Leverage Certificates – A Case of Innovative Financial Engineering

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Abstract

In this paper we introduce a new financial product named Leverage Certificates and provide detailed descriptions of the product specifications. In the paper we show that the payoff of a Leverage Certificate can be duplicated by the combination of a long position in a zero coupon bond, a short position in put options on an equity or an equity index (the underlying asset), a long position in up-and-out call options on the underlying asset, and a long position in cash-or-nothing up-and-in options. A pricing formula is developed to price the certificates. A certificate issued by Credit Suisse First Boston is presented as an example to examine how well the model fits empirical data. The results show that issuing Leverage Certificates is a profitable business and the results are in line with previous studies pricing other structured products. Moreover, the question of whether structured products with exotic options are mispriced more than structured products with plain vanilla options is tested. The result shows no statistically significant difference in the average mispricing. However, the profits for issuing certificates with exotic embedded options are lower than certificates with plain vanilla embedded options when controlling for the traditional inputs in option pricing using regression analysis.

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1. Introduction

Modern structured financial products -- i.e. newly created securities that combine fixed income securities, equities, and derivative securities – have been growing explosively in volume and complexity during the last two decades (Das, 2001; Hernandez et al., 2010; Hernandez et al., 2012). The complexity can be attributed, in part, to the incorporation of "*exotic*" derivatives in the design of the securities, including barrier options such as knock-in, knock-out, cash-or-nothing, and asset-or-nothing puts and calls. The complexity of the new products has also raised concerns, expressed publicly by regulators, about the ability for the average retail investor to understand them (Ricks, 1988; Lyon, 2005; NASD, 2005; Laise, 2006; Maxey, 2006; Simmons, 2006; Isakov, 2007).

Several studies in the literature emphasize this new trend of more complex securities. For example in Hernandez et al. (2008), the authors analyze the Bonus Certificates €123 billion market by examining a sample of 5,560 issues outstanding in August 2005 issued by banks in Europe. Bonus Certificates could be considered a second generation of Outperformance Certificates *"upgraded"* with barrier options.[1]

In Hernandez et al. (2010), the authors analyze the US dollar-denominated Reverse Exchangeable Bond $45 billion market by making a detailed survey of 7,426 issues of bonds issued between May 1998 and February 2007. The authors report an impressive growth in the Reverse Exchangeable Bond market in the period studied, 66% average growth rate per year. In addition, they show that the composition of the bond types also migrates over time from bonds featured with plain vanilla options to bonds characterized with exotic options. For instance, the

[1] For more details on Outperformance Certificates see Hernandez et al. (2012).

percentage of bonds with plain vanilla options decreases from 90% of the total market in 1999 to less than 20% in 2006. On the other hand, the percentage of bonds with barrier options increases from 10% of the total market to 80% of the total market during the same period.

One of the particularly interesting structured products recently created by investment banks is known as the Leverage Certificates (to be referred to as LC henceforth). The LC can be considered a “hybrid” certificate, under certain circumstances, it behaves as an Outperformance Certificate but in others, it behaves as a Reverse Exchangeable Bond.

The rate of return on the investment in the certificates is contingent upon the performance of a pre-determined underlying asset over a pre-specified period (known as observation period). As long as the underlying asset price has never reached a predetermined level (which is usually set above the initial price of the underlying asset and referred to as the knock-out level) during the observation period, the certificates behave as an Outperformance Certificate. Thus, if the price of the underlying asset goes up during the observation period (Scenario 1), the investors of the certificates will receive a return equal to twice the return on the underlying asset. However, if the price of the underlying asset goes down during the observation period (Scenario 2), the investors of the certificates will receive the same return as the underlying asset. See Hernandez et al. (2012) for more in-depth analysis of Outperformance Certificates.

On the other hand, if the underlying asset price ever reaches the knock-out level during the observation period, the certificates behave as a Reverse Exchangeable Bond. Thus, if the price of the underlying asset goes up during the observation period (Scenario 3), the investors of the certificates will receive the nominal amount of the certificate plus a rebate. However, if the price of the underlying asset goes down during the observation period (Scenario 4), the investors of the certificates will receive the same return as the underlying asset plus a rebate.

