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Pricing and Hedging Mandatory Convertible Bonds

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Working Paper Series in Finance

Paper No. 16

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www.finance.unisg.ch **January 2006**

Published in the Journal of Derivatives 13(3), 2006, 30-46.

Pricing and Hedging
Mandatory Convertible Bonds

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December 2004 (revised January 2006)

Abstract

This article examines the pricing and hedging of mandatory convertible bonds on the US market using daily market prices for a period of 498 trading days resulting in a sample of over 14,600 daily price observations. We explore the pricing and hedging performance based on a simple contingent claims model. On average, the pricing errors are lower than those found for standard convertible bonds. An analysis of the hedging performance of the model indicates that the model is useful for hedging as, on average, the hedging errors observed are relatively small and mostly unsystematic.

Keywords: mandatory convertibles, hybrid securities, convertible bonds
JEL classification: G12, G13, G15

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Published in the Journal of Derivatives 13(3), 2006, 30-46.

1 Introduction

We study the pricing and hedging of mandatory convertible bonds on the secondary market. So far, no such investigation has been conducted. The pricing of 40 mandatory convertibles is analyzed between May 2002 and April 2004 with a total of 498 trading days yielding a sample of 14,612 daily price observations. These securities were issued in the United States between October 2000 and July 2003 and mature between May 2004 and November 2006. We examine the US market for mandatory convertibles because of the availability of accurate daily market prices, its large size compared to other markets and the liquidity of many of its issues.

Mandatory convertibles are equity-linked hybrid securities and can be thought of as yield-enhanced equity. Mandatory convertibles pay higher dividends than common stock for a number of years and then mandatorily convert to common stock on a pre-specified date. These securities are the most equity-like of all convertible securities and, unlike normal convertibles, they provide little downside protection because mandatory convertibles usually have no fixed terminal value. Instead, the security will mandatorily convert into a variable number of shares at maturity. Mandatory convertibles have become popular in recent times: Chemmanur and Nandy [2003] report about $20 billion issued in 2001 implying a market share of approximately 18% of the convertible bond market.

Despite the large size of international and especially US mandatory convertible markets, very little research on the pricing of mandatory convertibles has been undertaken. Previous work includes Arzac [1997], who discusses the rationale for mandatory convertibles from

Published in the Journal of Derivatives 13(3), 2006, 30-46.

the point of view of issuers as well as investors. He notes that mandatory convertibles allow highly leveraged (or temporarily troubled) companies to restructure their balance sheet by helping to control for the "asymmetric information" problem. Furthermore, he describes the main features and a straightforward valuation method. Chen at al. [1999] provide an analysis of one (Masco Tech) mandatory convertible for a time period of one year. They use the same valuation method as Arzac [1997] and show that mandatory convertibles are not very sensitive to changes in volatility, risk-free interest rate, and credit spread.

There are also a few articles dealing with the rationale of and the stock market reactions to issuing mandatory convertibles: Huckins [1999] investigates the characteristics of firms issuing such bonds and the announcement effect on stock prices. She finds that companies that issue mandatory convertibles tend to be highly leveraged. She also finds a neutral response of the stock market to announcements and issues of mandatory convertibles and attributes this effect to the mitigation of adverse selection costs compared to equity issues. Chemmanur and Nandy [2003] provide a theoretical model explaining the announcement effect. Furthermore, they also show that, in equilibrium, the company issues straight debt, ordinary convertibles, or equity if the extent of asymmetric information is large, but the probability of being in financial distress is relatively small. It issues mandatory convertibles if the problem of asymmetric information is small but the probability of financial distress is high. Hegde and Krishnan [2003] test predictions of agency and asymmetric information theories to explain why some firms prefer to use mandatory convertibles as opposed to ordinary convertible securities. They find that the stock market

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reacts less negatively to a mandatory convertible issue than to an ordinary convertible issue.

The paper is organized as follows: In Section 2, we describe the structure and characteristics of a typical mandatory convertible and describe the pricing model. Section 3 gives an overview of the data set and the methodology for the empirical analysis. The empirical results of the pricing study are reported in Section 4. Section 5 examines the hedging performance and Section 6 concludes.

2 Pricing Model

2.1 Description of Mandatory Convertible Bonds

In our study, we analyze the most common mandatory convertible bond structure. Mandatories pay a coupon, are subject to the full downside risk of the stock, and participate (partially) in the upside potential of the stock. Typically, there is a flat payoff zone between a lower strike price and an upper strike price, where the payoff at maturity is fixed. These securities, referred to by various acronyms such as PIES, DECS, ACES, PRIDES, etc., therefore have characteristics of both common and preferred stock. For simplicity, we call the payoff structure described in this section simply "mandatory convertible" and use this term interchangeably with the acronyms given to these securities by the issuing investment banks.

