The Market and the Pricing of Outperformance Certificates

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The Market and the Pricing of Outperformance Certificates

Abstract

In this paper we introduce a new financial product named Outperformance Certificates. We study the €43 billion market by examining 1,507 issues of the certificates issued by banks in Europe. We also develop pricing formulas to price the certificates and empirically examine the profits in the primary market for issuing the certificates. We find that the dividend yields and ex-dividend dates play an important role in the profitability of the certificates. The underlying securities tend to have high dividend yield and large market capitalization. We also find the certificates tend to mature *soon* after the ex-dividend dates of the underlying assets.

The Market and the Pricing of Outperformance Certificates

I. Introduction:

Financial innovations, especially the creations of new financial products through the combination of fixed income securities, stocks, and derivative securities (known as structured products), have accelerated in the past two decades. The acceleration of financial innovation can be attributed to the rapid development of computer technology and financial engineering techniques (e.g. financial pricing models).

Financial innovations perform several important functions: they reduce the transaction costs by combining several separate financial products into one single product, complete the market by offering the payoffs not available in the market, and provide tax and regulative arbitrage opportunities, to name just a few.

Innovative investment banks that create the new financial products may be compensated for their innovation in two ways: They may earn positive *monopolistic* profits in the *primary* market when the newly created products are issued (Baubonis, Gastineau, and Purcell, 1993; Benet, Giannette, and Pissaris, 2006; Burth, Kraus, and Wohlwend, 2001; Chen and Kensinger, 1990; Chen and Sears, 1990; Stoimenov and Wilkens, 2005; Wilkens and Stoimenov, 2006)[1], they may also earn profits through larger market shares and lower marketing costs than *imitators* in the *competitive secondary* market (Tufano, 1989).

In this paper, we study a new financial product known as "*Outperformance Certificates*" to examine whether innovators of structured products earn a profit in the primary market.

[1] For detailed reports on how technical expertise, investment in information technology infrastructure, and especially the quantitative capabilities of product developers play an important role in the success in the development of new products and in deterring potential imitators to replicate the products, see Simmons (2006), and Mollenkamp and Fleming (2006).

The results in our paper show that indeed innovators of *Outperformance Certificates* can sell the certificate at prices 2%-3% above the *fair value* based on the *components* of the underlying assets. The results in the paper provided additional evidence that inventors of newly structured products are rewarded for their creativity and innovative ability.

Outperformance Certificates (also known by the commercial names of "*Sprint Certificates", "Accelerator Certificates",* or *"Speeders",* to be referred to as *certificates* henceforth) are one of the equity-linked "structured products" issued by major banks in Europe. The rate of return on the investment in the certificates is contingent upon the performance of a *pre-specified underlying equity* or *equity index* over a *pre-specified period* (known as *term to maturity*). If the price of the underlying asset goes up during the term to maturity, the investors of the certificates will receive a return equal to a *pre-specified multiple* (known as *performance factor*)[2] times the return on the underlying asset. If the price of the underlying asset goes down during the *term*, the investors of the certificates will receive the *same* return as the underlying asset. In calculating the return on the underlying asset, the certificate issuers will use only the change in the *asset price*, the *cash dividend* paid during the period is not included. In other words, investors in the Outperformance Certificates do not receive cash dividends even the underlying assets pay dividends during the term to maturity[3]. The returns on the certificates may or may not subject to a maximum limit. If the returns on the certificates are subject to a maximum limit, they are referred to as

[2] The *performance factor* is always greater than *100%* -- that is why the instruments are termed as "*Outperformance*" Certificates.

[3] It turns out the cash dividends play a very important role in certificate issuers' profits. As we will show the underlying assets tend to have higher dividend yields than other stocks in the industry, and a major portion of certificate issuers' profits come from the dividend payment.

capped certificates; otherwise, they are known as *uncapped* certificates. Appendixes 1 and 2 are examples of a capped and an uncapped certificate.

The banks that issued these *certificates* are usually well-recognized large banks in Europe or European branches of major U.S. banks including: ABN AMRO, Barclays, Citigroup, Deutsche Bank, DZBANK, Goldman Sachs, HSBC Trinkaus, Société Générale, United Bank of Swiss (UBS), WGZ-Bank, and Zürcher Kantonalbank.

The rest of the paper is organized as follows: The design of the certificates is introduced in Section II. The market for the products is presented in Section III. The pricing model of the certificates is developed in Section IV. In Section V, we price 1,237 issues of certificates that have complete data. We find that on average issuers earn a profit of 2%-3% in the € 43.1 billion market. The results show that innovators of the new securities can still earn a profit even though they cannot patent the new product. We further analyze the sources of the profits and find that dividends play a very important role in the issuers' profit. We find that the dividend yields of the underlying securities tend to be higher than the stocks in the same industry and the certificates tend to mature soon after the ex-dividend dates of the underlying assets. These results are reported in Section VI of the paper. We conclude the paper in Section VII.

II. Description of the Product:

The rate of return of a certificate is contingent upon the price performance of its underlying asset over its term to maturity.

The *beginning date* for calculating the gain (or loss) of the underlying asset is known as the *fixing date* (or *pricing date*) and the *ending date* of the period is known as the *expiration* *date.* The price of the underlying asset on the *fixing date* is referred to as the *strike price* (or *exercise price*), and the price of the underlying asset on the *expiration date* is referred to as the *valuation price*[4].

If we denote I_0 as the underlying asset price on the fixing date, I_T as the *valuation price*, PF as the *performance factor,* then for an initial investment in one *uncapped* certificate, the total value that an investor will receive on the *expiration date* (known as the *redemption value* or *settlement amount*), V_T, is equal to:

$$V_T = \begin{cases} I_0 \times \left[1 + PF\,\frac{(I_T - I_0)}{I_0}\right] & \text{if } I_T > I_0 \\ I_0 \times \left[1 + \frac{(I_T - I_0)}{I_0}\right] & \text{if } I_T \le I_0 \end{cases} \qquad \ldots(1)$$

The *redemption value*, V_T, for a *capped* certificate on the *expiration date* is equal to:

$$V_T = \begin{cases} I_0 \times \left[1 + PF\,\frac{(I_C - I_0)}{I_0}\right] & \text{if } I_T > I_C \\ I_0 \times \left[1 + PF\,\frac{(I_T - I_0)}{I_0}\right] & \text{if } I_0 < I_T \le I_C \\ I_0 \times \left[1 + \frac{(I_T - I_0)}{I_0}\right] & \text{if } I_T \le I_0 \end{cases} \qquad \ldots(2)$$

In Equation (2), the I_C is the *cap level* of the certificate imposed by certificate issuers in calculating the maximum *redemption value* (*settlement amount*).

Alternatively, the relationship between the rate of return on an *uncapped* certificate and the rate of return on the underlying asset based on the change in the underlying asset price

[4] For most cases in the sample the *strike prices* and the *valuation prices* are the *closing* prices on the *fixing date* and the *expiration date* respectively. In a few cases, the *opening* prices or the *average* prices during the previous three trading days are used as *strike* prices or *valuation* prices.

(without taking into account dividends) with a performance factor of two can be represented in Figure 1.