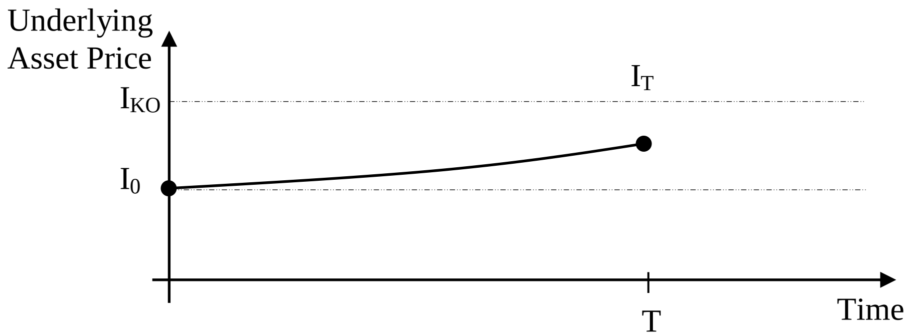

Figure 1: Repayment Scenario 1

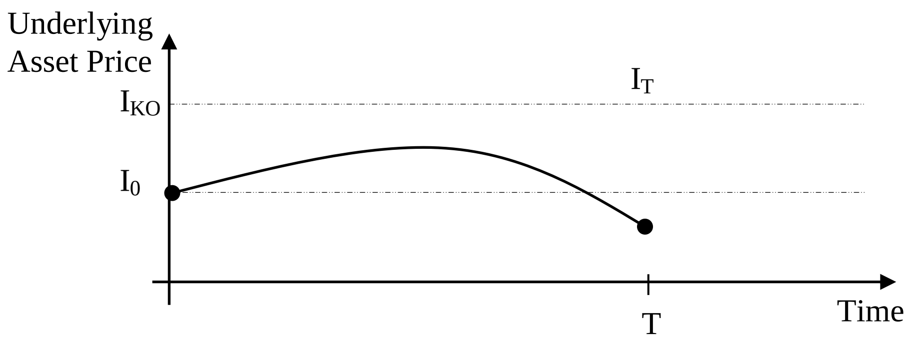

Figure 2: Repayment Scenario 2

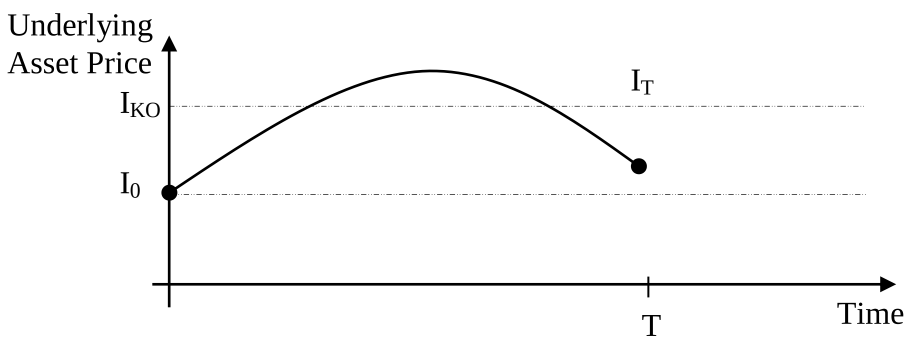

Figure 3: Repayment Scenario 3

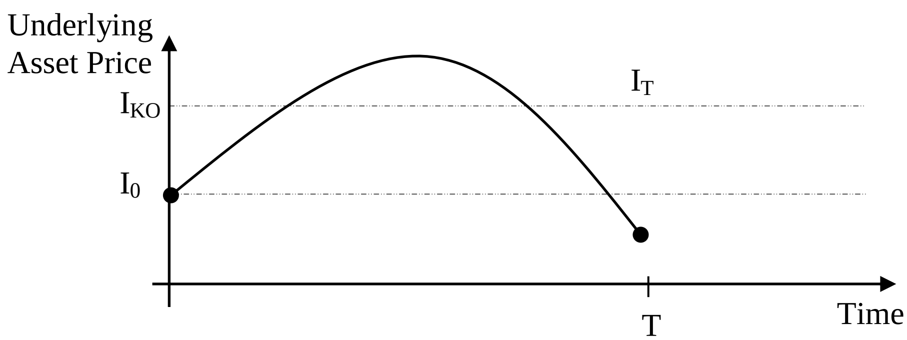

Figure 4: Repayment Scenario 4

In calculating the return on the underlying asset, the certificate issuers use only the change in the asset price; the cash dividends paid during the period are not included. In other words, investors in the LC do not receive cash dividends even though the underlying assets pay dividends during the term to maturity. Appendix 1 is an example of a Leverage Certificate.

The purpose of the paper is to extend Hernandez et al. (2010) and Hernandez et al. (2012) to Leverage Certificates and provide an in-depth economic analysis for the certificates to explore how the principles of financial engineering are applied to the creation of new structured products. A pricing model for the certificates is developed by using option pricing formulas. In addition, an example of a LC issued on June 14, 2004 by CSFB Credit Suisse First Boston (to be referred to as CSFB henceforth), a well-recognized large bank in Europe, is presented. In this example, the certificate is priced by calculating the cost of a portfolio with a payoff similar to the payoff of the certificate. Whether issuers of Leverage Certificates earn a profit in the primary market and whether certificates with "exotic" options (e.g. Bonus Certificates, Barrier Reverse Exchangeable Bonds, Phönix Certificates, Leverage Certificates, etc.) are more profitable than certificates with "plain vanilla" options (e.g. Outperformance Certificates, Plain Vanilla Reverse Exchangeable Bonds, Protect Certificates, etc.) are two questions answered in the paper.

The rest of the paper is organized as follows: The design of the certificates is introduced in Section 2. The pricing model is developed in Section 3. In Section 4, an example of LC is presented, the profit for issuing the certificate is calculated using the model developed in Section 3, and the question of whether structured products with exotic options are mispriced more than structured products with plain vanilla options is tested. In Section 5 presents the conclusions.

2. Description of the product

The rate of return of a certificate is contingent upon the price performance of its underlying asset during the observation period. The beginning date of the observation period is known as the initial fixing date and the ending date of the period is known as the final fixing date. The price of the underlying asset on the initial fixing date is referred to as the initial fixing level, and the price of the underlying asset on the expiration date is referred to as the final fixing level. If we define I_0 as the initial fixing level, I_{KO} as the knock-out level, and I_T as the final fixing level, then for an initial investment in one certificate with nominal amount of \$1,000, the total value that an investor will receive on the redemption date (known as the redemption value or settlement amount), V_T, is equal to:

$$V_T = \$1,000 \begin{cases} & \text{if all } I_t < I_{KO},\ t \in [0;T] \\ 1 + 2\left(\dfrac{I_T}{I_0} - 1\right) & \text{and } I_T > I_0 \\ \dfrac{I_T}{I_0} & \text{and } I_T \le I_0 \\ & \text{if some } I_t \ge I_{KO},\ t \in [0;T] \\ 1 + \dfrac{60}{1,000} & \text{and } I_T > I_0 \\ \dfrac{I_T}{I_0} + \dfrac{60}{1,000} & \text{and } I_T \le I_0 \end{cases} \quad \ldots(1)$$

Alternatively, the relationship between the terminal value of a certificate and the terminal value of the underlying asset based on the change in the underlying asset price (without taking into account dividends) with a knock-out level at 140% of the initial fixing level and a participation rate of 200% can be represented in Figure 4. The dashed line represents the terminal value of the certificate on maturity day T, as a function of the terminal value of the underlying asset when the knock-out level was never broken during the observation period. The solid line represents the terminal value of the certificate on maturity day T, as a function of the terminal value of the underlying asset when the knock-out level was broken during the observation period. The dotted line represents the terminal value of the underlying asset. The slope for the value of the underlying asset (dotted line) in Figure 4 is, of course, one. The slope for the value of the certificate, when the price of the underlying asset goes up and the knock-out level was never broken over the term to maturity (solid line), is equal to two.