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Typically, a mandatory convertible pays a coupon in percent of the par value that is 5 to 7 percentage points higher than the underlying common stock's dividend yield. The annual coupon is usually paid quarterly. The securities are usually issued with a maturity of 3 to 5 years. At maturity, they are mandatorily converted into common stock. Often, they are call-protected for most or all of their life. A unique characteristic of mandatory convertibles is that the conversion ratio depends on the price of the underlying stock. The payoff (V_T) at maturity (T) is given by:

$$V_T = \begin{cases} S_T \cdot R_U & \text{if } S_T \geq X_U \\ S_T \cdot R_B = P & \text{if } X_L < S_T < X_U \\ S_T \cdot R_L & \text{if } S_T \leq X_L \end{cases} . \tag{1}$$

At maturity, if the stock price has fallen below a lower strike price (X_L), investors usually receive a fixed lower ratio (R_L) of shares. If the stock price is between a lower (X_L) and an upper strike price (X_U), then investors receive stock worth as much as the par value (P), i.e., the stock price (S_T) is multiplied by the variable ratio (R_B) between the lower and the upper strike price. This variable ratio (R_B) is determined by dividing the par value (P) by the stock price at expiration (S_T). If the stock price is above the upper strike (X_U), the investor receives a fixed upper ratio (R_U) of shares. Exhibit 1 illustrates the payoff profile of a mandatory convertible at maturity.

[Exhibit 1]

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Note that the lower strike price multiplied by the lower ratio is equal to the upper strike price multiplied by the upper ratio and both are equal to the par value (*P*) of the mandatory convertible ($X_L \cdot R_L = X_U \cdot R_U = P$). The conversion ratio at the lower strike price is always higher than the ratio at the upper strike price. Therefore, if the stock increases from the lower strike price, an investor's participation is delayed until the upper strike price is reached. Above the upper strike price, the investor participates at a reduced rate equal to the upper conversion ratio, which is less than 1 (the reverse is true for $S_T < X_L$).

2.2 The Pricing Model

Arzac [1997] presents a simple valuation method, decomposing the securities into three basic components that are each readily valued individually: (1) the current value of the underlying common stock; (2) the fixed-income cash flow (present value of the coupon payments minus the present value of the dividend payments of the common stock); and (3) the stock options embedded in the security (R_U calls with strike price X_U minus R_L calls with strike price X_L). Chen at al. [1999] use the same valuation method as Arzac [1997].[1] Alternatively, the following equivalent decomposition can also be used: (1) a fixed income component with principle *P* paying the coupons *I*; (2) minus R_L puts with strike price X_L; (3) plus R_U calls with strike price X_U. For our analysis we use the second decomposition[2].

The fair value or the (theoretical) model price of the mandatory convertible is the price at which it could be replicated theoretically. In the secondary market, the fair value of the mandatory convertible at time *t* (V_t) consists of the following components[3]:

+ value of a call with upper strike price multiplied by the upper ratio ($c_{t,U} \cdot R_U$),

− value of a put with lower strike price multiplied by the lower ratio ($p_{t,L} \cdot R_L$),

+ present value of the (risk-free) par value[4] ($PV_t(P)$),

+ present value of the (risky) coupon payments ($PV_t(I)$).

Therefore, on valuation date *t*, the mandatory convertible has a value of

$$V_t = c_{t,U} \cdot R_U - p_{t,L} \cdot R_L + PV_t(P) + PV_t(I) \qquad (2)$$

The present value of the (riskless) par value is defined as

$$PV_t(P) = P \cdot e^{-(r_{t,\Delta T}) \cdot \Delta T} . \qquad (3)$$

and the present value of the (risky) coupon payment is defined as

$$PV_t(I) = \sum_{j=1}^{m} I \cdot e^{-(r_{t,t_j-t} + cs_t) \cdot (t_j - t)} . \qquad (4)$$

The notation is as follows:

P = par value of the mandatory convertible
t = time of valuation
T = maturity of the mandatory convertible
$\Delta T = T-t$ = the time in years until maturity of the mandatory convertible
V_t = value of the mandatory convertible at time t
R_U = upper ratio

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R_L = lower ratio

$c_{t,U}$ = price of a European call option with strike price X_U at time t

$p_{t,L}$ = price of a European put option with strike price X_L at time t

$PV_t(I)$ = present value of coupon payment of the mandatory convertible at time t

