universität wien

MASTERARBEIT

Titel der Masterarbeit

FX Option Strategy Indicator

Verfasser

Martin Ružek

Angestrebter akademischer Grad

Master of Science (MSc)

Wien, 2014

Studienkennzahl lt. Studienblatt:	A 066 920
Studienrichtung lt. Studienblatt:	Masterstudium Quantitative Economics, Management and Finance
Betreuer:	ao. Univ.-Prof. Dipl.-Ing. Dr. Erhard Reschenhofer

Eidesstaatliche Erklärung

“Ich erkläre hiermit in Eides Statt, dass ich die vorliegende Arbeit selbstständig und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus fremder Quelle direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht. Die Arbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.“

....

(Datum) (Unterschrift)

Acknowledgment

In the first place I would like to thank my advisor Erhard Reschenhofer from the Department of Statistics and Operations Research at the University of Vienna, for his very quick, straightforward, and thoughtful advice, which made the writing of the thesis much easier and fun.

I want to express big thanks to my colleagues from Tatra Banka for their support and knowledge, which they were willing to share with me. Days spent with you opened my eyes and let me into the life of a trader on financial markets, which I was later able to convert into lines in this thesis.

Last, but the biggest thanks goes to my parents, without whose support and patience during my elementary, high school, and university life this moment would be impossible.

Abstract

This thesis develops a foreign currency option strategy indicator which is based on the hypothesis that extreme moves tend to be reversed later and therefore possibly create a speculative investment opportunity. Bollinger bands are used for the generation of signals to trade vanilla options with different maturities. The indicator is back-tested using daily data of EUR/USD, EUR/PLN, and USD/PLN currency pairs and traded options. The data are obtained from three different data bases and are completed with the help of Bloomberg's OVML function. The results of the back-testing show that trading strategies based on this indicator typically produce a large number of relatively small losses and a small number of very big gains. A detailed analysis of these results suggests that the indicator should be amended by the inclusion of a trend identification procedure and possibly also by elements of a fundamental analysis.

Keywords

Foreign currency options, option strategies, currency pair, Bollinger band, moving average, technical indicator

Zusammenfassung

Diese Magisterarbeit entwickelt einen Indikator für das Handeln von Wechselkursoptionen, dem die Vorstellung zugrunde liegt, dass extreme Ausschläge sich später abschwächen bzw. umkehren und damit spekulative Trading-Möglichkeiten schaffen. Zur Erzeugung von Signalen für das Handeln von Wechselkursoptionen mit verschiedenen Laufzeiten werden Bollinger Bänder verwendet. Der Indikator wird mit historischen Tagesdaten der Wechselkurse EUR/USD, EUR/PLN und USD/PLN und von gehandelten Optionen getestet. Die Daten stammen von drei verschiedenen Datenbanken und werden mit Hilfe der Bloomberg-Funktion OVML vervollständigt. Die empirischen Ergebnisse zeigen, dass Teststrategien, die auf diesem Indikator basieren, typischerweise viele kleine Verluste und wenige große Gewinne produzieren. Eine ausführliche Analyse der Ergebnisse legt nahe, den Indikator durch ein Verfahren zur Trendidentifikation und eventuell durch Elemente einer Fundamentalanalyse zu ergänzen.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

Greed and laziness are considered to be the main flaws of the human nature (Patterson, 1997). Some people argue that their existence is inevitable for evolution of the human kind in every aspect. There are many examples, where greed and laziness were the main substances of making a change in the way this world is functioning today. Without them improvement would be almost impossible, because they are the core catalyst of progress. The invention of electricity led to the invention of computers, whose algorithms are used in financial markets to simplify bankers' work and create opportunities to make even higher profit. Therefore greediness can be interpreted as the human inexhaustible determination of finding new ways of making money by investing and speculating. Ambitious forecasting models and trading algorithms are under constant development, with a goal to increase the value of the investment.

The two above mentioned flaws, are the main drivers of writing a thesis, which aims to create a model that simplifies traders' work and increases the possibility of making profit on any currency pair. The model seeks situations of strong one directional price movements and creates a signal, to trade a currency pair by the purchase of the vanilla option. The idea behind the model is that after a strong move the underlying currency pair tends to be either overbought or oversold, thus there is a big probability of a price correction.