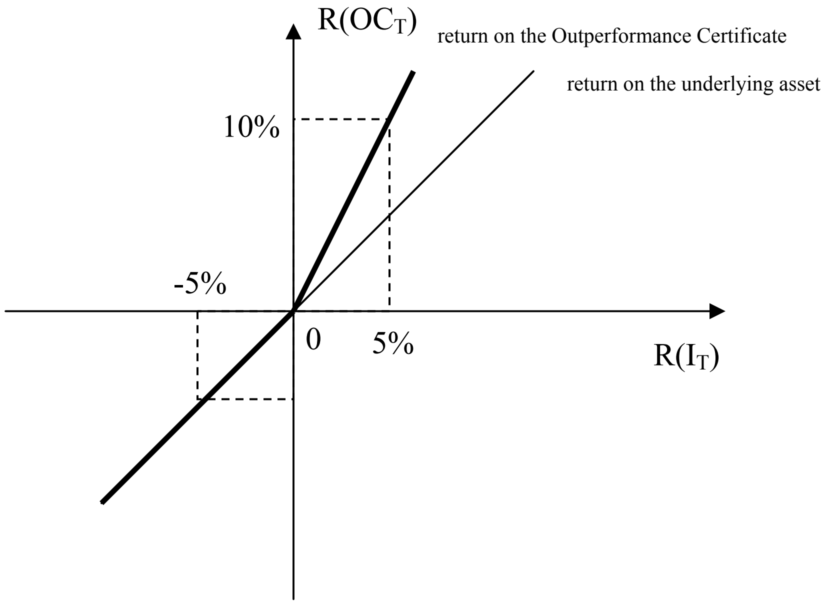

Figure 1: The rate of return of an uncapped Outperformance Certificate, R (OC_T) as a function of the rate of the return on the underlying asset, R (I_T), with a performance factor of two.

The slope for the return on the underlying asset in Figure1 is, of course, one. The slope for the return on the certificate, when the price of the underlying asset goes *up*, is equal to the performance factor. The slope for the return on the certificate, when the price of the underlying asset goes *down*, is one.

Similarly, the relationship between the rate of return on a *capped* certificate and the rate of return on the underlying asset based on the change in the underlying asset price (without taking into account dividends) with a performance factor of two and a capped return of 10% on the certificate can be represented in Figure 2.

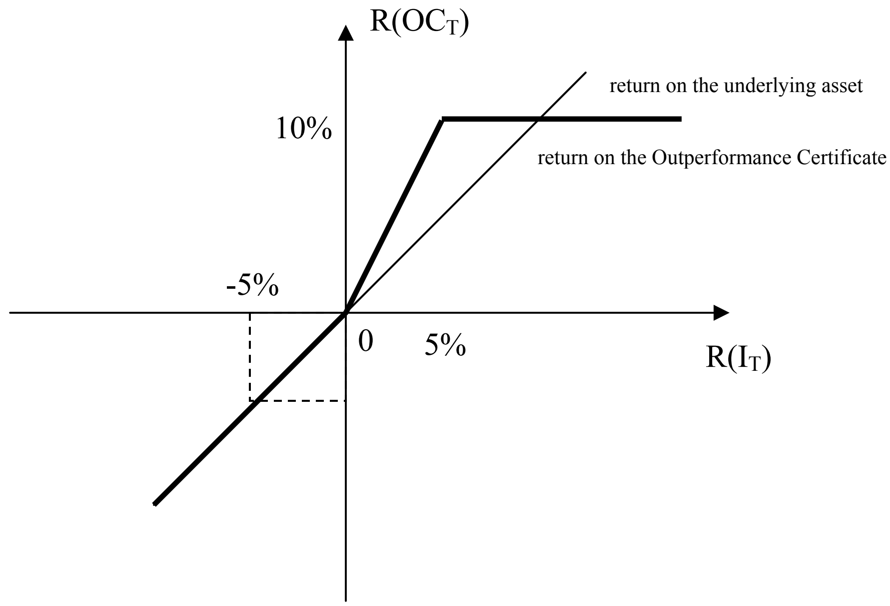

Figure 2: The rate of return of a capped Outperformance Certificate, R (OC_T) as a function of the rate of the return on the underlying asset, R (I_T), with a performance factor of two.

III. The Outperformance Certificate Market:

In Table 1 we present the descriptive statistics for both the *uncapped* and the *capped* certificate markets. For *uncapped* certificates, the *median* size is € 20.7 million with 500,000 certificates in each issue. The *median* term to maturity is 709 days with a median performance factor of 1.52. The total value issued is €14.9 billion on 593 issues.

For *capped* certificates, the *median* size is € 19.5 million with 500,000 certificates in each issue. The *median* term to maturity is 492 days with a median performance factor of 2.00. The total value issued is €28.2 billion on 911 issues. The *combined* value of capped and uncapped certificates is about €43.1 billion on 1,507 issues. It is worth noting that the median performance factor for *capped* certificates of 2.00 is *higher* than the median performance factor for *uncapped* certificates of 1.52. That is because *capped* certificates have a ceiling on the returns, therefore issuers are more willing to *increase* the performance factor to compensate for capped returns.

In Table 2 we break down the statistics for the *uncapped* and the *capped* certificate markets by *country* in which the issuing banks are located. It is obvious that Germany dominates both the *uncapped* and the *capped* certificate markets. In the *uncapped* market, 475 (out of a total of 596) issues of the certificates with a total value of €13.3 billion (out of a total value of €14.9 billion) are issued in Germany. Similarly, in the *capped* market, 630 (out of a total of 911) issues of the certificates with a total value of €21.2 billion (out of a total value of €28.3 billion) are issued in Germany. The performance factors for *capped* certificates are consistently higher than those for *uncapped* certificates.

Although not reported when we break down the certificate market statistics by issuers, the major issuers of the *uncapped* certificates are all major banks in Europe such as Sal. Oppenheim of Germany (with 80 issues for €2.71 billion), BHF bank of Germany (with 88 issues for €1.97 billion), Deutsche Bank (with 47 issues for €1.47 billion), Goldman Sachs European Office (with 24 issues for €1.33 billion), and BNP Paribas of France (with 50 issues for €1.13 billion). The major issuers of the *capped* certificates include major banks BNP Paribas of France (with 238 issues for €7.15 billion), Deutsche Bank (with 107 issues for €5.47 billion), UBS of Switzerland (with 115 issues for €4.92 billion), and DZ Bank of Germany (with 74 issues for €4.00 billion). Once again, the performance factors for *capped* certificates are consistently higher than *uncapped* certificates across issuers.

IV. The Pricing of Outperformance Certificate:

A. Uncapped Outperformance Certificate:

As we show in Appendix 3 of the paper, the *redemption value*, V_T, for an initial investment in one uncapped Outperformance Certificate with a *strike price* of I_0, a *performance* *factor* of PF, and a term to maturity T, is exactly the same as the payoff for holding the following three positions:

1. A long position in 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 the underlying asset and the maturity dates are the ex-dividend dates of cash dividends;
3. A long position in call options on the underlying asset. The number of options is the performance factor minus one (known as additional performance factor). The exercise price of the options is I_0 and the term to expiration of the options is T, the same as the term to maturity of the certificate.