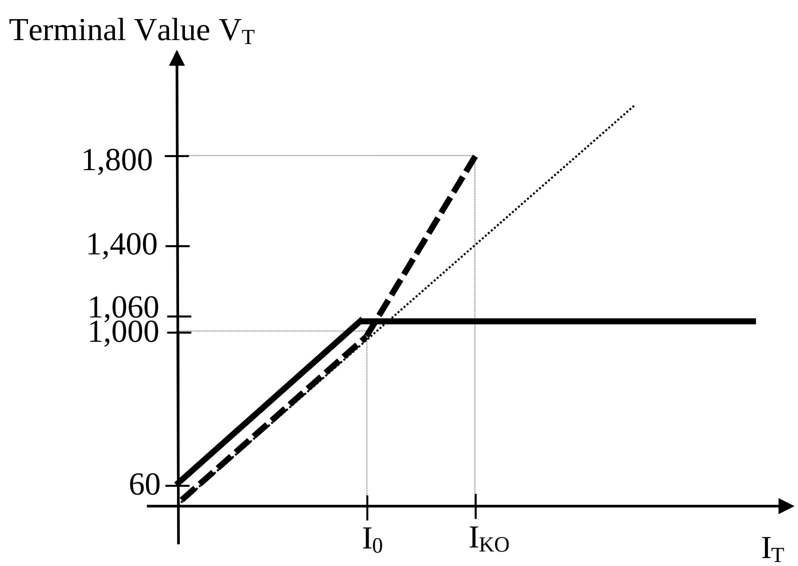

Figure 5: The terminal value of an investment in one Leverage Certificate as a function of underlying asset price I_T, with a knock-out level at 140% of the initial fixing level and participation rate of 200%.

3. The pricing of Leverage Certificates

The terminal value from Equation (1), V_T, for an initial investment in one LC with knock-out level I_{KO}, and term to maturity T, when the underlying asset price has never reached the knock-out level during the observation period, can be expressed mathematically as:

$$V_T = \$1{,}000 \begin{cases} 1 + 2\left(\dfrac{I_T}{I_0} - 1\right) & \text{if } I_T > I_0 \\ \dfrac{I_T}{I_0} & \text{if } I_T \le I_0 \end{cases}$$

$$= \frac{\$\ 1{,}000}{I_0}\begin{cases} I_0 + \ 2\left(I_T - I_0\right) & \text{if } I_T > I_0 \\ I_T & \text{if } I_T \le I_0 \end{cases}$$

$$= \frac{\$\ 1{,}000}{I_0}\begin{cases} I_T + \ \left(I_T - I_0\right) & \text{if } I_T > I_0 \\ I_T & \text{if } I_T \le I_0 \end{cases}$$

$$= \frac{\$\ 1{,}000}{I_0}\left(I_T + \begin{cases} \left(I_T - I_0\right) & \text{if } I_T > I_0 \\ 0 & \text{if } I_T \le I_0 \end{cases} \right)$$

$$= \frac{\$\ 1{,}000}{I_0}\left[I_T + \max\left(0; I_T - I_0\right)\right] \qquad \ldots(2)$$

And, the terminal value from Equation (1), V_T, when the underlying asset price has reached the knock-out level during the observation period can be expressed mathematically as:

$$V_T = \$\ 1{,}000\begin{cases} 1 + \dfrac{60}{1{,}000} & \text{if } I_T > I_0 \\ \dfrac{I_T}{I_0} + \dfrac{60}{1{,}000} & \text{if } I_T \le I_0 \end{cases}$$

$$= \begin{cases} \$1{,}000 + \$60 & \text{if } I_T > I_0 \\ \$1{,}000\dfrac{I_T}{I_0} + \$60 & \text{if } I_T \le I_0 \end{cases}$$

$$= \$60 + \begin{cases} \$1{,}000 & \text{if } I_T > I_0 \\ \$1{,}000\dfrac{I_T}{I_0} & \text{if } I_T \le I_0 \end{cases}$$

$$= \$60 + \$1{,}000 * \min\left(1; \frac{I_T}{I_0}\right)$$

$$= \$60 + \$1{,}000 * \min\left(0; \frac{I_T}{I_0} - 1\right) + \$1{,}000$$

$$= \$1{,}000 + \frac{\$1{,}000}{I_0} * \min\left(0; I_T - I_0\right) + \$60$$

$$= \$1{,}000 - \frac{\$1{,}000}{I_0} * \max\left(0; I_0 - I_T\right) + \$60 \qquad \ldots(3)$$

The I_T in Equation (2) is the payoff for a long position in the underlying asset. A long position in the underlying asset will generate a payoff I_T on maturity date T plus cash dividends on ex-dividend dates. Since LC do not pay cash dividends, the payoff I_T in Equation (2) can be duplicated by taking a long position in the underlying asset, and a short position on zero coupon bond of which the face values are equal to the amount of dividends and the maturity dates are the ex-dividend dates. The payoff max (0; I_T-I_0) in Equation (2) is the payoff of a long position for a call option on the underlying asset with an exercise price I_0. So the payoff for investing in one LC as presented in Equation (2) (i.e. as long as the underlying asset price has never reached the knock-out level during the observation period) is the same as the combined payoffs of taking the following three positions:[2]

1. Long $\frac{\$1,000}{I_0}$ shares of the underlying asset;

2. A short position in zero coupon bonds. The face values of the bonds are the cash dividends to be paid by $\frac{\$1,000}{I_0}$ shares of the underlying asset and the maturity dates are the ex-dividend dates of cash dividends;

3. Long $\frac{\$1,000}{I_0}$ shares of call options on the underlying asset. The exercise price of the option is I_0, and the term to expiration is T, the same as the term to maturity of the certificate.

The combination of Position 1, a long position in the underlying asset, and Position 2, a short position in zero coupon bonds, can be synthetically replicated by the combination of a long

[2] Same replicating portfolio as in Hernandez et al. (2012) for Outperformance Certificates.

position in a zero coupon bond, a short position in put options and a long position in call options. This relationship can be seen easily from the put-call parity

$$C - P = S - Xe^{-rT} \qquad \ldots(4)$$

$$S = Xe^{-rt} - P + C \qquad \ldots(5)$$

Thus, the payoff for investing in one LC as presented in Equation (2) (i.e. as long as the underlying asset price has never reached the knock-out level during the observation period) is also the same as the combined payoffs of taking the following three positions:

1. Long one zero coupon bond with face value equal to \$1,000;

2. Short $\frac{\$1,000}{I_0}$ shares of put options on the underlying asset. The exercise price of the options is I_0 and the term to expiration of the option is T (which is the term to maturity of the bond).

3. Long $2*\frac{\$1,000}{I_0}$ shares of call options on the underlying asset. The exercise price of the option is I_0, and the term to expiration is T, the same as the term to maturity of the certificate.