Later in the paper the foreign currency option strategy indicator is back-tested and results are evaluated by using the foreign currency historical database. Based on these calculations, the paper stresses the importance of technical indicators and presents a new method of implementing strategies on the foreign exchange market, which uses only vanilla option trades.

The first part of the paper addresses the terminology, definitions, and trading advice that are an important substance of knowledge when discussing the functioning and the effectiveness of the foreign currency option strategy model. Chapter one includes detailed evaluation of vanilla options, explains option "Greeks" and its dynamics with respect to time lapse and price change, depicts payoff diagrams of different option types, and in the end it familiarizes the reader with option strategies that are used in the world of financial markets on regular basis.

Chapter three clarifies terms and parameters of models and algorithms that play an essential role in the technical analysis of financial data. The chapter focuses on the explanation of market trends, moving averages, and Bollinger bands. A fundamental

knowledge of technical indicators is inevitable for understanding the calculation processes incorporated in the foreign currency option strategy indicator.

The fourth chapter is dedicated to the introduction of the foreign currency option strategy indicator. The model is broken down to individual pieces and their functioning and calculations are precisely revealed. The strategy of holding a monthly, three weeks, two weeks, and a weekly option is combined with trade signals based on the Bollinger band indicator. Afterwards the model is back-tested on historical data of three currency pairs (EUR/USD, EUR/PLN, and USD/PLN). The yield curves of every back-tested strategy, which is used by the model, are compared and analyzed. After the evaluation of results additional modifications of processes are introduced in order to improve efficiency and profitability of the model.

In the fifth chapter, the results before and after the modification are compared and precisely analyzed. Additional findings are explained and further model modifications are proposed, the aim of which is to create more constant shape of a yield curve with even higher profitability.

The last chapter concludes all the important results based on the calculations from the previous chapters and suggests the final proposal for the further improvement of the foreign currency option strategy indicator.

2. OPTIONS

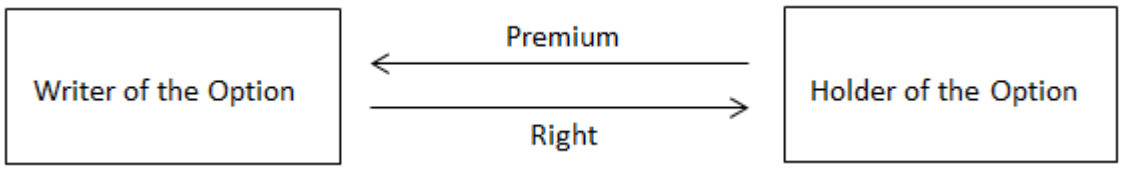
Options make an important category in the securities called derivatives. The value of an option contract is derived from the underlying asset. Currency options are very liquid financial derivatives that are being used all over the world. The elasticity of options' parameters, the possibility to trade the price direction, and the volatility makes option derivatives very popular. Options are derived from a wide range of underlying assets. The most popular assets are stocks, stock indexes, precious metals, currencies, government bonds, and futures contracts.

2.1. Foreign Exchange Options

According to the Finance Trainer International (Options, p. 3) the Foreign exchange option (FXO) gives the right - but not the obligation- to the option buyer to buy (or to sell) a defined currency amount (notional) at a before agreed rate (strike price) at the expiry date. This means, that the holder/owner has the right to exercise the option, if this gives him an advantage compared to the actual market value. The writer/seller of an option has the obligation to buy (or to sell) a defined currency amount at a strike price at an expiry date with a settlement date usually two days after the expiry date. The writer receives a premium on an exact premium pay date for this obligation.

It is important to mention that the owner of the option can let it expire, thus creates him a loss equal to the value of the price premium he paid at the beginning of the contract. In case the owner exercises the option, the writer suffers a loss equal to the difference between the FX spot price and the strike.

Figure 1: Option Transaction



2.1.1. Contract Specifications

An option contract consists of six specifications or terms: the option type, the underlying asset, the strike price, the expiration date, the exercise style, the contract unit (notional), the premium, the trade date, the premium payment date, and the settlement date. The Company Finance Trainer International defines the option contract specifications in the following way (Options, p. 4-5):

Option Type – Simple or Vanilla options can be either Call or Put. A call option gives the holder the right, but not the obligation, to buy the underlying asset at a predetermined price at an exact day and time. A put option provides the owner with the right, but not the obligation, to sell the underlying asset at a predetermined price at an exact day and time.