Since the payoff of an uncapped certificates is the same as the combined payoffs of the above three positions, we can calculate the fair value of the certificates based on the value of the three positions. Any selling price of the certificates above the value of the above three positions is the gain to the certificate issuer.

The value of *Position 1* is the price of underlying asset on fixing date I_0. The value of *Position 2* is the present value of cash dividends to be paid by the underlying asset, to be denoted as PV_D. The value of *Position 3* is the value of APF shares of call options with each call value of C where

$$C = I_0 e^{-qT} N(d_1) - X e^{-rT} N(d_2) \qquad \ldots(3)$$

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 certificate, X is the exercise price [5] and

[5] Theoretically, the exercise price X should be the same as I_0, the price of the underlying asset on the issue date. For most cases this is true, but there are exceptions. For instance, in some cases the underlying assets prices on the day (or a few days) before or after the issue date are used as exercise prices. In some cases the *rounded* underlying assets prices on the issue date are used as the exercise prices. To use a general notation to cover all possible cases

$$d_1 = \frac{\ln\left(\frac{I_0}{X}\right) + \left(r - q + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \qquad \ldots(4)$$

$$d_2 = d_1 - \sigma\sqrt{T} \qquad \ldots(5)$$

Where σ is the standard deviation of the underlying asset return. Therefore, the total cost, TC, for each uncapped certificate is

$$\text{TC} = I_0 - PV_D + \text{APF}* \left[I_0 e^{-qT} N(d_1) - Xe^{-rT} N(d_2)\right] \qquad \ldots(6)$$

And the profit function for the issuer is

$$\prod = P - TC$$

$$= P - \left\{I_0 - PV_D + \text{APF}* \left[I_0 e^{-qT} N(d_1) - Xe^{-rT} N(d_2)\right]\right\} \qquad \ldots(7)$$

Where P is the issue price of one uncapped certificate.

It is evident from Equation (6) that higher dividend yield for underlying assets will reduce the total cost TC (and therefore increase the profit $\prod$) for issuing certificates in two ways: a higher dividend yield will lead to a *higher* value of PV_D and it will also lead to a *lower* value of the option C. We will show in Section VI of the paper that in choosing the underlying assets, certificate issuers tend to choose the underlying assets with high dividend yields in the industry.

B. Capped Outperformance Certificate:

As we show in Appendix 4 of the paper, the *redemption value*, V_T, for an initial investment in a capped certificate with a *strike price* (also known as *issue price*) of I_0, a

for the exercise price, we use X, as opposed to I_0 in the equations in the paper. In the empirical data, we use the *actual* exercise prices taken from the prospectuses.

performance factor of PF, a *cap level* of I_C, and a term to maturity T, is the same as the payoff for holding the following four positions:

1. A long position in the underlying asset and
2. A short position in zero coupon bonds. The face values of the zero coupon bonds are the cash dividends to be paid by the underlying asset and maturity dates of the bonds are the ex-dividend dates.
3. A long position in call options on the underlying asset. The number of calls is the performance factor minus one (PF-1). The exercise price of the options is I_0 and the term to expiration of the options is T, the same as the term to maturity of the certificate.
4. A short position in call options on the underlying asset with an exercise price of I_C and the term to expiration of T. The number of calls is the performance factor (PF).

Since the payoff of a capped certificate is the same as the combined payoffs of the above four positions, we can calculate the fair value of the certificate based on the value of the four positions. Any selling price above the value of the four positions is the gain to the certificate issuer.

The value of *Position 1* is the price of underlying asset on fixing date I_0. The value of *Position 2* is the present value of cash dividends to be paid the underlying asset, to be denoted as PV_D. The value of *Position 3* is the value of APF shares of call options with each call value of C_1 where

$$C_1 = I_0\, e^{-qT}\, N(d_1) - X\, e^{-rT}\, N(d_2) \qquad \ldots(8)$$

Where r is the risk-free rate of interest, T is the term to maturity of the capped certificate, and

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

$$d_2 = d_1 - \sigma\sqrt{T} \qquad \ldots(10)$$

Where q is the dividend yield of the underlying asset and σ is the standard deviation of the underlying asset return.

The value of *Position 4* is the value of PF shares of call options with each call value of C_2 where

$$C_2 = \mathrm{I}_0\, \mathrm{e}^{-\mathrm{qT}}\, \mathrm{N}(\mathrm{d}_3) - I_C\, \mathrm{e}^{-\mathrm{rT}}\, \mathrm{N}(\mathrm{d}_4) \qquad \ldots(11)$$

Where

$$d_3 = \frac{\ln\left(\frac{I_0}{I_C}\right) + \left(r - q + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \qquad \ldots(12)$$

$$d_4 = d_3 - \sigma\sqrt{T} \qquad \ldots(13)$$

Therefore, the total cost, TC, for each capped Outperformance Certificate is

$$\begin{aligned} \mathrm{TC} &= \mathrm{I}_0 - \mathrm{PV}_\mathrm{D} + \mathrm{APF} * \mathrm{C}_1 - \mathrm{PF} * \mathrm{C}_2 \\ &= \mathrm{I}_0 - \mathrm{PV}_\mathrm{D} + \mathrm{APF} * [\, \mathrm{I}_0\, \mathrm{e}^{-\mathrm{qT}}\, \mathrm{N}(\mathrm{d}_1) - \mathrm{X}\, \mathrm{e}^{-\mathrm{rT}}\, \mathrm{N}(\mathrm{d}_2)\,] \\ &\qquad - \mathrm{PF} * [\, \mathrm{I}_0\, \mathrm{e}^{-\mathrm{qT}}\, \mathrm{N}(\mathrm{d}_3) - I_C\, \mathrm{e}^{-\mathrm{rT}}\, \mathrm{N}(\mathrm{d}_4)\,] \end{aligned} \qquad \ldots(14)$$

And the profit function for the issuer is

$$\prod = P - TC$$

$$= P - \{ I_0 - PV_D + APF * [I_0 e^{-qT} N(d_1) - X e^{-rT} N(d_2)] - PF * [I_0 e^{-qT} N(d_3) - I_C e^{-rT} N(d_4)] \} \quad \ldots(15)$$

Therefore, the profit for each issue of the certificates can be calculated by Equation (7) (for *uncapped* certificates) or Equation (15) (for *capped* certificates). We calculate the profit for each *uncapped* and *capped* certificate that has complete data (580 issues of uncapped certificates and 657 issues of capped certificates, with a total of 1,237 issues). The details of the data analyses and the empirical results are presented in the next section.

V. The Profitability of Outperformance Certificates:

In this section, we examine the profits for issuing Outperformance Certificates in great details. We first calculate the profit for each issue of certificate that has complete data based on Equation (7) (for *uncapped* certificate) and Equation (15) (for *capped* certificate). We then classify the certificates 1) by *type*, 2) by *country* in which the issuing banks are located, and 3) by *term to maturity*. We find that issuing certificates is *profitable* for both *types*, among all the *countries* in which the issuing banks are located, and across all the *maturities* of the certificates.