The payoff \$1,000 and \$60 in Equation (3) can be duplicated by taking a long position in zero coupon bonds with face value equal to \$1,000 and \$60 respectively, and maturity T. The $\max(0; I_0 - I_T)$ in Equation (3) is the payoff for a long position in a put option on the underlying asset with an exercise price of I_0. So the payoff for investing in one LC as presented in Equation (3) (i.e. when the underlying asset price has reached the knock-out level during the observation period) is the same as the combined payoffs of taking the following three positions: [3]

1. Long one zero coupon bond with face value equal to \$1,000;

[3] Same replicating portfolio can be found in Hernandez et al. (2010) for Reverse Exchangeable Bonds.

2. Short $\frac{\$1{,}000}{I_0}$ shares of put options on the underlying asset. The exercise price of the options is I_0 and the term to expiration of the option is T (which is the term to maturity of the bond).

3. Long one zero coupon bond with face value equal to $60;

The combination of the replicating portfolios for the payoffs presented in Equation (2) (i.e. when the underlying asset price has never reached the knock-out level during the observation period) and Equation (3) (i.e. when the underlying asset price has reached the knock-out level during the observation period) results in the replicating portfolio for the payoff for investing in one LC and such payoff is the same as the combined payoff of taking the following five positions:

1. Long one zero coupon bond with face value equal to $1,000;

2. Short $\frac{\$1{,}000}{I_0}$ shares of put options on the underlying asset. The exercise price of the options is I_0 and the term to expiration of the option is T (which is the term to maturity of the certificate).

3. Long 2* $\frac{\$1{,}000}{I_0}$ shares of call options on the underlying asset. The exercise price of the option is I_0, and the term to expiration is T, the same as the term to maturity of the certificate.

4. Short 2* $\frac{\$1{,}000}{I_0}$ shares of up-and-in call options on the underlying asset. The exercise price of the options is I_0, the barrier is I_{KO}, and the term to expiration of the option is T, the same as the term to maturity of the certificate.

5. Long 60 up-and-in cash-or-nothing options. The barrier of the option is I_{KO} and the term to expiration of the option is T, the same as the term to maturity of the certificate.

Position 4 exists if the price of the underlying asset has ever reached the knock-out level during the observation period (i.e. up-and-in call options). Position 5, the $60 cash rebate, exists if the price of the underlying asset has ever reached the knock-out level during the observation period (i.e. up-and-in cash-or-nothing options). Based on the In-Out Parity (Hull; 2003), the value of a regular call equals the value of an up-and-out call, C_{uo}, plus the value of an up-and-in call, C_{uo}.

$$C = C_{uo} + C_{ui} \qquad \ldots(6)$$

Solving for C_{uo},

$$C_{uo} = C - C_{ui} \qquad \ldots(7)$$

Position 3 and Position 4 combined is equal to 2*$1,000/$I_0$ shares in up-and-out call options on the underlying asset. So, the portfolio of securities with the same payoff as the payoff of a LC can be simplified to four positions:

1. Long one zero coupon bond with face value equal to $1,000;

2. Short $\frac{\$1{,}000}{I_0}$ shares of put options on the underlying asset. The exercise price of the options is I_0 and the term to expiration of the option is T (which is the term to maturity of the bond).

3. Long 2* $\frac{\$1{,}000}{I_0}$ shares of up-and-out call options on the underlying asset. The exercise price of the option is I_0, the barrier is I_{KO}, and the term to expiration is T, the same as the term to maturity of the certificate.

4. Long 60 up-and-in cash-or-nothing options. The barrier of the option is I_{KO} and the term to expiration of the option is T, the same as the term to maturity of the certificate.

Since the payoff of LC is the same as the combined payoffs of the above four positions, the fair value of the certificate can be calculated based on the value of the four positions. Any selling price of the certificate above the value of the above four positions is the gain to the certificate issuer. The value of Position 1 is the price of a zero coupon bond with a face value \$1,000 and maturity date T. So it has a value of $\$1{,}000\, e^{-rT}$. The value of Position 2 is the value of \$1,000/I_0 shares of put options with each option having the value P: [4]

$$P = I_0 e^{-rT} N(-d_2) - I_0 e^{-qT} N(-d_1) \qquad \ldots(8)$$

Where r is the risk-free rate of interest, q is the dividend yield of the underlying assets, T is the term to maturity of the LC, X (≡ I_0) is the exercise price and

$$d_1 = \frac{\ln\left(\frac{I_0}{I_0}\right) + \left(r - q + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \qquad \ldots(9)$$

$$= \frac{\left(r - q + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \qquad \ldots(10)$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Where σ is the standard deviation of the underlying asset return. The value of Position 3 is the value of 2*\$1,000/I_0 shares of up-and-out call options with each option having the value C_{uo}. Based on Hull (2003), the price for an up-and-out call, C_{uo}, can be written as:

$$C_{uo} = C - C_{ui} \qquad \ldots(11)$$

Where

[4] The pricing formula for this put option is a special case of the Black-Scholes general model for a put in which the exercise price X is the same as the initial stock price (i.e. X = I_0).

C: is the regular call premium

C_{ui}: is the premium for the up-and-in call and

$$C_{ui} = I_0 \left[N(x_1) e^{-qT} - e^{-rT} N\left(x_1 - \sigma\sqrt{T}\right) - e^{-qT} \left(\frac{I_{KO}}{I_0}\right)^{2\lambda} \left[N(-y) - N(-y_1)\right] + \right.$$
$$\left. + e^{-rT} \left(\frac{I_{KO}}{I_0}\right)^{2\lambda-2} \left[N\left(-y + \sigma\sqrt{T}\right) - N\left(-y_1 + \sigma\sqrt{T}\right)\right]\right] \qquad \ldots(12)$$

r is the risk-free rate of interest, T is the term to maturity of the certificate, σ is the standard deviation of the underlying asset return, q is the dividend yield of the underlying asset, and

$$x_1 = \frac{\ln\left(\frac{I_0}{I_{KO}}\right) + \lambda\sigma^2 T}{\sigma\sqrt{T}} \qquad \ldots(13)$$

$$y = \frac{\ln\left(\frac{I_{KO}}{I_0}\right)^2 + \lambda\sigma^2 T}{\sigma\sqrt{T}} \qquad \ldots(14)$$

$$y_1 = \frac{\ln\left(\frac{I_{KO}}{I_0}\right) + \lambda\sigma^2 T}{\sigma\sqrt{T}} \qquad \ldots(15)$$

$$\lambda = \frac{r - q + \frac{\sigma^2}{2}}{\sigma^2} \qquad \ldots(16)$$

The value of *Position 4* is the value of 60 up-and-in cash-or-nothing options with each option having the value CN_{ui}. Based on Haug (2007), the price for up-and-in cash-(at-expiration)-or-nothing option, CN_{ui}, can be written as:

$$CN_{ui} = e^{-rT} \left[N\left(x_2 - \sigma\sqrt{T}\right) + \left(\frac{I_{KO}}{I_0}\right)^{2\mu} N\left(-y_2 + \sigma\sqrt{T}\right)\right] \qquad \ldots(17)$$

