

UNIVERSITÁ BOCCONI SPECIALIZED MASTER IN QUANTITATIVE FINANCE AND RISK MANAGEMENT

Derivatives Assignment

COMMERZBANK INVESTMENT CERTIFICATE EVALUATION

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1 Introduction

This report provides a detailed quantitative and qualitative evaluation of an investment certificate issued by Commerzbank on April 25, 2014, with a maturity date of April 25, 2018. The certificate is based on the Commerzbank Efficiency Growth Index and the Index itself is based on the Efficiency Growth Fund, a mutual fund created with the aim of achieving a target volatility level by strategically leveraging the investments in the fund within predefined constraints.

The report is structured in two parts: a quantitative analysis and a qualitative assessment. The quantitative section applies the Black-Scholes model to evaluate the fair value of the certificate at issuance, at the end of each month until maturity and on the redemption date. The second part will consist of a qualitative analysis.

2 Quantitative Analysis

A certificate essentially functions as a call option on the underlying Index, as it gives the holder exposure to the Index's positive performance without requiring full ownership of the Index itself. Therefore, to evaluate the certificate, we used an option pricing model, such as the renowned Black-Scholes model, to compute its fair value.

2.1 Methodology

To perform a quantitative evaluation of the certificate using the Black-Scholes model, we first identified and calculated all the components required to apply the formula. We began by calculating the daily values of the Efficiency Growth Index starting from April 14, 2024, to ensure sufficient data for the necessary computations. The values were determined using data from the Efficiency Growth Fund and the formula presented in Equation (1),

$$Index_{t} = Index_{t-1} \times \left(1 + W_{t-1} \left(\frac{Basket_{t}}{Basket_{t-1}} - 1\right) + (1 - W_{t-1}) \times Rate_{t-1} \times \frac{Act_{t,t-1}}{Conv}\right)$$
(1)

where,

- $\mathbf{Index_t}$, is the value of the Efficiency Growth Index at time t, starting with an initial value $\mathbf{Index_0} = 100$.
- W_{t-1} , is the weighting of the Basket on the immediately preceding Index calculation date.
- Basket_t, is the value of the Efficiency Growth Fund at time t.
- $Rate_{t-1}$, is the reference interest rate at time t-1, more specifically Euribor 1M was used.
- $Act_{t,t-1}$, represents the day count between consecutive Index calculation dates.
- Conv, is the year conversion factor equal to 360.

As outlined in Equation (1), the daily Index values were calculated by first determining the weighting of the Basket in the Index, W_t . The weighting depends on the realized volatility, as the Index aims to enhance the yield of the underlying fund through leverage. Therefore, we first calculated the realised volatility using the following equation,

$$\text{RealisedVol}_{t-\text{lag}} = \sqrt{\frac{252}{20}} \times \sqrt{\sum_{k=1}^{20} \left(\ln \left(\frac{Basket_{t-n+k-\text{lag}}}{Basket_{t-n+k-1-\text{lag}}} \right) \right)^2 - \frac{1}{n} \left(\sum_{k=1}^{20} \ln \left(\frac{Basket_{t-n+k-\text{lag}}}{Basket_{t-n+k-1-\text{lag}}} \right) \right)^2}$$
(2)

where we set n, the volatility window, equal to 20 which corresponds to the number of days used to calculate the realised volatility. We used 252 as the annualising factor, which represents the expected number of Index calculation dates in each calendar year and lastly, Lag corresponds to a lag factor of 2 days. To address the issue of missing data on days when the Luxembourg market was closed, we decided to exclude these dates from our analysis to maintain a consistent and reliable time series for both the Efficiency Growth Index and the corresponding interest rate variables.

In addition, the weight was adjusted daily based on the realised volatility and a target volatility of 6%, using the following formula,

$$W_t = \min\left(\text{MaxW}, \frac{\text{TargetVol}}{\text{RealisedVol}_{\text{t-lag}}}\right)$$
 (3)

where MaxW represents the maximum weight of the risky asset in the Index, capped at 150%.