A. Data Description:

In order to calculate the profit, we need the following data for each certificate: 1) the price of the certificate, P, 2) the price of the underlying asset, I_0, 3) the cash dividends to be paid by the underlying assets and the ex-dividend dates so we can calculate the dividend yield, q[6], 4)

[6] Equations (7) and (15) are based on continuous dividend yield. Since the dividends for individual stocks are discrete, we use the following approach to calculate the *equivalent* continuous dividend yield for stocks that pay discrete dividends. For an underlying asset which is an individual stock 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

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

the risk-free rate of interest, r, 5) the exercise price of the options component in the certificate, X, 6) the volatility of the underlying asset, σ , 7) the term of maturity of the certificate which is also the term to expiration of the option, T, 8) the performance factor, PF, and 9) the cap level, I_C, for a capped certificate.

The prices for the certificate, P, are obtained from the final term sheets published on the web pages of each bank. We further double check the prices and other variables from the Bloomberg Information System and several websites to ensure the accuracy of the data[7]. The prices of underlying assets are obtained from Bloomberg; dividend data are taken from IBES on Bloomberg; the risk-free rates of interest are the yields of government bonds of which the terms to maturity match those of the certificates[8]. The exercise prices (X) of the options, the terms to maturity of the certificates (T), the performance factors (PF), and the cap levels (I_C) for capped certificates are taken from the prospectuses. The volatilities (σ) of the underlying assets are the

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

$$-qT = \ln\left[1 - \frac{\sum_{i=1}^{n} D_i e^{-r t_i'}}{I_0}\right]$$

$$q = -\frac{\ln\left[1 - \frac{\sum_{i=1}^{n} D_i e^{-r t_i'}}{I_0}\right]}{T}$$

[7] These websites include OnVista (Germany http://www.onvista.de/), the Yahoo (Germany http://de.yahoo.com/), ZertifikateWeb (Germany http://www.zertifikateweb.de/), TradeJet (http://www.tradejet.ch), Berlim-Bremen Boerse Stock Exchange (http://www.berlinerboerse.de), Stuttgart Boerse Stock Exchange (http://www.boerse-stuttgart.de/), and Swiss Stock Exchange (http://www.swx.com).

[8] When we cannot find a government bond that matches the term of maturity for a particular certificate, we use the linear interpolation of the yields from two government bonds that have the closest maturity dates surrounding that of the certificate.

implied volatility obtained from Bloomberg based on the *call* options of the underlying asset[9]. For a few cases in which the *implied* volatility is not available for an underlying asset, we use the *historical* volatility calculated from the underlying stock prices in the previous 260 days.

B. *Empirical Results of the Profitability Analysis:*

In Table 3, we present the profitability for issuing Outperformance Certificates by type of certificate and by country in which the issuing banks are located. The profitability is measured by the profit (∏) as a percentage of the total issuing cost (TC), i.e.

$$\text{Profitability} = \prod / \text{TC} = (\text{P} - \text{TC}) / \text{TC} \quad \ldots (16)$$

The results in Table 3 show that average profit for all the 580 issues of *uncapped* certificates in the sample is a hefty 3.15% above the issuing cost and the average profit for the 657 issues of *capped* certificates is 2.56%. With a total market value of €14.9 billion for the *uncapped* certificates and a total market value of €28.3 billion for the *capped* certificates, the profitability measures translate into a profit of €469 million for the *uncapped* certificates and a profit of €724 million for the *uncapped* certificates for a total profit of €1.193 billion for the entire Outperformance Certificate market.

The profit for issuing the certificates can consistently be observed no matter how we break down the data. We break down the profit by *countries* in which the certificates are issued in Table 3, and by *term to maturity* of the certificates in Table 4. The results in these tables *consistently* indicate that the profit of issuing the certificates is *positive* and statistically

[9] The implied volatility calculated by the Bloomberg System is the weighted average of the implied volatilities for the three call options that have the closest at-the-money strike prices. The weights assigned to each implied volatility are linearly proportional to the "degree of near-the-moneyness" (i.e. the difference between the underlying asset price and the strike price) with the options which are closer-to-the-money receive more weight.

significantly making the issuance of the certificates a profitable business for the issuing firms. Although not reported same conclusion is reached when we break down the profit by issuer or by industry of the underlying assets.

VI. Explanations for the Profitability of the Certificates:

In this section, we attempt to provide some explanations for the success of the certificates. Given that investors in certificates do *not* receive the dividends paid by underlying assets, three interestingly related questions arise in terms of the dividend payment of the underlying assets:

First, it is interesting to know whether the issuance of certificates can still be profitable if the issuers *had* promised paying the dividends of the underlying assets to the certificate investors; In other words, what role does the absence (or the presence) of dividend payment play in the profitability of the certificate issues? The results of our analyses suggest that if certificate issuers had promised to pay dividends of the underlying assets, the profit will be significant reduced and even completely wiped out.

The importance of the absence of dividend payment in the profitability of certificate issuance lead to the second interesting question: do certificate issuers have an incentive to use the level of dividend yield as a selection criterion for underlying assets? In other words, do certificate issuers have a tendency to select stocks with *high* dividend yield as the underlying assets? Since the certificate issuers only pay the investors based on the *price appreciation* of the underlying assets but not based on *dividends*, do certificate issuers have an incentive to select securities that pay *high* dividend so that issuers of certificates can capture the benefits of the price drop of the underlying asset over the life time of the certificates? The results of our analyses suggest that the answer to this question is *positive* and we find that the underlying securities tend to have *higher* dividend yields than the average dividend yield for all the stocks in the same *industry* at the *country* level as well for the *region* (i.e. Western Europe).

Since the dividend yield play such an important role in the profitability of certificate issuance and certificate issuers tend to select *high* dividend yield stocks as the underlying securities, we further ask: do certificate issuers have an incentive to *time* the *maturity date* of the certificates by making certificate mature *soon* after the *ex-dividend date* on which the underlying asset price tends to drop? We also find evidence supporting this conjecture. Now we present evidence for each of the above three questions.

From Equation (7), the profit function of an uncapped certificate is:

$$\prod = P - \left\{ I_0 - PV_D + \text{APF} * \left[I_0 e^{-qT} N(d_1) - X e^{-rT} N(d_2) \right] \right\} \qquad \ldots(17)$$

If the certificate issuers have to pay dividends to investors, then the profit function becomes:

$$\prod' = \prod - \text{PV}_\text{D}$$
$$= P - \left\{ I_0 + \text{APF} * \left[I_0 e^{-qT} N(d_1) - X e^{-rT} N(d_2) \right] \right\} \qquad \ldots(18)$$

If a certificate is selling at par (i.e. $P = I_0$), then the new profit function for the uncapped certificate becomes Equation (19), which is always negative:

$$\prod' = - \text{APF} * \left[I_0 e^{-qT} N(d_1) - X e^{-rT} N(d_2) \right] \qquad \ldots(19)$$

Therefore, if an uncapped certificate issuer had promised to pay dividends of the underlying assets to investors, and the certificate is selling at *par* (or *discount*), then the issuer would have suffered losses in issuing the certificate. In order to make a profit, the issuer must sell the certificate at a premium (even in this case, the profit would have been significantly reduced due to the dividend payment to the certificate investors). Since most issuers choose to sell the certificates at or close to *par*, [10] the profit of the certificates is mainly contributed by not making dividend payment to investors.