$PV_t(P)$ = present value of par value at time t

I = coupon for a given bond

t_j = date of the j-th coupon payment, $j = 1,2, \ldots, m$ with $t \leq t_j \leq T$

r_{t,t_j-t} = continuously compounded riskless interest rate at time t for the period $t_j - t$

$r_{t,\Delta T}$ = continuously compounded riskless interest rate at time t for the period ΔT

cs_t = credit spread of the mandatory convertible at time t

The Black and Scholes [1973] and Merton [1973] model can be applied to these options only if it can be assured that early exercise is never optimal. Otherwise, numerical techniques such as binomial trees would have to be used. However, if the coupon payments exceed the (expected) dividend payments (this is the case in our sample) on the common stock, then early exercise is never optimal. It is therefore viable to use the Black-Scholes-Merton option pricing formula for European options on shares paying a known dividend yield. The dividend yield at time t is expressed as a continuously compounded annual rate q_t. The value for a call $c_{t,k}$ and a put $p_{t,k}$ at time t for an option with strike price X_k is given by:

$$c_{t,k} = S_t \cdot e^{-q_t \cdot \Delta T} \cdot \phi(d) - X_k \cdot e^{-r_{t,\Delta T} \cdot \Delta T} \cdot \phi(d - \sigma_t \cdot \sqrt{\Delta T}) \qquad (5)$$

$$p_{t,k} = X_k \cdot e^{-r_{t,\Delta T} \cdot \Delta T} \cdot \phi(-d + \sigma_t \cdot \sqrt{\Delta T}) - S_t \cdot e^{-q_t \cdot \Delta T} \cdot \phi(-d)$$

with $d = \{\ln(\frac{S_t}{X_k}) + (r_{t,\Delta T} - q_t + \frac{\sigma_t^2}{2}) \cdot \Delta T\} / \sigma_t \cdot \sqrt{\Delta T}$,

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where S_t is the market price of the underlying asset at time t, q_t the continuously compounded annual dividend yield at time t, σ_t the volatility for the underlying asset at time t, and $\phi(.)$ is the standard normal cumulative distribution function.

In our model, mandatory convertible prices depend on several parameters, namely credit spreads, stock price volatilities, risk-free interest rates and dividend yields. The price impact of those parameters varies greatly. Because mandatory convertibles are essentially yield-enhanced common stock, they are very sensitive to a change in the underlying stock (see Section 5 for an analysis of the hedging performance). Dividend estimations can be critical, because future dividends of the underlying stock are uncertain and the coupon payments of the mandatory convertible are fixed. Due to the offsetting nature of the embedded option spread, a change in volatility has only a minor effect on the mandatory convertible value (see Section 4 for a detailed analysis). Therefore, the impact of the volatility model on model prices is limited. A change in credit spread affects only the present value of the coupon payments and therefore also has a limited impact on prices. Finally, because mandatory convertibles are akin to stock rather than debt, they are not very sensitive to changes in interest rates.

3 Data Set and Methodology

Mandatory convertible bonds are not always issued by corporate debtors. There are also "synthetic" bonds created by investment banks in response to investor demand without the corporate's involvement. In those cases, the counterparty is the bank, not the corporate

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debtor. In this study, however, the counterparties of all mandatory convertibles analyzed are corporate debtors.

Our sample covers 46 mandatory convertible bonds. We exclude 4 callable[5] securities and 2 bonds where companies have repurchased a large fraction of the outstanding securities. Therefore, we examine market prices of 40 US mandatory convertibles from May 28, 2002 to April 22, 2004 (representing 498 trading days) issued in the US between October 2000 and July 2003 and maturing between May 2004 and November 2006. The sample contains 14,612 data points. Mandatory convertible prices and stock prices were provided by Reuters and Datastream, respectively. For the riskless interest rate, we use the interpolated US zero curve yield calculated from swap rates for the respective maturity, provided by Datastream. Apart from directly observable input parameters, such as stock prices, prices of mandatory convertibles and interest rates, the pricing model requires input parameters that have to be estimated and thus are a source of estimation error. These variables include dividend yields, credit spreads and volatilities. Information on current dividend yields at time *t* of the underlying common stock was provided by Datastream. For an appropriate default-adjusted interest rate ($r_{t,\Delta t} + cs_t$), we use the credit ratings provided by Moody's and use the respective Moody's median bond spread data that provide average credit spreads (cs_t) for time *t*. Although a change in credit spreads can often have significant effects on the pricing of traditional convertible bonds, its impact here is limited because credit spreads affect only the present value of the coupon payments.

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