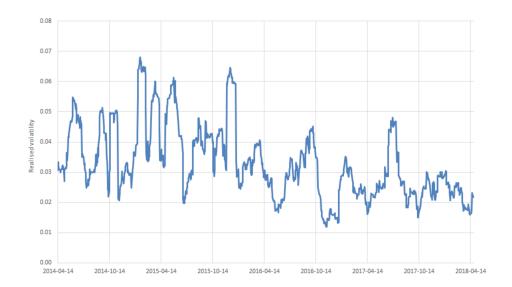


Figure 1: Realised volatility

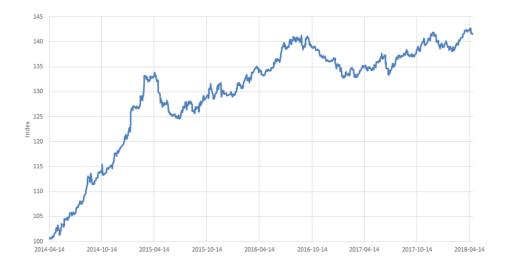


Figure 2: Index

2.2 Fair price valuation

Given the functional form of its payoff, the certificate can be considered as an European Call option with underlying S_t and strike price K given by:

$$K = CA$$

$$S_t = CA \left(\frac{\text{Index}_t}{\text{Strike}} (1 - 1.1\%)^4 \right)$$
(4)

where CA = 1000.

As a result, the fair price of the certificate was calculated using the Black-Scholes formula:

$$C = SN(d_1) - Ke^{-rT}N(d_2)$$

$$\tag{5}$$

where

$$d_1 = \frac{\ln(\frac{S}{K}) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$
(6)

- **C** is the price of the call option.
- T is the time to maturity, expressed in years.
- r the risk-free interest rate.
- σ the annualized volatility of the underlying asset.
- \bullet N(d) the cumulative distribution function of the standard normal distribution.

The risk-free interest rate r_t for a given time t was estimated from the interest rate data provided by linear interpolation. More precisely, denoting with T_t the time to the certificate maturity at time t and with $r_{0,t}$ and $r_{1,t}$ the provided interest rates at time t associated with the closest time horizons to T_t , the estimated risk-free rate was obtained using the following formula,

$$r_t = r_{0,t} + \frac{r_{1,t} - r_{0,t}}{T_{1,t} - T_{0,t}} (T_t - T_{0,t})$$

$$\tag{7}$$

where $T_{0,t}$ and $T_{1,t}$ are the time horizons associated to $r_{0,t}$ and $r_{1,t}$ respectively.

The daily volatility σ_d of the underlying S is given by the following expression,

$$\sigma_d^2[S] = \operatorname{Var}\left[\frac{S_t - S_{t-1}}{S_{t-1}}\right]$$

$$= \operatorname{Var}\left[\frac{\operatorname{Index}_t}{\operatorname{Index}_{t-1}}\right]$$

$$= \operatorname{Var}\left[W_{t-1}\left(\frac{\operatorname{Fund}_t}{\operatorname{Fund}_{t-1}} - 1\right) + (1 - W_{t-1})r_{t-1}\frac{\operatorname{Act}_{t,t-1}}{\operatorname{conv}}\right]$$
(8)

which can be estimated by calculating the sample variance of the Efficiency Growth Index daily returns. These quantities depend on three key data sources:

- Efficiency Growth Fund daily quotes, available for the period July 13, 2011, to April 25, 2018.
- $Act_{t,t-1}$, available for the period April 15, 2014, to April 25 2018.
- Euribor 1M daily quotes, available for the period April 1, 2014, to April 25, 2018.

