond/DL-VarHybranl1424-UndRegS-Bond-XS1076957700*

Graphical presentation of this Credit Suisse Group AG CoCo bond price dynamics is shown in Figure 3.

Figure 3: Historical prices of Credit Suisse Group AG Obligation 6.25% Coupon, 2015




Source: http://www.quotenet.com/bond/chart/XS1076957700

In order to test two CoCo pricing models, we use 19th June 2015 as a pricing date for this issue. This data correspond with a full year of market history of this issue. Summarizing fundamental information on this bond issue on pricing date, we prepare input data, presented in Table 2.

Table 2: Instrument data of Credit Suisse Group AG, as of 19th June 2015

| **Market data (Bond)** | | |
|---|---|---|
| Coupon | 6.25% | |
| Maturity | 18-Dec-24 | 9.51 (yr) |
| Issue Date | 18-Jun-14 | |
| Pricing Date | 19-Jun-15 | |
| Settle Date | 24-Jun-15 | |
| Face Value | 1000 USD | |
| Bond Price | 100.00% | |
| Accrued | 0.10% | |
| Bond Price (Dirty) | 100.10% | |
| Z Spread | 367.22 | bps |
| Asset Swap Spread | 354.42 | bps |

| | | |
|---|---|---|
| Conversion Price | | |
| Conversion Ratio | | |
| Issue Size | 2,500,000,000 | |
| Currency | USD | |
| Coupon (paid semiannually each 18th June and 18th December until 2014) | 3.25 | |

Source: http://www.allonhybrids.com

**4. Methodology**

In this Section we provide analytical framework for two selected pricing models employed in this research. The process of how to price a CoCo using the equity derivative model we present according to Wilhels and Bethe (2014), and credit derivative approach according to De Spiegeleer and Schoutens (2014).

***4.1 Equity Derivatives Model (EDM)***

The pricing formula consists of three components:

$$PV = A + B + C$$

Where $A$ represents a straight bond with time to maturity $t_T$, $B$ represents a knock-in forward struck at conversion price $C_p$, and $C$ represents a strip of binary down-and-in options, each with time to maturity $t_i \leq t_T$. Within a Black–Scholes framework, the components of Equation A7 (for barrier option pricing formulas, see Haug 2007, 152) are given by

$$A = N\,exp(-rt_T) + \sum_i c_i exp(-rt_i)$$

$$B = C_r S exp(qt_T)\left[\left(\frac{S^*}{S}\right)^{2\beta} N(w) + N(-u)\right] - C_r C_p exp(-rt_T)\left[\left(\frac{S^*}{S}\right)^{2\beta-2} N\left(w - v\sqrt{t_T}\right) + N\left(-u + v\sqrt{t_T}\right)\right]$$

$$C = -\sum_i c_i exp(-rt_i)\left[\left(\frac{S^*}{S}\right)^{2\beta} N(w) + N(-u)\right] - C_r C_p exp(-rt_T)\left[\left(\frac{S^*}{S}\right)^{2\beta-2} N\left(w - v\sqrt{t_T}\right) + N\left(-u + v\sqrt{t_T}\right)\right]$$

Where auxiliary variables are defined as:

$$\beta = \frac{r - q + v^2/2}{v^2}$$

$$u = \frac{\ln(\frac{S}{S^*})}{v\sqrt{t_T}} + \beta v\sqrt{t_T} \quad \text{and} \quad u_i = \frac{\ln(\frac{S}{S^*})}{v\sqrt{t_i}} + \beta v\sqrt{t_i}$$

$$w = \frac{\ln(\frac{S^*}{S})}{v\sqrt{t_T}} + \beta v\sqrt{t_T} \quad \text{and} \quad u_i = \frac{\ln(\frac{S^*}{S})}{v\sqrt{t_i}} + \beta v\sqrt{t_i}$$

Where
$N$ = the CoCo bond's nominal
$c_i$ = the discrete coupon payments (derived from the bond's coupon rate $c$ and coupon frequency $f$)
$S$ = the share price
$q$ = the share's continuously compounded dividend yield
v = the (implied) share price volatility
$r$ = the continuously compounded interest rate (assumed to be flat across the term structure)
$S^*$ = the share price trigger level for the conversion
$Cr = N/C_p$, the conversion ratio.