Where

$$x_2 = \frac{\ln\left(\frac{I_0}{I_{KO}}\right) + \left(r - q + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \quad \ldots(18)$$

$$y_2 = \frac{\ln\left(\frac{I_{KO}}{I_0}\right) + \left(r - q + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \quad \ldots(19)$$

$$\mu = \frac{r - q - \frac{\sigma^2}{2}}{\sigma\sqrt{T}} \quad \ldots(20)$$

Therefore, the total cost, TC, for each LC is

$$TC = \$1{,}000e^{-rT} - \frac{\$1{,}000}{I_0}P + 2 * \frac{\$1{,}000}{I_0}\ C_{uo} + \$60\ \ CN_{ui} \quad \ldots(21)$$

If B_0 is the issue price of the certificate, any selling price above the fair value is the gain to the certificate issuer. And the profit function for the issuer of certificates is

$$\Pi = B_0 - TC \quad \ldots(22)$$

The profitability is measured by the profit (∏) as a percentage of the total issuing cost (TC), i.e.

$$\text{Profitability} = \frac{\Pi}{\text{TC}} * 100\%$$

$$= \frac{\text{B}_0 - \text{TC}}{\text{TC}} * 100\% \quad \ldots(23)$$

4. Empirical Results

In this section, a LC issued by CSFB Credit Suisse First Boston on June 14, 2004 using the Swiss Market Index (SMI) as the underlying asset is empirically examined. The LC is the "Leverage Certificates in CHF on the Swiss Market Index (SMI) – June 29, 2004 until June29, 2007" (ISIN CH0018852654), and the major characteristics of the certificate are listed in Appendix I of the paper.

Based on the information in Appendix I, the certificate was sold at CHF 1,000.00 (par). The final fixing date or expiration date (i.e. the date on which the closing price of the underlying asset will be used as final fixing level) was set on June 14, 2007, one year later than the initial fixing date. In order to calculate the issuer's profit, the following data is needed for the certificate: 1) the price of the underlying asset, I_0, 2) the cash dividends to be paid by the underlying asset and the ex-dividend dates so the dividend yield, q, can be calculated, 3) the risk-free rate of interest, r, and 4) the volatility of the underlying asset, σ. Equations (8), (12) and (17) are based on continuous dividend yield. Since the dividends from the underlying asset are discrete, the following approach to calculate the equivalent continuous dividend yield for underlying asset that pays discrete dividends is used. For an underlying asset with a price I_0 at t=0 (the issue date) and which pays n dividends during a time period T with cash dividend D_i being paid at time t_i, the equivalent dividend yield q will be such that

$$I_0 - \sum_{i=1}^{n} D_i e^{-r t_i} = I_0 e^{-qT}$$

$$q = -\frac{\ln\left[1 - \frac{\sum_{i=1}^{n} D_i e^{-r t_i}}{I_0}\right]}{T} \quad \ldots(24)$$

The prices and dividends of the underlying asset are obtained from Bloomberg; the risk-free rate of interest is the yield of government bonds (alternatively, swap rates) of which the term to maturity match those of the certificate. If a government bond that matches the term of maturity for a particular certificate cannot be found, a linear interpolation of the yields from two government bonds that have the closest maturity dates surrounding that of the certificate are used. The volatility (σ) of the underlying asset is the implied volatility obtained from Bloomberg based on the options of the underlying asset. If the implied volatility is not available, the historical volatility calculated from the underlying asset prices in the previous 260 days is used.

The one-year rate of interest, r, on June 14, 2004, the initial fixing date of the certificate, based on the Swiss Franc swap rates is 1.907%. The dividend yield, q, of the Swiss Market Index is 2.086%. The Swiss Market Index value on the initial fixing date of the certificate, I_0, is 5,633.60. The historical volatility of the Swiss Market Index is 20.73% on the issue date. Therefore, the total cost of issuing one LC, TC, based on Equation (18) is

$$TC = \text{CHF } 944.40 - \text{CHF } 136.76 + \text{CHF } 39.92 + \text{CHF } 14.48 = \text{CHF } 862.04 \qquad \ldots(25)$$

The profit for issuing the LC, π, is

$$\Pi = \text{CHF } 1{,}000 - \text{CHF } 862.04 = \text{CHF } 137.96 \qquad \ldots(26)$$

The profitability (%) for issuing the LC, π, is

$$\Pi = \text{CHF } 137.96 \,/\, \text{CHF } 862.04 = 16.0\% \qquad \ldots(27)$$

So the profit for issuing each LC is approximately CHF 137.96. Since the cost of issuing a LC is about CHF 862.04 per certificate, then, a profit of CHF 137.96 seems reasonable. Alternatively, the rate of return on such a transaction can be examined. A profit of CHF 137.96 on a transaction that requires an investment of CHF 862.04 translates into a profitability of 16% (5.07% annual rate of return over the three year period). The consistency between the empirical result calculated from the pricing model developed in the paper and the reported mispricing in the literature for structured products suggests the model developed in the paper is sound and robust. The result provides additional evidence that inventors of newly structured products are rewarded for their creativity and innovative ability. Several studies have reported, based on large surveys, that structured products have been overpriced, 2%-7% on average, in the primary market based on theoretical pricing models (Abken, 1989; Baubonis et al., 1993; Burth et al., 2001; Wilkens et al., 2003; Grünbichler and Wohlwend, 2005; Stoimenov and Wilkens, 2005; Benet et al., 2006; Hernandez, Brusa and Liu, 2008; Hernandez, Lee and Liu, 2010a and 2010b;

Hernandez, Jones and Gu, 2011; Hernandez, Tobler and Saubert, 2011; Hernandez, Lee, Liu and Dai, 2012) for various types of structured products. In Table 1, the details on thirteen surveys are presented.