Similarly, we know from that the profit function for a capped certificate is:

$$\prod = P - \{I_0 - PV_D + APF * [\, I_0\, e^{-qT}\, N(d_1) - X\, e^{-rT}\, N(d_2)\,] - PF * [\, I_0\, e^{-qT}\, N(d_3) - I_C\, e^{-rT}\, N(d_4)\,]\,\} \qquad \ldots(20)$$

If the certificate issuers had to pay dividends to investors, then the profit function becomes:

$$\prod' = \prod - PV_D$$
$$= P - \{I_0 + APF * [\, I_0\, e^{-qT}\, N(d_1) - X\, e^{-rT}\, N(d_2)\,] - PF * [\, I_0\, e^{-qT}\, N(d_3) - I_C\, e^{-rT}\, N(d_4)\,]\,\} \qquad \ldots(21)$$

If a certificate is issued at par (i.e. P = Io), then the new profit function for the capped certificate becomes:

$$\prod' = APF * [\, I_0\, e^{-qT}\, N(d_1) - X\, e^{-rT}\, N(d_2)\,] - PF * [\, I_0\, e^{-qT}\, N(d_3) - I_C\, e^{-rT}\, N(d_4)\,]\,\} \qquad \ldots(22)$$

Although the $\prod'$ may still be positive (depending on the relationship between APF, PF, $[\, I_0\, e^{-qT}\, N(d_1) - X\, e^{-rT}\, N(d_2)\,]$ and $[\, I_0\, e^{-qT}\, N(d_3) - I_C\, e^{-rT}\, N(d_4)\,]$)[11], the profit $\prod'$ is unambiguously smaller than $\prod$ by the value of PV_D.

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[10] As shown in Table 1, both the median and the mean of the selling price of the certificate, P, as a percentage of the underlying asset price on the issue date, I_0, are equal to or very close to 1.00.

[11] That is because APF < PF, but $[\, I_0\, e^{-qT}\, N(d_1) - X\, e^{-rT}\, N(d_2)\,] > [\, I_0\, e^{-qT}\, N(d_3) - I_C\, e^{-rT}\, N(d_4)\,]$ due to that the former is a call with an exercise price of X, while the latter is a call with a higher exercise price of I_C.

Given the fact that the certificate issuers do *not* pay dividends to investors and *not* paying dividends plays an important role in the profitability of the issuers, it is natural to ask the second question: do issuers have an incentive to choose underlying assets that have *higher* dividend yield?

In order to answer this question, we compare the dividend yield of the underlying assets with the average dividend yield of all the stocks in the same industry at country level as well as at the regional level (i.e. Western Europe). We also calculate the percentile ranking in dividend yield for the underlying assets against all the stocks in the same industry at the country level as well as at the regional level. We present the results in Panel A of Table 5. The dividend yield for all the underlying assets (2.28% on average) is statistically significantly higher than the average dividend yield for the stocks in the same industry at the country level (1.61% on average) and at the regional level (1.64% on average). The average percentile ranking of the underlying assets' dividend yield among all the stocks in the same industry is 76% at the country level and 69% in the region. The results indicate that the dividend yields of underlying assets are significantly higher than the average dividend yield for the stocks in the same industry.

Along the same line on how certificate issuers select underlying securities to increase the profits, we also hypothesize that in order to enhance the marketability of the certificates to potential investors, issuers have a tendency to select securities that are highly recognized by investors. Therefore, we hypothesize that underlying securities tend to be the stocks of large firms. In addition, stocks of large firms are also more liquid in the equity market and their options are also more widely held. The liquidity of the stocks and options will facilitate the hedging for issuing certificates. Based on the hypothesis, we empirically examine the firm size of the underlying securities as measured by the market capitalization and the results are reported in Panel B of Table 5. As shown in the panel, the market capitalization for the underlying assets of the certificates (€39.7 billion on average) is significantly higher than the average market capitalization of the firms in the same industry at the country level (€12.0 billion on average) as well as at the regional level (€4.1 billion on average). The average percentile ranking of the market capitalization for the underlying assets among all the stocks in the same industry is 93% at the country level and 95% at the regional level. The results confirm our conjecture.

To answer the question of whether certificate issuers have an incentive to time the *maturity date* of the certificates by making certificate mature *soon* after the *ex-dividend date* so that they can take advantage of the price drop of the underlying asset after the ex-dividend date, we calculate, for each issue of the certificate, the number of days between the maturity date of a certificate and the ex-dividend date of the underlying asset immediate *before* the maturity date, as a percentage of the number of days between two consecutive ex-dividend dates. Our hypothesis is that, in the absence of deliberate choice of the certificate's maturity date, the maturity date, on average should fall near the middle of two consecutive ex-dividend dates. Therefore, the average number of days between the maturity date of the certificate and the ex-dividend date immediate before the maturity date as a percentage of the number of days between two consecutive ex-dividend dates should be insignificantly different from 0.5. In case the issuers of the certificates purposely design the maturity date in such a way that the certificates mature *soon* after an ex-dividend date, we would expect the measure to be significantly less than 0.5. We present the test results in Table 6.

Since the underlying securities may pay dividends annually, semi-annually, or quarterly (with the majority of stocks paying dividends annually in Europe), we break down the data by the frequency of the dividend payment per year. As shown in Table 6, for both the *uncapped* and the *capped* certificates, the majority of certificates tend to mature soon after an ex-dividend date with the measure significantly less than 0.5. The results in the table suggest that the certificate issuers tend to time the maturity date of the certificate in such a way that certificates mature soon after the ex-dividend dates.

VII. Conclusion:

In this paper we introduce a newly structured product known as Outperformance Certificates and we provide detailed descriptions of the product specifications. We also study the €43 billion certificate market by examining a sample of 1,507 issues of the certificates issued by major banks in Europe. We further develop pricing models for two types of certificates – uncapped and capped certificates – and we empirically examine the profits in the primary market for issuing the two types of certificates. We find that issuance of the certificates is profitable for the issuers in our sample. We further show that the dividend yield plays a very important role in the profitability of issuing the certificates. The dividend yield of the underlying assets tends to be higher than the average dividend yield. We also find that issuers tend to select underlying securities with *large* market capitalization. Issuers also tend to select the *maturity dates* so that the certificates mature *soon* after the *ex-dividend dates* of the underlying securities.

This paper, to the best of our knowledge, is the first and only study systematically analyzes the Outperformance Certificates in such a large scale. The study provides insights into the design, the payoff, the market, the pricing, and the profitability of the newly designed financial products. The methodology and approach used in this paper can be easily extended to the analysis of other structured products.

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TABLE 1

Descriptive statistics for the *uncapped* and the *capped* Outperformance Certificate markets. The statistics include the mean, the median, the minimum, and the maximum values of 1) the issue size measured in millions of €, 2) the issue size measured in numbers of the certificates, 3) the term to maturity in number of calendar days, 4) the performance factor, 5) the cap level for *capped* certificates, 6) the maximum redemption level for *capped* certificates, 7) the issue price as a percentage of the underlying asset price at the time of the issue, 8) the total value of the markets, and 9) the total number of issues of the certificates.