### *4.2 Credit Derivatives Model (CDM)*

To calculate the CoCo price with the Credit Derivative approach we are going to use following key formula

$$Price = \sum_{i=1}^{T} CF_i e^{(-Y*t_i)}$$

Where $CF_i$ is the cash flow at time $t_i$, Y the yield and T the maturity time. This equation is the formula for pricing a normal bond. A normal bond is priced by calculating the present value of all the cash flows that the bond holder will get until the bond matures. We can use this formula for calculating the price of a CoCo too since a CoCo is just like a normal bond if it does not trigger during its maturity (Hull 2012, p80).

To get the price we need to determine the yield, $Y_{CoCo}$ by adding the risk free rate, r and the CoCo credit spread. $S_{CoCo}(T)$. To do this we will use following formula

$$Y_{CoCo} = r + S_{CoCo}(T)$$

The CoCo credit spread can be calculated using following

$$S_{CoCo}(T) = (1 - R_{CoCo}) \times \lambda_{CoCo}$$

Secondly, to be able to calculate the $\lambda_{CoCo}$, we need to determine the probability of conversion up to time T which is defined as $p^*(T)$.

It is problematic to determine the probability of conversion for a CoCo with an accounting trigger and a regulatory trigger. Hence, it is difficult to model the behavior of the governmental authority and the movement of an accounting ratio. However, for a CoCo characterized by a market trigger the value of p*(T) can be easier to determine.

By assuming that the share price follows a continuous time stochastic process, so-called a geometric Brownian motion (GBM) we can calculate p*(T) by using the Black-Scholes formula for barrier option pricing.

In the Black-Scholes model the log-price of the stock is following a standard normal distribution. Furthermore, in the Black-Scholes model, the probability p*(T) that a stock price hits the barrier level S* before time T, is given by

$$p^* = N\left(\frac{\log\left(\frac{S^*}{S}\right) - \mu T}{\sigma\sqrt{T}}\right) + \left(\frac{S^*}{S}\right)^{\frac{2\mu}{\sigma^2}} \mathrm{N}\left(\frac{\log\left(\frac{S^*}{S}\right) + \mu T}{\sigma\sqrt{T}}\right)$$

Where $S_0$ is the share price at the issue date, σ is the volatility of the stock price, and μ is given by

$$\mu = r - q - \frac{\sigma^2}{2}$$

Where $q$ is the continuous dividend yield.

Further, $\lambda_{CoCo}$ can is calibrated and the probability of conversion for a CDS CoCo is calculated. Hence,

$$p^*(T) = 1 - e^{(-\lambda_{CoCo}T)}$$

By solving the equation for $\lambda_{CoCo}$ we get

$$\lambda_{CoCo} = -\frac{\ln\left(1 - p^*(T)\right)}{T}$$

and $\lambda_{CoCo}$ tell us at which default intensity grade the CoCo would trigger.

Further, we need to calculate the recovery rate, $R_{CoCo}$. Now when the values for $\lambda_{CoCo}$ and for $R_{CoCo}$ are computed, the next step is to calculate the credit spread by using Equation (12) for $S_{CoCo}(T)$. With the CoCo credit spread we are able to compute the yield to maturity, $Y_{CoCo}$ , using Equation (14). Furthermore, the cash flow is the only missing variable in order to be able to calculate the price of a CoCo bond. The total cash flow is the sum of all the cash flows that are going to be made in the future until the CoCo matures. The price of the CoCo is computed by adding the present values of the cash flows,i.e. in the same way the value of a bond is calculated. The cash flows are the same from $t_0$ to $t-1$, namely the face value $F$ multiplied with the coupon rate $c$. The last cash flow at time $t$ consists of the face value multiplied with the coupon rate, plus the face value of the CoCo. Thus, if $CF_i$ is the cash flow at time $t_i$ then the present value $PV(CF_i)$ is given by

$$PV(CF_i) = CF_i e^{(-Y*t_i)}$$

where $Y$ is the yield that defines the interest rate that makes the total discounted cash flows to reflect the market value of the CoCo today.

**5. Empirical results**

Based on the projections of fundamental (Table 1), and market data (Table 2), two contingent convertible bond pricing models have been elaborated and analysed below.