[Insert Table 1 about here]

Given the mispricing of the Leverage Certificate (i.e. a security with exotic embedded options) is larger than the average mispricing reported in the literature, an interestingly related question arises in terms of the mispricing: it is interesting to know whether the issuance of structured products with exotic options (e.g. Bonus Certificates, Barrier Reverse Exchangeable Bonds, Phönix Certificates, Leverage Certificates, etc.) is more or less profitable than the issuance of structured products with plain vanilla options (e.g. Outperformance Certificates, Plain Vanilla Reverse Exchangeable Bonds, Protect Certificates, etc.). In other words, are certificates with options that more difficult to understand, price and hedge mispriced more? In the literature, we tend to find a higher profit for the issuance of exotic structured products than plain vanilla structured products. In Table 2, the details on fifteen studies classified by type of products are reported. The results in the paper are in line with previous studies presented in Table 2 that compared issuing prices with theoretical fair values.

[Insert Table 2 about here]

In order to answer this question, the profitability of a sample of structured products with plain vanilla options outstanding in August 2005 is compared with a sample of structured products with exotic options also outstanding in August 2005. The sample for structured products with plain vanilla options includes 205 Plain Vanilla Reverse Exchangeable Bonds from Hernandez, Lee and Liu (2010a), 26 Plain Vanilla Reverse Exchangeable Bonds from Hernandez, Lee and Liu (2010b), 54 Protect Certificates from the Hernandez, Jones and Gu

(2011), and 1,237 Outperformance Certificates from Hernandez, Lee, Liu and Dai (2012). The sample for structured products with exotic options includes 5,214 Bonus Certificates from Hernandez, Brusa and Liu (2008), 558 Barrier Reverse Exchangeable Bonds from Hernandez, Lee and Liu (2010a), 22 Barrier Reverse Exchangeable Bonds from Hernandez, Lee and Liu (2010b), and 24 Phönix Certificates from Hernandez, Tobler and Saubert (2011),

Table 3 provides descriptive statistics by product type. The average overpricing amounts to 3.33% for products with plain vanilla embedded options, to 3.04% products with exotic embedded options. All product types exhibit a positive mean mispricing, ranging from 2.65% for Bonus Certificates to 16.15% for Barrier Reverse Exchangeable Bonds denominated in Japanese Yen. To assess the statistical significance of the observed mean overpricing, we employ two-sided t-tests. In all subsamples presented in Table 3, the null hypothesis of no mispricing can be rejected at the 1% level. However, the results of the test of equal means suggest that there is no statistical difference in the mispricing of products with plain vanilla embedded options and the mispricing products with exotic embedded options.

[Insert Table 3 about here]

We also conduct a linear regression with the dependent variable the profitability and the explanatory variables dummies for each group of securities. Since all independent variables are qualitative, the regression model is equivalent to a comparison of means. Table 4 summarizes the regression results for the comparison of means between the different product types. Since no dummy variable is defined for Outperformance Certificates, the constant measures the average mispricing for Certificates. The coefficients give the difference in mean mispricing between Outperformance Certificates and each other product type. The results show that Bonus Certificates with 71% of the sample and exotic embedded options do not show lower mispricing than Outperformance Certificates with 17% of the sample and plain vanilla embedded options. However, less popular securities (i.e. Barrier Reverse Exchangeable Bonds, Protect Certificates, and Phönix Certificates) in August 2005 show a higher average mispricing than more popular securities (i.e. Bonus Certificates and Outperformance Certificates). Figure 5 shows the distributions of profits by product type.

[Insert Table 4 about here]

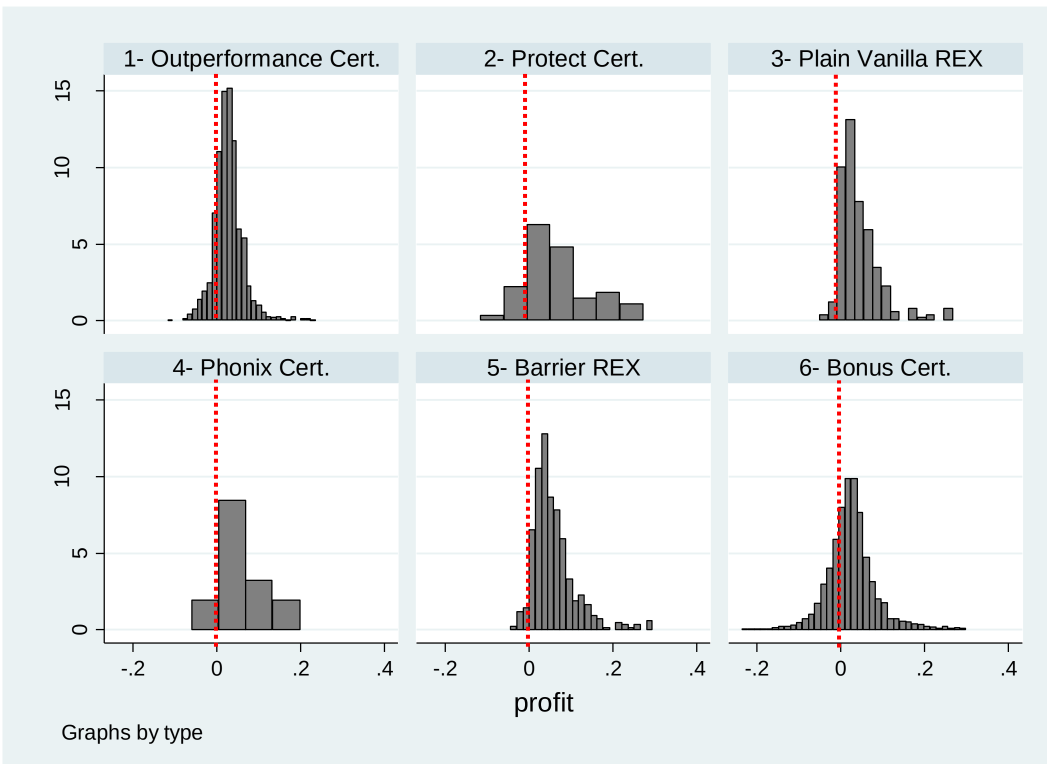

Figure 6: Distributions of the profits in the primary market by certificate type.