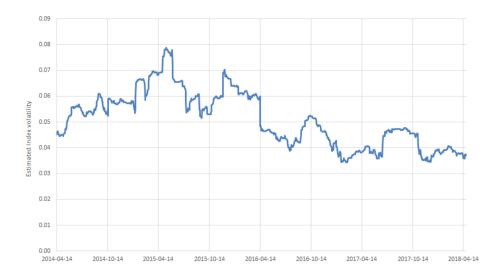


Figure 3: Estimated Index volatility

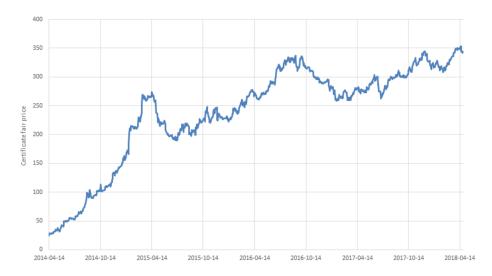


Figure 4: Certificate fair price

As a result, the fair price valuation of the certificate at inception would have been calculated using a value for σ_d estimated with a sample size equal to only 10, which was considered to be too small. With the aim of estimating the value of the daily volatility, for any given date, with a sample size equal to 90, the missing values for ${\rm Act}_{t,t-1}$ and Euribor 1M were estimated. In particular, ${\rm Act}_{t,t-1}$ was calculated for the period from November 13, 2013 to March 31, 2014, considering the dates of the Efficiency Growth Fund quotes. Euribor 1M values, instead, were assumed to be constant in the period from November 6, 2013 to March 31, 2014 and equal to the value recorded on April 1, 2014. Although this approximation introduces some inaccuracy, we considered it acceptable since, in Equation (8), the term depending on the value of the interest rate is expected to be negligible with respect to the term depending on the Efficiency Growth Fund return. More precisely, the ratio between such terms can be written as follows:

$$\frac{(1 - W_{t-1})r_{t-1}\frac{\operatorname{Act}_{t,t-1}}{\operatorname{conv}}}{W_{t-1}\left(\frac{\operatorname{Fund}_{t}}{\operatorname{Fund}_{t-1}} - 1\right)} \approx \frac{(1 - W_{t-1})1\%\frac{1}{360}}{W_{t-1}\left(\frac{\operatorname{Fund}_{t}}{\operatorname{Fund}_{t-1}} - 1\right)} \approx \frac{1 - W_{t-1}}{W_{t-1}}\frac{1}{36000\left(\frac{\operatorname{Fund}_{t}}{\operatorname{Fund}_{t-1}} - 1\right)} \ll 1.$$
 (9)

For each date, the annualized volatility was retrieved multiplying the value of the daily volatility by the factor $\sqrt{252}$.

2.3 Sensitivity Analysis

To assess the sensitivity of the estimated fair prices to the parameters of the Black-Scholes formula, the Greeks Delta, Rho and Vega were calculated. The values obtained at certificate issuance, April 25, 2014, are reported below:

$$\delta \approx 0.47, \qquad \nu \approx 763, \qquad \rho \approx 1684.$$
 (10)

The values of ν and ρ are particularly relevant, since they allow to quantify the impact of the volatility and the interest rate, quantities which were not readily available but that had to be estimated as discussed above. In particular, the obtained values indicate that:

- 1. A change of 0.01 units in the value of the volatility results in a change of EUR 7.63 in the estimated fair price of the certificate;
- 2. A change of 0.001 units in the value of the interest rate results in a change of EUR 1.68 in the estimated fair price of the certificate.

2.4 Black-Scholes Assumptions

Since we use the Black-Scholes model for the valuation of the call option and, consequently, the certificate, it is essential to carefully assess the validity of the model's key assumptions to ensure there are no violations and to evaluate how any deviations from these assumptions could impact the valuation.

2.4.1 Normality and independence of log-returns

Since in the Black-Scholes model the stock price follows a geometric Brownian motion, the log-returns are assumed to be independent and normally distributed. To highlight possible deviations from the normality assumption, the QQ-plot was computed.

From Figure 5, we can conclude that the log-returns follow a distribution characterized by high kurtosis and, therefore, heavier tails than the Normal distribution. As a result, the model underestimates the probability of extreme events, namely, large price movements of the underlying. Since the payoff of a call option cannot be negative, the right tail of the stock log-returns distribution cannot be neglected, while extreme negative price movements are not particularly relevant. In particular, underestimating extreme positive price movements leads to the underestimation of the call price.