The market data used for employment of selected pricing models are as follows:

Table 3: Market data of Credit Suisse Group AG, as of 19th June 2015, at 9:52 AM

| | | |
|---|---|---|
| Dividend Yield | 2.00% | |
| Volatility | 41.76% | |
| Interest Rate | 2.40 | A/365 |
| Spot Price | 25.4800 | |
| CDS Spread | 119 | A/360 |
| Recovery (CDS) | 40.00% | |
| FX (CHFUSD) | 1.08 | |

Source: http://www.allonhybrids.com

Table 4 summarizes the outcomes of two CoCo pricing models: credit derivative model (CDM), and equity derivative mode (EDM). Comparing them allows commenting and concluding on differences in choosing possible evaluating tools such as CDM and EDM.

Table 4: Comparative data on CDM and EDM

| | Credit Derivatives (Rule of Thumb) | Equity Derivatives |
|---|---|---|
| Implied Trigger (Interpolated) | 3.56 | 3.86 |
| Conversion Price | 9999999.00 | 9999999.00 |
| CoCo Spread (CDS) | 406 | 406 |
| CoCo Spread (Z) | 433 | 433 |
| CoCo Model Price (%) | 95.63 | 95.63 |
| CoCo Model Price (Dirty %) | 95.73 | 95.73 |
| Recovery | 0.00 | 0.00% |

General characteristics of this issue could be summarized as follows: (1) this issue has perpetual maturity, (2) has BB rating rated by Standard&Poor's, (3) has a AT1 capital position according to Basel III capital requirements, (4) has mechanical capital trigger, and (5) loss absorption mechanism is permanent principal write-down.

In this case permanent CoCo's principal write-down is done because issuer wanted under no circumstances to further dilute the strategic shareholders of the bank and jeopardize their majority. The CoCo bond has a full write-down scenario in case the CET1 trigger is hit. Contingent convertibles can only belong to the Additional Tier 1 category if they have no set maturity date and have cancellable coupons.

According to pricing models employed, implied trigger (interpolated) for CDM is 3.56 (14% of share price 25.48, as of 19th June 2015), while for EDM is 3.86 (15.1% of share price), comparing to the CET1 trigger level 5.125. As we can conclude, both models gave roughly the same results. Still, comparing the models, we can state that EDM approach is more accurate as it assumes more realistic treatment of cash flow (it breaks down a CoCo bond into different derivative instruments: bond, forward and options). In that manner, the process of CoCo can be replicated, and applying these instruments, the payoff structure of CoCo can be approximated and analyzed. On the other side, CDM moves away from the underlying stock and focuses on the similarities with bonds, even though stock price is the main driver for coco valuation.

Nevertheless, the main critiques underlying the Black-Scholes methodology is found in its assumptions: log returns of assets are independent and identically normally distributed. Considering volatility of prices on financial markets, it is practically impossible to apply this simplistic assumption in analysis of financial instruments (Michael A. et al., 2008). Additionally, the constant volatility assumption of the Black-Scholes model is empirically unreasonable, because of the stock returns fat-tail distribution. Even though volatility in Black-Scholes could be set to high levels, it cannot asses prices process properly. As Michael A. et al. (2008) state, there is a reasonable risk of well know jump *effect* in share prices, during stock trading near the trigger level. Finally, in EDM and CDM conversion trigger is defined as accounting based capital measure, while regulatory and discretionary triggers and not included in the model.

## 5. Concluding remarks

This paper provides a description of Contingent Convertible bonds (CoCos),that convert to equity during financial turmoil. Main characteristic of this credit derivative instrument is transfer of responsibility for bearing the costs of poor bank's performance from the taxpayers to the bondholders. The main features of CoCos are trigger points and mechanisms of loss absorption. In our analysis CoCo has high trigger point mechanism, and as loss absorption it has permanent principal write-down.

The analytical models for CoCo pricing depends on many different input variables that in the end affect the CoCo price. Our results show that both models, EDM and CDM, which are formulated based on Black-Scholes methodology, give approximately the same results considering implied trigger of CoCo bond issued by Credit Suisse Group AG. According to its mathematical specification, EDM performs better, as it assumes more realistic treatment of cash flow. Nevertheless, because of Black-Scholes methodology simplified assumptions, the analysis of contingent convertibles must comprise of more complex models, which will represent the extension of existing ones. Therefore, the future research should focus on creation and appliance of more unified, simulation based model in pricing of CoCo, which will be feasible with availability of long term data series (CoCo bonds being a relatively new hybrid instrument introduced in 2009).

This paper contributes to academic literature on complex convertible financial instrument such as CoCo by employing empirical approach to selected pricing models. Although some academics and practitioners address many criticisms against CoCos, it is evident that CoCos record high volume of issuance and attract lot of professional attention.

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