In order to measure how the profit of the certificates are affected by the characteristics of the certificates, we also run an ordinary least square regression analysis for issuers' profit as a function of seven variables related to the characteristics of the certificates. The seven variables are (1) the volatility of the underlying asset in percentage (Volatility), (2) the dividend yield of the underlying asset in percentage (Dividend Yield), (3) the term to maturity of the certificate in years (Time to Maturity), (4) the strike price of the option component in the certificate as a percentage of the reference price of the underlying asset (Strike), (5) the coupon rate of the certificate in percentage (Coupon Rate), (6) a dummy for *capped* certificates (Capped), (7) a dummy variable for certificates with exotic embedded options (Exotic). Variables 1-5, traditional inputs of option pricing formulas, are used as control variables and variables 6-7 as instruments to test the influence of specific factors on the mispricing of the certificates. The value of each variable used in the regressions is adjusted for the mean in the sample.

The results of regression analysis, presented in Table 5, show that the profit of the certificates is *positively* associated with the volatility, the dividend yield of the underlying assets, the term to maturity of the certificates, and when the certificate is capped. The term to maturity of the certificate and the dividend yield of the underlying asset are positively related to the issuers' profit, as expected, because investors in the certificates do not receive the dividends paid by the underlying assets. The results show that issuing capped certificates tends to be more profitable than uncapped certificates because in capped certificates, investors' gains are restricted by the cap. The coupon rate of the certificates, a major cost component, is expected to reduce the profits to the issuers and the results in Table 5 confirm our conjectures. The strike price of the option component in the certificate is *negatively* associated with the profit of the certificates.

Finally, the results show that issuing certificates with exotic embedded options tends to be less profitable than certificates with plain vanilla embedded options. Unfortunately, further analysis of issuer-specific factors on the pricing behavior would be desired but it would require information not publicly available (e.g. profits from issuance of other over-the-counter products, hedging costs, etc.).

5. Conclusion

In this paper a newly structured product known as Leverage Certificates is introduced and detailed descriptions of the product specifications are provided. A pricing formula is developed to price the certificates. This paper shows that the payoff of a Leverage Certificate can be duplicated by the combination of a long position in a zero coupon bond, a short position in put options on the underlying asset, a long position in up & out call options on the underlying asset, and a long position in up & in cash-or-nothing options. A certificate issued by CSFB Credit Suisse First Boston is presented as an example to examine how well the model fits empirical data. Moreover, the test of whether structured products with exotic options (e.g. Bonus Certificates, Barrier Reverse Exchangeable Bonds, Phönix Certificates, Leverage Certificates, etc.) are mispriced more than structured products with plain vanilla options (e.g. Outperformance Certificates, Plain Vanilla Reverse Exchangeable Bonds, Protect Certificates, etc.) is presented. The results of the test show no statistical difference in the average mispricing of products with plain vanilla embedded options and the mispricing of products with exotic embedded options. However, using regression analysis and controlling for the traditional inputs in option pricing, the profits for issuing certificates with exotic embedded options is lower than certificates with plain vanilla embedded options. The methodology used in this paper can be extended to the analysis of other structured products.

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Appendix I - Example of a Leverage Certificate

The certificate in Appendix 1 was issued by investment bank Credit Suisse First Boston using the Swiss Market Index as the *underlying asset*. The *initial fixing date* CSFB set for the certificate was June 14, 2004 and the *issue price* of the certificate was CHF 1,000 per certificate (issued at par). The *final fixing date* was set on June 14, 2007.

CREDIT
SUISSE

Leverage Certificates in CHF on the Swiss Market Index (SMI®)

June 29, 2004 until June 29, 2007

Issuer	CREDIT SUISSE FIRST BOSTON, London Branch, London
Underlying	Swiss Market Index (SMI®) ("Index"), Bloomberg Ticker SMI
Issue Price	CHF 1,000 ("**Nominal Amount**")
Swiss Security Number / ISIN	1 885 265 / CH 001 885 265 4
Listing	None
Initial Fixing Date	June 14, 2004
Initial Fixing Level	5,633.60 (100% of the official closing level of the Index on the Initial Fixing Date)
Knock-Out Level	7,887.04 (140% of the Initial Fixing Level)
Payment Date	June 29, 2004
Observation Period	From the Initial Fixing Date until and including the Final Fixing Date
Last Trading Date	June 14, 2007, until the end of the SWX Swiss Exchange trading hours
Final Fixing Date	June 14, 2007
Final Fixing Level	100% of the official closing level of the Index on the Final Fixing Date
Redemption Date	June 29, 2007
Redemption Price	1- If, during the Observation Period, the Underlying **never** trades **at or above** the Knock-Out Level, and - if the Final Fixing Level is *higher* than the Initial Fixing Level, the Redemption Price is: $\text{CHF } 1{,}000.00\left(1+2\left(\frac{\text{Final Fixing Level}}{\text{Initial Fixing Level}}-1\right)\right)$ or - if the Final Fixing Level is *equal to or lower* than the Initial Fixing Level, the Redemption Price is: $\text{CHF } 1{,}000.00\,\frac{\text{Final Fixing Level}}{\text{Initial Fixing Level}}$ 2- If, during the Observation Period, the Underlying **ever** trades **at or above** the Knock-Out Level, the Redemption Price is: $\min\left(\text{CHF } 1{,}000.00;\text{CHF } 1{,}000.00\,\frac{\text{Final Fixing Level}}{\text{Initial Fixing Level}}\right)+\text{CHF } 60.00$
Minimum Trading Lot	1 Leverage Certificate
Issue Size	10,000 Leverage Certificates

Table 1 – Surveys of mispricing of modern structured products in the primary market