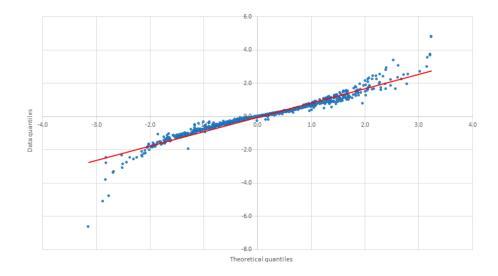


Figure 5: QQ plot

2.4.2 Absence of Dividends

The underlying asset of the certificate is the Index, which, as previously described and represented in Equation 1, is a combination of the interest rate and the fund. According to the fund's Key Investor Information Document (KIID), it does not distribute any dividends. Therefore, the assumption of no dividends in the Black-Scholes model remains valid.

2.4.3 Constant risk-free interest rate

In the Black-Scholes model the risk-free interest rate is assumed to be known and constant for all maturities. These assumptions are clearly violated in our case since, for every relevant date, we estimated the risk-free rate computing the linear interpolation of known rates, namely Euribor rates or Swaps rates, depending on the maturity. This implies that the value of the interest rate used in the Black-Scholes model was not exact nor constant, causing potential inaccuracies in the estimated option price.

2.4.4 Constant Volatility

To guarantee a closed-form solution to the Black-Scholes equation, the model assumes that implied volatility remains constant throughout the option's life. However, while we cannot draw definitive conclusions about the relationship between volatility and strike prices based on a single option, it is evident that this assumption is violated in our analysis, as the volatility does not remain constant over time. Throughout our analysis, we relied on the implied volatility values previously outlined in the report. As illustrated in the implied volatility graph in Figure 3, the fluctuations over the life of the option are apparent. Volatility peaked at 0.08 in April 2015, with a low point slightly below 0.04 in April 2018. This violation of the constant volatility assumption has a clear impact on the fair price of the option, representing a notable limitation in our analysis that requires further investigation.

2.4.5 No Taxes and Transaction Costs

The final key assumption for our analysis is the absence of transaction costs and taxes. As stated in the KIID, there is no protection fee associated with the certificate. The only stated cost is an annual commission of 1.43% for investing in the Efficiency Growth Fund. However, due to the nature of the certificate, Commerzbank is not required to purchase the fund to replicate the Index. As a result, this commission was excluded from the option's payoff calculation.

Consequently, the only potential costs are transaction fees incurred when trading the instrument on Borsa Italiana. These costs introduce a minor deviation in the derivation of the Black-Scholes formula, which can affect the accuracy of the computed fair price of the option. The extent of this effect varies across different markets and market participants, making precise evaluation very difficult.

3 Qualitative Analysis

3.1 Investor's viewpoint

In this section, we explain from the investor's perspective why and when this certificate could be a good investment, as well as the risks and costs associated with it.

Since this certificate is a call option, one of its advantages is that it offers the possibility of investing with limited cost—an investor cannot lose more than the cost of the certificate.

Although the payoff structure is straightforward—payment at maturity depends on predefined values and the index value, which is the only source of uncertainty—the complexity of the index structure makes this certificate unattractive to unprofessional investors. Thus, retail investors are unlikely to purchase it.

The index provides exposure to the underlying fund, which primarily invests in fixed-income instruments, and to the 1-month Euribor rate. As a result, interest rate changes are the primary driver of the certificate's value. However, since purchasing this illiquid certificate involves high commissions, there are simpler ways to speculate on interest rate movements (e.g., interest rate swaps, which are far more liquid). Therefore, companies seeking exposure only to interest rate changes would likely opt for a simpler and less costly approach. Thus, we believe that purchasing the certificate could

be a good investment only for someone who believes in the growth of the index and wants positive exposure with limited potential losses, or for someone looking to hedge the risk associated with the index growth.