Type	Statistic	Issue Size (€ Mill.) [a,g]	Issue Size (# of certificates) [b]	Maturity (# of days)	Performance Factor	Cap Level [c]	Max. Redemption Level [d]	Issue Price [e]	
Uncapped									
	Mean	25.20	694,730	853	1.59	n.a.	n.a.	100.29	
	Median	20.70	500,000	709	1.52	n.a.	n.a.	100.00	
	Min	0.81	20,000	85	1.08	n.a.	n.a.	92.27	
	Max	211.00	5,000,000	2563	3.10	n.a.	n.a.	114.42	
	Total Amount Issued [f]								14,944
	Total Number of Issues								596
Capped									
	Mean	31.02	1,058,041	508	2.03	15.13	30.61	99.78	
	Median	19.50	500,000	492	2.00	14.29	28.58	100.00	
	Min	0.92	4,600	146	2.00	3.42	6.84	91.05	
	Max	677.40	200,000,000	1,819	4.00	50.00	100.00	112.05	
	Total Amount Issued [f]								28,263
	Total Number of Issues								911

[a] in million Euros [b] in number of certificates [c] as a percent above the issue price [d] as a percent above the issue price [e] as a percentage of the underlying asset's price on the issue date for 584 issues that have the complete data [f] in million Euros [g] three of the 596 issues do not have enough information about issue amount.

TABLE 2

The descriptive statistics for the *uncapped* and the *capped* Outperformance Certificate markets by *country* in which the issuing banks are located. The descriptive statistics in the table include the mean and the median for 1) the issue size measured in millions of €, 2) the issue size measured in numbers of the certificates, 3) the term to maturity in number of calendar days, 4) the performance factor, 5) the cap level for *capped* certificates, 6) the maximum redemption level for *capped* certificates, 7) the total value of the markets and 8) the total number of issues of the certificates.

Type	Country	Statistic	n	Total Amount Issued (€ Mill.) [a]	Issue Size (€ Mill.) [a]	Issue Size (# of certificates) [b]	Maturity (# of days)	Performance Factor	Cap Level [c]	Max Redemption Level [d]	Issue Price [e]
Uncapped	Germany	Mean	475	13,394.07	28.38	755,826	859	1.58	n.a.	n.a.	100.23
		Median			22.17	500,000	730	1.51	n.a.	n.a.	100.00
	Great Britain	Mean	37	1,101.20	29.76	1,087,838	812	1.59	n.a.	n.a.	99.28
		Median			20.40	1,000,000	884	1.50	n.a.	n.a.	99.25
	Netherlands	Mean	35	214.00	6.11	230,857	1,353	1.46	n.a.	n.a.	100.74
		Median			6.40	200,000	1,085	1.50	n.a.	n.a.	100.00
	Netherlands Antilles	Mean	42	105.75	2.52	112,976	491	1.82	n.a.	n.a.	101.48
		Median			1.86	80,000	512	1.80	n.a.	n.a.	101.79
	Switzerland	Mean	7	129.29	18.47	307,146	366	1.51	n.a.	n.a.	100.07
		Median			16.52	300,000	364	1.50	n.a.	n.a.	100.00
Capped	Austria	Mean	15	94.81	6.32	1,000,000	729	2.00	20.26	40.53	98.83
		Median			3.69	1,000,000	729	2.00	20.00	40.00	98.99
	Germany	Mean	630	21,242.38	33.72	697,758	516	2.00	15.77	31.56	99.71
		Median			26.00	500,000	508	2.00	14.88	29.77	99.94
	Great Britain	Mean	100	5,464.41	54.64	916,000	507	2.10	12.81	27.47	100.23
		Median			40.48	1,000,000	446	2.00	11.68	23.65	100.07
	Netherlands	Mean	29	421.58	14.54	11,800,000	410	2.00	13.42	26.84	100.00
		Median			5.62	400,000	368	2.00	12.50	25.00	100.00
	Netherlands Antilles	Mean	101	372.14	3.68	132,155	524	2.14	15.74	32.78	99.58
		Median			3.94	90,000	486	2.00	14.38	31.25	99.32
	Switzerland	Mean	36	668.02	18.56	1,746,944	306	2.00	7.78	15.56	100.10
		Median			18.72	125,000	331	2.00	6.80	13.60	100.00

[a] in million Euros [b] in number of certificates [c] as a percent above the strike price (i.e. issue price) [d] as a percent above the strike price (i.e. issue price) [e] as a percentage of the underlying asset's price on the issue date

TABLE 3

The average term to maturity (in years), equivalent dividend yield, and profitability measured by the profit (∏) as a percentage of the total issuing cost for the Outperformance certificates by the *country* in which the certificates are issued. The p-value tests the probability that the profitability is equal to zero.

Type	Country	n	Maturity (Years)	Equivalent Dividend Yield	Profitability in Percentage	p-value
Uncapped						
	Germany	461	2.35	3.40	3.06	< 0.001
	Great Britain	36	2.15	3.96	2.80	< 0.001
	Netherlands	34	3.61	3.92	4.98	< 0.001
	Netherlands Antilles	42	1.35	4.98	3.18	< 0.001
	Switzerland	7	1.00	4.91	1.80	< 0.001
	Complete Sample	580	2.32	3.6	3.15	< 0.001
Capped						
	Austria	15	2.00	0.95	3.83	0.019
	Germany	384	1.39	1.52	3.73	< 0.001
	Great Britain	96	1.38	1.39	3.05	< 0.001
	Netherlands	28	1.11	2.55	3.62	< 0.001
	Netherlands Antilles	101	1.44	1.32	1.63	< 0.001
	Switzerland	33	0.83	1.61	1.45	< 0.001
	Complete Sample	657	1.37	1.51	2.56	< 0.001

TABLE 4

The average term to maturity (in years), equivalent dividend yield, and profitability measured by the profit (∏) as a percentage of the total issuing cost for the Outperformance certificates by the *term to maturity* of the certificates. The p-value tests the probability that the profitability is equal to zero.

Type	Maturity (Years)	n	Maturity (Years)	Equivalent Dividend Yield	Profitability in Percentage	p-value
Uncapped						
	$T \leq 1$	6	0.86	5.19	1.45	< 0.001
	$1 < T \leq 2$	307	1.65	3.72	2.63	< 0.001
	$2 < T \leq 3$	170	2.47	3.67	3.45	< 0.001
	$3 < T \leq 4$	53	3.31	3.49	4.69	< 0.001
	$4 < T \leq 5$	15	4.45	3.64	6.83	< 0.001
	$5 < T$	29	6.05	1.71	2.56	0.003
	Complete Sample	580	2.32	3.6	3.15	< 0.001
Capped						
	$T \leq 1$	51	0.79	2.07	1.92	< 0.001
	$1 < T \leq 2$	586	1.38	1.48	2.64	< 0.001
	$2 < T \leq 3$	13	2.15	1.14	2.12	0.049
	$3 < T$	7	3.02	0.73	1.71	0.401
	Complete Sample	657	1.37	1.51	2.56	< 0.001

TABLE 5

In Panel A we compare the dividend yield for all 143 underlying securities with the average dividend yield for all the firms in the same industry at the country level as well as the regional level. We also calculate the average ranking in dividend yield of underlying assets against all the firms in the same industry at the country level as well as at the regional level. In Panel B we compare the market capitalization for all 143 underlying securities with the average market capitalization for all the firms in the same industry at the country level as well as the regional level. We also calculate the average ranking in market capitalization of underlying assets against all the firms in the same industry at the country level as well as at the regional level.