Survey	Securities	Sample	Mispricing
Abken, P. (1989)	Equity Linked CDs	42	4%
Baubonis, C., G. Gastineau, and D. Purcell (1993)	Equity Linked CDs	5	2% - 4%
Burth, S., T. Kraus, and H. Wohlwend (2001)	Reverse Exchangeable Bonds	275	2%
Wilkens, S., C. Erner, and K. Roder (2003)	Reverse Exchangeable Bonds	906	3% - 4%
Grünbichler, A., and H. Wohlwend (2005)	Various	192	3% - 4%
Stoimenov, P., and S. Wilkens (2005)	Various	2,304	2% - 6%
Benet, B., A. Giannetti, and S. Pissaris (2006)	Reverse Exchangeable Bonds	31	4% - 6%
Hernandez, R., J. Brusa, and P. Liu (2008)	Bonus Certificates	5,214	2% – 4%
Hernandez, R., W. Lee, and P. Liu (2010a)	Reverse Exchangeable Bonds	6,515	3% - 6%
Hernandez, R., W. Lee, and P. Liu (2010b)	Reverse Exchangeable Bonds	1,013	2% - 8%
Hernandez, R., J. Jones, and Y. Gu (2011)	Protect Certificates	54	4% - 19%
Hernandez, R., C. Tobler, and L. Saubert (2011)	Phönix Certificates	58	4% - 7%
Hernandez, R., W. Lee, P. Liu, and T. Dai (2012)	Outperformance Certificates	1,237	2% - 5%

Table 2 – Studies of of mispricing of modern structured products in the primary market by type of options (plain vanilla vs. exotic)

		Mispricing			
		Plain Vanilla		Exotic	
Study	Securities	Sample	Percent	Sample	Percent
Abken, P. (1989)	Equity Linked CDs	42	4%		
Baubonis, C., G. Gastineau, and D. Purcell (1993)	Equity Linked CDs	5	3% - 4%		
Benet, B., A. Giannetti, and S. Pissaris (1996)	Reverse Exch. Bonds	31	4% - 6%		
Burth, S., T. Kraus, and H. Wohlwend (2001)	Reverse Exch. Bonds	275	2%		
Wilkens, S., C. Erner and K. Roder (2003)	Reverse Exch. Bonds	906	3% - 4%		
Grünbichler, A. and H. Wohlwend (2005)	Various	176	3% - 4%	16	4%
Stoimenov, P. and S. Wilkens (2005)	Various	1,858	2% - 4%	446	3% - 5%
Hernandez, R., J. Brusa, and P. Liu (2008)	Bonus Certificates			5,214	2% – 4%
Hernandez, R., J. Brusa, and P. Liu (2008)	Bonus Certificates - Special Case			12	20%
Hernandez, R., W. Lee, and P. Liu (2010a)	Reverse Exch. Bonds	2,502	3% - 5%	4,013	4% – 6%
Hernandez, R., W. Lee, and P. Liu (2010b)	Reverse Exch. Bonds	739	1% - 6%	274	5% - 30%
Hernandez, R., C. Tobler, and J. Brusa (2010)	Express Certificates	1	2%		
Hernandez, R., J. Jones, and Y. Gu (2011)	Protect Certificates	54	4% - 19%		
Hernandez, R., C. Tobler, and P. Liu (2011)	Certificates Plus Reloaded			1	3%
Hernandez, R., C. Tobler, and L. Saubert (2011)	Phönix Certificates			58	4% - 7%
Hernandez, R., W. Lee., P. Liu, and T. Dai (2012)	Outperformance Certificates	1,237	2% - 5%		

Table 3 – Statistics for mispricing in the primary market for securities outstanding in August 2005

	N	Mean	Std.	p-value
All	7,340	3.10%	6.48%	<0.001
Plain Vanilla Products				
Plain Vanilla REX in USD	205	4.39%	5.20%	<0.001
Plain Vanilla REX in JPY	26	6.17%	6.48%	<0.001
Protect Certificates	54	8.91%	10.96%	<0.001
Outperformance Certificates	1237	2.85%	3.65%	<0.001
All	1,522	3.33%	4.57%	<0.001
Exotic Products				
Bonus Certificates	5,214	2.65%	6.78%	<0.001
Barrier REX in USD	558	6.06%	5.99%	<0.001
Barrier REX in JPY	22	16.61%	16.48%	<0.001
Phönix Certificates	24	5.83%	6.04%	<0.001
All	5,818	3.04%	6.89%	<0.001
Two Sample t-test				
Exotic Products vs. Plain Vanilla Products	7,340	-0.28%	0.19%	0.1207

Table 4 – Comparison of mean mispricing in the primary market for different securities outstanding in August 2005

Independent Variable	Coefficient	St. Err.	t-stat	p-value	
Constant (Outperformance Certificates)	2.85	.0018	15.71	**<0.001**	**
Protect Certificates	6.06	.0089	6.84	**<0.001**	**
Plain Vanilla REX	1.74	.0045	3.82	**<0.001**	**
Phönix Certificates	2.98	.0131	2.27	**0.023**	*
Barrier REX	3.60	.0032	11.21	**<0.001**	**
Bonus Certificates	-0.20	.0020	-1.00	0.318	

Sample size: 7,340

Table 5 – OLS regression analysis for the issuer's profit as a function of (1) the volatility of the underlying asset in percentage (Volatility), (2) the dividend yield of the underlying asset in percentage (Dividend Yield), (3) the term to maturity of the certificates in years (Time to Maturity), (4) the strike price of the option component in the certificate as a percentage of the reference price of the underlying asset (Strike), (5) the coupon rate of the certificate in percentage (Coupon Rate), (6) a dummy for capped certificates (Capped), and (7) a dummy for certificates with exotic embedded options (Exotic). p-values are listed in parentheses.

	Model			
Variable	(1)	(2)	(3)	(4)
Intercept	**3.10**	**2.33**	**4.19**	**2.80**
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
Volatility [a]	**0.30**	**0.30**	**0.30**	**0.30**
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
Dividend Yield [a]	**1.64**	**1.75**	**1.66**	**1.75**
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
Term to Maturity [a]	**0.28**	**0.62**	**0.36**	**0.63**
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
Strike [a]	**-0.03**	**-0.02**	**-0.01**	**-0.01**
	(<0.01)	(<0.01)	(0.01)	(<0.01)
Coupon Rate [a]	0.04	**-0.09**	**0.09**	-0.06
	(0.15)	(<0.01)	(<0.01)	(0.03)
Capped		**2.90**		**2.73**
		(<0.01)		(<0.01)
Exotic			**-1.38**	**-0.54**
			(<0.01)	(<0.01)
Number of Obs.	7,340	7,340	7,340	7,340
Adjusted R^2	0.3167	0.3383	0.3215	0.3389

[a] mean adjusted values