The key risks associated with this investment are:

- 1. Market Risk: The certificate is an option whose payout depends on index performance. If the index underperforms, the investor will receive a low payout upon expiration, resulting in a negative profit;
- 2. Liquidity Risk: Only a small number of certificates are issued, and the product is unpopular and complex. If an investor wants to sell the certificate before its expiration, they will need to pay a significant premium due to low liquidity. The liquidity is so limited that investors probably will hold the certificate until maturity;
- 3. Counterparty Risk: Since the investor is buying a call option from Commerzbank, there is a risk that the bank may default and fail to make the payout at the expiration date.

The primary cost for investors is the commission paid to the issuer. By commission we mean the difference between the fair price and the selling price of the certificate. Due to the certificate's illiquidity and complexity, the issuer charges a significant commission. The price of the certificate is EUR 90.00, while the fair price is estimated to be around EUR 29.31 that is more than 3 times higher.

Additionally, as stated in paragraph 7 of the Terms and Conditions of the Base Prospectus, all fees, taxes, and duties must be paid by the investor.

3.2 Issuer's viewpoint

In this section, we explain the benefits of issuing the certificate and the sources of revenue related to it. Since the issuer sells a call option, the only source of profit is the premium paid upfront. This premium contains a significant margin—the difference between the selling price (EUR 90.00) and the estimated fair price (EUR 29.31). With 30,000 certificates issued, the estimated revenue for the issuer is EUR 1,820,700.

By selling a call option, the issuer gets a negative Delta and negative Gamma exposure. The bank must dynamically hedge this position to mitigate risks. For instance, the bank could purchase the underlying asset to hedge Delta exposure. Alternatively, since interest rate changes are the primary driver of the index value, the bank might hedge using interest rate derivatives. In any case, hedging involves costs. However, we believe these costs are lower than the significant margin gained from issuing the certificates, making the issuance profitable for the bank.

3.3 Conclusion

To summarize, ex ante the high commissions make this investment attractive only in specific cases, such as when an investor needs to hedge negative Delta and Gamma exposure to the index or when the investor has a strong belief in high index performance and wants to bet on it with limited costs.

For the issuer, we conclude that issuing this certificate was profitable due to the high margins. From the final payout, we can see that it was also a profitable investment for the investor.



Key investor information

This document provides you with key investor information about this Fund. It is not marketing material. The information is required by law to help you understand the nature and the risks of investing in this Fund. You are advised to read it so you can make an informed decision about whether to invest.

EURO GLOBAL BOND, a compartment of EFFICIENCY GROWTH FUND

Share Class: P EUR, (Accumulation) LU0622616760

This SICAV is managed by Pharus Management Lux S.A.

Objectives and investment policy

The objective of this Fund is to over-perform the European investment grade fixed income market.

The Fund mainly invests in a diversified portfolio of bonds and any other debt securities (including money market instruments), denominated in Euros. The choice of investment will not be limited geographically, nor by economic sector. The Fund may use derivative techniques and instruments for hedging and for any other purposes.

The Fund will not invest in open-ended undertakings for collective investment.

Investments in debt securities, within the meaning of Council Directive 2003/48/EC ("EU Savings Directive") on the taxation of savings income, may exceed 25% of the Fund's net assets. It is therefore presently expected that capital gains realized by investors on the disposal of shares in the Fund may be subject to the reporting or withholding requirements imposed by the EU Savings Directive.

The investor can buy or sell shares of the Fund on any day which is a Valuation Date in line with the provisions in the prospectus.

The Net Asset Value is calculated on every day which is a bank business day in Luxembourg.

Recommendation: This Fund is suitable for investors who are willing to accept an investment horizon of at least 3 to 5 years.

This share class is not distributing dividends.

The currency of the Fund is EUR and the share class currency is EUR.

Risk and reward profile



This indicator represents the annual historical volatility of the Fund over a 5-year period.