	Underlying Asset	Country	Region
Panel A			
Average Dividend Yield (%)	2.28	1.61	1.64
p-value [a]		< 0.001	< 0.001
Percentile Rank [b]		76.1	68.8
p-value [c]		< 0.001	< 0.001
Panel B			
Market Capitalization (€ Million)	39,665	12,004	4,122
p-value [d]		< 0.001	< 0.001
Percentile Rank [b]		92.8	94.7
p-value [c]		< 0.001	< 0.001

[a] The probability that the difference between the underlying asset's dividend yield and the average dividend yield for all the firms in the same industry to be zero.

[b] The formula used to compute the percentile ranking is the following:

$$\text{Percentile Ranking} = \left[\frac{\frac{N - \text{Absolute Rank} + 1}{N} + \frac{N - \text{Absolute Rank}}{N}}{2} \right]$$

[c] The probability that the percentile ranking is indifferent from 50%.

[d] The probability that the difference between the underlying asset's market capitalization and the average market capitalization for all the firms in the same industry to be zero.

TABLE 6

Average number of days between the maturity date of a certificate and the ex-dividend date of the underlying asset immediate before the maturity date, as a percentage of the number of days between two consecutive ex-dividend dates, breaking down by the frequency of the dividend payment per year (i.e. once per year, twice per year, and four times per year).

	Dividend Payment Frequency			
	1 per year	2 per year	4 per year	Pooled
Uncapped				
n	407	91	18	516
Mean Value [a]	0.27	0.36	0.50	0.29
Equality Dist. Test p-value [b]	<0.001	<0.001	0.44	<0.001
Normality Test p-value [c]	<0.001	<0.001	0.20	<0.001
Capped				
n	460	30	12	502
Mean Value [a]	0.44	0.57	0.43	0.45
Equality Dist. Test p-value [b]	<0.001	0.79	0.20	<0.001
Normality Test p-value [c]	<0.001	<0.001	0.78	<0.001

[a] Number of days between the maturity date of a certificate and the ex-dividend date of the underlying asset immediate before the maturity date, as a percentage of the number of days between two consecutive ex-dividend dates.

[b] Probability that the average time between the expiration date of the certificate and the previous ex-dividend date of the underlying asset, as a percentage of the time between ex-dividend dates is equal to 0.50.

[c] Probability that the distribution of the time between the expiration date of the certificate and the previous ex-dividend date of the underlying asset, as a percentage of the time between ex-dividend dates is normal.

Appendix 1: Example of an Uncapped Performance Certificate

The uncapped certificate in Appendix 1 was issued by investment bank UBS using Daimler-Chrysler as the *underlying asset*. The *fixing date* UBS set for the certificate was March 24, 2006 and the *issue price* of the certificate (i.e. the stock price on the *fixing date*) was €46.85. The date that an investor must make the payment for the purchase of the certificate (known as the *payment date*) was March 31, 2006. The *expiration date* (i.e. the date on which the closing price of the underlying asset will be used as the *valuation price*) was set on May 11, 2009 and the *performance ratio* for the certificate was set 150%.

UBS Investment Bank

UBS Outperformance Certificates on DAIMLERCHRYSLER

Underlying: Valor: 945657; ISIN: DE0007100000; Reuters: DCXGn.DE; Bloomberg: DCX GY

Product Details

Underlying	DAIMLERCHRYSLER
Ratio	1:1
Reference Price	EUR 46.85
Issue Price	EUR 46.85
Strike Price (Pb)	EUR 46.85
Participation Rate (PR)	150.00%
Secutirity Identification Codes	ISIN: CH0024234764

Dates

Issue Date	27.02.2006
Subscription Period	27.02 - 24.03.2006
Fixing Date	24.03.2006
Initial Payment Date	31.03.2006
Last Trading Day	07.05.2009
Expiration Date	11.05.2009
Redemption Date	18.05.2009

General Information

Issuer	UBS AG, London Branch
Lead Manager	UBS Limited, London
Issue Size	500,000
Structure	Long Underlying + At-the-money Strike Call
Redemption	The Holder of 1 UBS Outperformance Certificate has the right to receive at the Redemption Date the Redemption Amount in Euro which is calculated according to the following formulae: 1) If Pv > Pb R = [Pb + (Pv – Pb) * PR] * Ratio 2) If Pv <= Pb R = Pv * Ratio With: R = Redemption Amount Pv = Valuation Price Pb = Strike Price PR = Participation Rate
Valuation Price	Closing Price of the Underlying on the Expiration Date
Listing	Frankfurt, Stuttgart (Third Section)

Appendix 2: Example of a capped Performance Certificate

The example of the *capped* certificate in Appendix 2 was issued by UBS using Nokia as the *underlying asset*. The *fixing date* (or *pricing date*) UBS set for the certificate was July 12, 2004 and the *issue price* of the certificate (i.e. the closing stock price on the *pricing date*) was €11.59. The date that an investor must make the payment for the purchase of the certificate (known as the *payment date*) was July 14, 2004. The *expiration date* (i.e. the date on which the closing price of the underlying asset will be used as the *valuation price*) was set on July 14, 2006 with a term to expiration of two years. The *performance factor* for the certificate was set 200%. The *cap level* (the maximum *valuation price* to be used for calculating the *redemption value* (also known as *settlement amount*) of the certificate) was set at €14.80, which would generate a net return of 55.39%.

UBS Investment Bank

Speeder on NOKIA OYJ

Underlying: Valor: 945657; ISIN: DE0007100000; Reuters: DCXGn.DE; Bloomberg: DCX GY

Product Details

Underlying	NOKIA OYJ
Reference Price	EUR 11.59
Issue Price	EUR 11.59
Strike Price (Pb)	EUR 11.59
Cap Level (C)	EUR 14.80
Conversion	1:1
Maximum Return	55.3925798 %
Secutirity No.	ISIN: CH0018906567

Dates

Issue Date	28.06.2004
Pricing Date	12.07.2004
Payment Date	14.07.2004
Last Trading Day	12.07.2006
Expiration Date	14.07.2006
Redemption Date	21.07.2006

General Information

Issuer	UBS AG, London Branch
Lead Manager	UBS Limited
Issue Size	500,000
Redemption	- Physical settlement of Underlying if Underlying at Expiration closes lower than Strike Price. - If the closing price of the Underlying at Expiration is higher than or to the Strike Price but lower than the Cap Level, the Holder of 1 Certificate receives a settlement amount which is calculated as follows: A = [S + 2 * (CP – S)] * R Where: A = Settlement Amount; S = Strike Price; CP = Closing Price of the Underlying on the Expiration Date; R = Ratio. - If the underlying Share at Expiration closes higher than or at the Cap Level, the Holder of 1 Certificate receives a settlement amount which is calculated as follows: A = [S + 2 * (C – S)] * R Where: C = Cap Level.
Listing	Frankfurt, Stuttgart (Third Section)

Appendix 3

In this Appendix, we show that the payoff of an uncapped Outperformance Certificate is the same as the combined payoffs of the following three positions:

1. A long position in 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 the underlying asset and the maturity dates are the ex-dividend dates of cash dividends;
3. A long position in call options on the underlying asset. The number of options is the performance factor minus one (PF-1). The exercise price of the options is I_0 and the term to expiration of the options is T, the same as the term to maturity of the certificate.