Underlying Asset – In this thesis we will elaborate only on the options, of which underlying assets are currency crosses (EUR-USD, EUR-PLN, and USD-PLN). The currency pairs show, how much of the quote/second currency is needed to buy one unit of the base/first currency. The underlying is the instrument; the buyer of the option has the right to buy.

Strike Price – The FX Option's strike price or the exercise price is a currency cross level at which the option owner/holder has the right but not the obligation to buy or sell the underlying.

Expiration Date – It is a predetermined last date and time, when the option owner/holder has the right to exercise the option.

Contract Unit (Notional) – The contract unit or the notional is the amount of the underlying asset that the option owner/holder can buy or sell for the strike price at the expiration date.

Premium – It is a price the buyer has to pay to the seller of the option.

Trade Date – A date when the option is dealt is called the trading date.

Premium Payment Date – It is the day, when the option has to be paid; usually it is two days after the trade date.

Settlement Date – For American options (can be exercised during the entire holing period) it is two bank days after the exercise date, and for European options (can be exercised only at the day of the expiration) it is two bank days after the expiration date.

2.1.2. Real Life Example

The best way to describe the above mentioned terminology is to provide a brief real life example from a trading floor. When dealer requests a market maker on the over-the-counter (OTC) market for a price, he types following line:

EUR CALL USD PUT N 100K EUR K 1.38 EXP 20/5/14 EUR %

This line contains all the important information about the option trade. The market maker understands that the dealer is interested in a call option on the EUR/USD currency cross with a contract size (notional) 100.000 EUR, the strike price is at 1.38 EUR/USD, expiration date is 20 May 2014, and the price premium is quoted in EUR percentage, which is calculated form the notional.

Market maker's answer to this request would be a line that contains a bid and an offer quote:

0.456 / 0.478 %

When the market maker quotes both sides of the price premium, dealer reveals his interest by typing: *I buy at 0.478%* or *I sell at 0.456%*.

The market maker confirms the traded price premium and both parties discuss contract details (premium payment date, settlement date…). Very often counterparties negotiate the price premium until both sides are satisfied with the outcome. In the foreign exchange market, options are not quoted in prices but rather in values of implied volatility. The next chapter is dedicated to the price premium calculations.

2.1.3. Value of an Option

In 1973 Fisher Black and Myron S. Scholes derived and published the most famous and widely used formula for determining the prices of the European-style option. The Black-Scholes option pricing model assumes, under certain assumptions, that the underlying asset price movements are calculated by a statistical process known as the *Geometric Brownian Motion* (Brown & Reilly, 2006, p. 912).

The methodology of the model is derived from the risk neutrality argument, which incorporates the idea that risk averse and risk neutral investors place the same price/value on an option if a riskless trade can be created by holding the options and the underlying asset. This method doesn't include the risk premium in the option price because the stock

price already contains it. The price of the underlying asset evolves according to the lognormal distribution. The lognormal distribution is used to derive the expected value of the option payoff. Due to the expected payoff at maturity this value has to be discounted in order to receive the current option value/premium. The above mentioned arguments allow the formula to be expressed only by one random state variable, the underlying asset's price. The other variables, which are a part of the formula, are observable and therefore treated as fixed parameters. The only random state variable in the Black-Scholes option pricing model is the volatility. Option traders tend to quote an option price in terms of the implied volatility. In 1998, Sorensen, Miller & Cox listed assumptions, under which the Black-Scholes model works:

- Underlying asset prices are subject to a log-normal distribution.
- Throughout the life of the option no dividends are paid.
- The annualized riskless interest rate is constant.
- Efficiency of the underlying market (can be traded continuously).
- Considering only European-style options.
- During the option period volatility of the underlying stays constant.

In order to receive a correct value of the European FX option, the Black-Scholes model, originally derived for stocks, has to be modified. In 1983 Garman and Kohlhagen derived a modification of Black-Scholes model, which converted volatilities to prices. Garman and Kohlhagen's formula is mathematically identical to the formula of dividend-paying stocks, which was derived by Merton in 1973. It is important to be aware of the fact that FX options are influenced by the interest rates of the base (domestic) currency as well as by the quoted (foreign) currency. Therefore the modern formula replaced stock's dividend yield by the foreign currency's continuous compounded risk-free interest rate.