Risk Category 3 reflects limited potential gains and/or losses for the portfolio. This is due to investments in bonds on the worldwide market.

This current risk profile is based on historical data and may not be a reliable indication of the future risk profile of the Fund.

The risk category shown is not guaranteed and may shift over time. The lowest category does not mean "risk free".

The Fund does not apply any capital guarantee or asset protection measures.

Significant risk(s) for the Fund not taken into account in this indicator include the following:

Concentration risk: To the extent that the Fund's investments are concentrated in a particular country, market, industry or asset class, the Fund may be susceptible to loss due to adverse occurrences affecting that country, market, industry or asset class.

Credit risk and interest rate risk: The Fund invests in bonds, cash or other money market instruments. There is a risk that the issuer may default. The likelihood of this happening will depend on the credit-worthiness of the issuer. The risk of default is usually greatest with bonds that are rated as sub-investment grade. An increase in interest rates may cause the value of fixed-income securities held by the Fund to decline. Bond prices and yields have an inverse relationship, when the price of a bond falls the yield rises.

Derivative for hedging purpose: The use of derivatives for hedging in a rising market may restrict potential gains.

Emerging market risk: The Fund may invest in developing overseas markets which carry a higher risk than investing in larger established markets. Investments in emerging markets are likely to experience greater rises and falls in value and may suffer trading problems.

Charges

The charges and commissions are used to cover the Fund's operating costs, including marketing and distribution of shares. These charges reduce the potential growth of your investment.

otential one-off charges taken before or after you invest		
Entry charge	5.00%	
Exit charge	3.00%	
This is the maximum that might be t invested and before the proceeds of	,	
Charges taken from the Fund ove	r a year	
Ongoing charges	1.43%	
Charges taken from the Fund under specific conditions		
Performance fee	None	

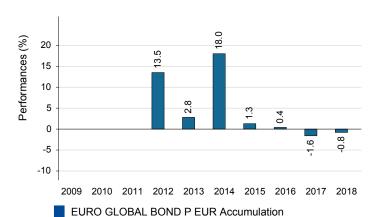
The entry and exit charges shown are maximum rates. In certain cases, the charges paid may be lower.

The ongoing charges figure is based on expenses for the previous year, ending on 31 December 2018. This figure may vary from year to year. It excludes portfolio transaction costs, except in the case of an entry/exit charge paid by the Fund when buying or selling shares in another collective investment undertaking.

A conversion commission 1% maximum of the net asset value may be charged.

For more information about charges, please refer to the Fund's prospectus, section charges, which is available on www.pharusmanco.lu and on www.egfund.it or at the registered office of the Fund.

Past performance



The performance figures shown in the bar chart are not a reliable indication of future performance.

Fund creation date: 2011 Share class launch date: 2011 Base currency: Euro.

Practical information

Depositary: CACEIS Bank, Luxembourg Branch

Efficiency Growth Fund is an umbrella fund, consisting of separate compartments, each issuing one or more share classes. For more information about other share classes please refer to the prospectus and periodic reports.

This key investor information document is prepared for a share class.

Assets and liabilities of each compartment of Efficiency Growth Fund are segregated, meaning that your investment in one compartment is only impacted by profits and loss in this compartment.

The details of the up-to-date remuneration policy of Pharus Management Lux S.A., are available on www.pharusmanco.lu/en/documents/documents/. A paper copy will be made available free of charge upon request.

More detailed information on this Fund, such as the full prospectus as well as the latest annual and semi-annual report, the statutes, and investor information, can be obtained, in English, free of charge from Pharus Management Lux S.A., 16, avenue de la Gare, L-1610 Luxembourg, Grand-Duchy of Luxembourg or on its website: www.pharusmanco.lu and at www.egfund.it or at the registered office of the Fund.

Any shareholder may request the conversion of all or part of his shares in one compartment into shares of another compartment, on the basis of the respective net asset value as calculated on the valuation day of the compartments concerned.

The Net Asset Value per share is calculated daily and is available on www.egfund.it, www.fundsquare.net and at the registered office of the Fund.