The redemption value, from Equation (1), for holding one *uncapped* Outperformance Certificate, V_T, is:

$$V_T = \begin{cases} I_0 \times \left[1 + PF\dfrac{(I_T - I_0)}{I_0}\right] & \textit{if } I_T > I_0 \\ I_0 \times \left[1 + \dfrac{(I_T - I_0)}{I_0}\right] & \textit{if } I_T \le I_0 \end{cases}$$

$$= \begin{cases} I_0 + PF\,(I_T - I_0) & \textit{if } I_T > I_0 \\ I_0 + (I_T - I_0) & \textit{if } I_T \le I_0 \end{cases}$$

If we define APF (*additional performance factor*) as performance factor minus one, i.e. APF ≡ (PF – 1), then

$$V_T = \begin{cases} I_0 + (1 + APF)(I_T - I_0) & \textit{if } I_T > I_0 \\ I_T & \textit{if } I_T \le I_0 \end{cases}$$

$$= \begin{cases} I_0 + (I_T - I_0) + APF\,(I_T - I_0) & \textit{if } I_T > I_0 \\ I_T & \textit{if } I_T \le I_0 \end{cases}$$

$$= \begin{cases} I_T + APF\,(I_T - I_0) & if\, I_T > I_0 \\ I_T & if\, I_T \le I_0 \end{cases}$$

$$= I_T + \begin{cases} APF\,(I_T - I_0) & if\, I_T > I_0 \\ 0 & if\, I_T \le I_0 \end{cases}$$

$$= I_T + \text{Max}\left[0;\, APF\,(I_T - I_0)\right]$$

$$= I_T + APF\ \text{Max}\left[0; I_T - I_0\right]$$

$$= I_T + APF \times \text{Max}\left[0; I_T - I_0\right] \tag{A3-1}$$

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 Outperformance Certificates do *not* pay cash dividends, the payoff I_T in Equation (A3-1) 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 $\text{Max}\left[0, I_T - I_0\right]$ in Equation (A3-1) is the payoff of a long position for a call on the underlying asset with an exercise price I_0. So the payoff for investing in one Outperformance Certificate is the same as the combined payoffs of taking the three positions given at the beginning of the Appendix.

Appendix 4

In this Appendix, we show that the payoff of a capped Outperformance Certificate is the same as the combined payoffs of the following four positions:

1. A long position in the underlying asset and
2. A short position in zero coupon bonds. The face values of the zero coupon bonds are the cash dividends to be paid by the underlying asset and maturity dates of the bonds are the ex-dividend dates.
3. A long position in call options on the underlying asset. The number of calls is the performance factor minus one (PF-1). The exercise price of the options is I_0 and the term to expiration of the options is T, the same as the term to maturity of the certificate.
4. A short position in call options on the underlying asset with an exercise price of I_C and the term to expiration of T. The number of calls is the performance factor (PF).

The redemption value, from Equation (2), for holding one *capped* Outperformance Certificate, V_T, is:

$$V_T = \begin{cases} I_0 \times \left[1 + PF\dfrac{(I_C - I_0)}{I_0}\right] & if\, I_T > I_C \\ I_0 \times \left[1 + PF\dfrac{(I_T - I_0)}{I_0}\right] & if\, I_0 < I_T \le I_C \\ I_0 \times \left[1 + \dfrac{(I_T - I_0)}{I_0}\right] & if\, I_T \le I_0 \end{cases}$$

$$= \begin{cases} I_0 + PF(I_C - I_0) & if\, I_T > I_C \\ I_0 + PF(I_T - I_0) & if\, I_0 < I_T \le I_C \\ I_0 + (I_T - I_0) & if\, I_T \le I_0 \end{cases}$$

If we define APF (*additional performance factor*) as performance factor minus one, i.e.

APF ≡ (PF – 1), then

$$V_T = \begin{cases} I_0 + (1+APF)(I_C - I_0) & if\, I_T > I_C \\ I_0 + (1+APF)(I_T - I_0) & if\, I_0 < I_T \le I_C \\ I_T & if\, I_T \le I_0 \end{cases}$$

$$= \begin{cases} I_0 + (I_C - I_0) + APF\,(I_C - I_0) & if\, I_T > I_C \\ I_0 + (I_T - I_0) + APF\,(I_T - I_0) & if\, I_0 < I_T \le I_C \\ I_T & if\, I_T \le I_0 \end{cases}$$

$$= \begin{cases} I_C + APF\,(I_C - I_0) & if\, I_T > I_C \\ I_T + APF\,(I_T - I_0) & if\, I_0 < I_T \le I_C \\ I_T & if\, I_T \le I_0 \end{cases}$$

$$= \begin{cases} I_T - (I_T - I_C) + APF\,(I_C - I_0) & if\, I_T > I_C \\ I_T + APF\,(I_T - I_0) & if\, I_0 < I_T \le I_C \\ I_T & if\, I_T \le I_0 \end{cases}$$

$$= I_T + \begin{cases} -(I_T - I_C) + APF\,(I_C - I_0) & if\, I_T > I_C \\ APF\,(I_T - I_0) & if\, I_0 < I_T \le I_C \\ 0 & if\, I_T \le I_0 \end{cases}$$

$$= I_T + \begin{cases} APF\,(I_T - I_0) - (I_T - I_C) - APF\,(I_T - I_C) & if\, I_T > I_C \\ APF\,(I_T - I_0) & if\, I_0 < I_T \le I_C \\ 0 & if\, I_T \le I_0 \end{cases}$$

$$= I_T + \begin{cases} APF\,(I_T - I_0) - PF\,(I_T - I_C) & if\, I_T > I_C \\ APF\,(I_T - I_0) & if\, I_0 < I_T \le I_C \\ 0 & if\, I_T \le I_0 \end{cases}$$

$$= \left[I_T + \text{Max}[0; APF\,(I_T - I_0)] - \text{Max}[0; PF\,(I_T - I_C)]\right]$$

$$= \left[I_T + \text{Max}[0; APF\,(I_T - I_0)] - \text{Max}[0; PF\,(I_T - I_C)]\right]$$

$$= \left[I_T + APF\ \text{Max}[0; (I_T - I_0)] - PF\ \text{Max}[0; (I_T - I_C)]\right] \qquad \text{…(A4-1)}$$

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 Outperformance Certificates do *not* pay cash dividends, the payoff I_T in Equation (A4-1) can be duplicated by taking a *long* position in the underlying asset, and a *short* position on zero coupon bonds of which the face values are equal to the amount of dividends and the maturity dates are the ex-dividend dates.

The payoff $\text{Max}\left[0;(I_T - I_0)\right]$ in Equation (A4-1) is the payoff of a *long* position for a call on the underlying asset with an exercise price I_0 and the payoff $-\text{Max}\left[0;(I_T - I_C)\right]$ in Equation (A4-1) is the payoff of a short position for a call on the underlying asset with an exercise price of I_C. Therefore, the payoff for investing in one *capped* Outperformance Certificate is the same as the combined payoffs of taking the four positions given at the beginning of the Appendix.