The Fund is subject to the tax laws and regulations of Luxembourg. Depending on your own country of residence, this might have an impact on your investments. For further details please consult a tax adviser.

The Management Company may only be held liable on the basis of any statement contained in this document that is misleading, inaccurate or inconsistent with the relevant parts of the prospectus for the Fund.

Efficiency Growth Fund is authorized in Luxembourg and is supervised by the Commission de Surveillance du Secteur Financier (CSSF). The Management Company is authorized in Luxembourg and is supervised by the Commission de Surveillance du Secteur Financier (CSSF). This key investor information is accurate as at 14 February 2019.

COMMERZBANK AKTIENGESELLSCHAFT

Frankfurt am Main

Final Terms

dated 14 April 2014

relating to

Certificates

Certificates relating to the Commerzbank Efficiency Growth Index ISIN DE000CZ37TL7

to be publicly offered in the Italian Republic and to be admitted to trading on the regulated market of Borsa Italiana S.p.A. (SeDeX)

with respect to the

Base Prospectus

dated 5 March 2014

relating to

Italian Certificates relating to a Proprietary Index



INTRODUCTION

These Final Terms have been prepared for the purpose of Article 5 (4) of Directive 2003/71/EC (the "Prospectus Directive") as amended (which includes the amendments made by Directive 2010/73/EU (the "2010 PD Amending Directive") to the extent that such amendments have been implemented in a relevant Member State of the European Economic Area), as implemented by the relevant provisions of the EU member states, in connection with Regulation 809/2004 of the European Commission and must be read in conjunction with the base prospectus relating to Certificates (the "Base Prospectus") and any supplements thereto.

The Base Prospectus and any supplements thereto are published in accordance with Article 14 of Directive 2003/71/EC in electronic form on the website of Commerzbank Aktiengesellschaft at http://pb.commerzbank.com. Hardcopies of these documents may be requested free of charge from the Issuer's head office (Kaiserstraße 16 (Kaiserplatz), 60311 Frankfurt am Main, Federal Republic of Germany).

In order to obtain all information necessary for the assessment of the Certificates both the Base Prospectus and these Final Terms must be read in conjunction.

All options marked in the Base Prospectus which refer (i) to the Certificates and (ii) the underlying index and (iii) to information on the subscription period shall apply.

The summary applicable to this issue of Certificates is annexed to these Final Terms.

Issuer: Commerzbank Aktiengesellschaft

Information on the Underlying: Information on the Index underlying the Certificate is available

on Bloomberg ticker CBKSEFFE Index.

Offer and Sale: Commerzbank offers from 14 April 2014 30,000 Certificates

relating to the Commerzbank Efficiency Growth Index (the "Certificates") at an initial issue price of EUR 90 per Certificate.

The Certificates will be sold and traded by the Issuer only through the regulated market of Borsa Italiana S.p.A. (Mercato Telematico of securitised derivatives ("SeDeX") starting from the date established by Borsa Italiana S.p.A. in a public notice.

Consent to the usage of the Base Prospectus and the Final Terms:

The Issuer hereby grants consent to use the Base Prospectus and these Final Terms for the subsequent resale or final placement of the Certificates by any financial intermediary.

The offer period within which subsequent resale or final placement of Certificates by financial intermediaries can be made, is valid only as long as the Base Prospectus and the Final Terms are valid in accordance with Article 9 of the Prospectus Directive as implemented in the relevant Member

State.

The consent to use the Base Prospectus and these Final Terms is granted only in relation to the following Member State(s):

Italian Republic

Payment Date: 25 April 2014

Clearing number: WKN CZ37TL

ISIN DE000CZ37TL7

Issue Currency: Euro ("EUR")

Minimum Trading Size: One Certificate

Listing: The Issuer intends to apply for the listing and trading of the

Certificates on the regulated market of Borsa Italiana S.p.A.

(Mercato Telematico of securitised derivatives ("SeDeX").

Applicable Terms and

Conditions:

Type A