Garman and Kohlhagen (1983) derived the value of the European FX Call and Put Option by using following formulas:

$$C = Se^{-qt}N(d_1) - Ke^{-rt}N(d_2) \quad (1)$$

$$P = Ke^{-rt}N(-d_2) - Se^{-qt}N(-d_1) \quad (2)$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - q + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}} \qquad d_2 = d_1 - \sigma\sqrt{t} \quad (3)$$

With:

C = European Call Option Value

P = European Put Option Value

S = Spot or currency exchange rate (base over quote)

K = Strike (exchange rate)

r = Domestic risk-free interest rate (continuously compounded)

q = Foreign risk-free interest rate (continuously compounded)

t = Time till option's expiration (in years)

σ = Implied volatility of underlying asset price (exchange rate price)

N = Cumulative normal distribution function

2.1.4. Volatility and Implied Volatility

Whether a historical or implied volatility (σ, sigma), it plays an important role in the calculation of the value of the option price. Historical volatility measures the price fluctuation on annual basis and is derived from the annualized standard deviation of the log-returns. Statistically it means that with a probability of 68.26% the value of underlying will stay in a range of plus or minus one standard deviation from the current price. Historical volatility is computed from the averaged log returns of daily price time (daily exchange rate close price) series. According to the Finance Trainer International Company, the formula for the annualized standard deviation is:

$$\hat{\sigma}_a = \sqrt{\frac{B}{N-1} \cdot \sum_{t=1}^{N} (r_i - \bar{r})^2}. \quad (4)$$

Where the factor B for annualization equals to

$$B = \frac{N}{k} \cdot d. \quad (5)$$

The sequence of log-returns is

$$r_i = \ln \frac{S_i}{S_{i-1}}. \quad (6)$$

The average log-return $\bar{r}$ is given by

$$\bar{r} = \frac{1}{N} \sum_{t=1}^{N} \ln \frac{S_i}{S_{i-1}}. \quad (7)$$

K = number of calendar days in the time series

D = number of calendar days in a year

S_i = time series

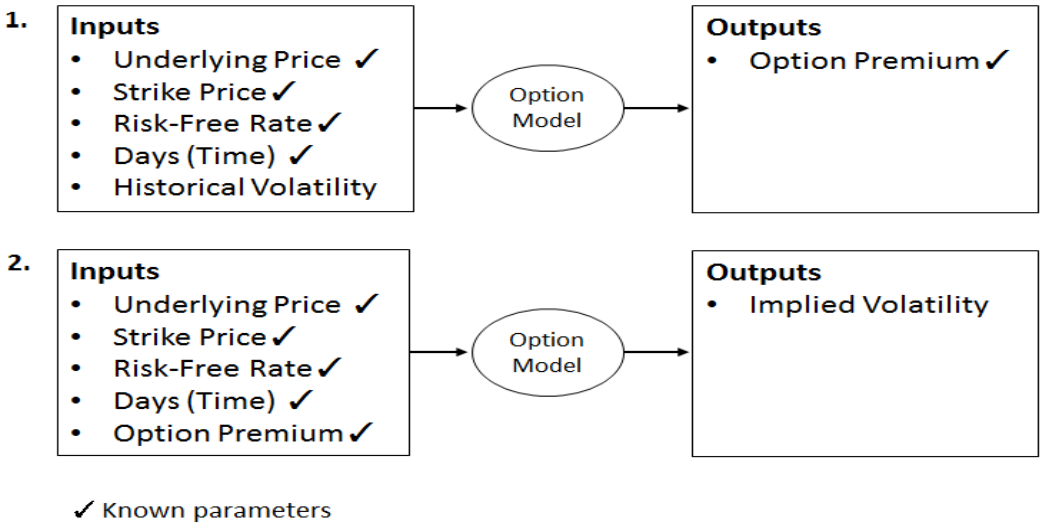
i = 1,…, N (Wystup, 2006, p. 30)

There exist two information sources on the volatility. We can obtain the volatility data from estimating a historic volatility, as shown above, or use active option markets. Traders quote volatility on liquid currency pair markets on daily basis. These quotes contain traders' views on the future volatility levels. If the volatility increases, the price of calls and puts increase, too. Due to continual change of volatility levels, option traders need to hedge their volatility exposure. Therefore we can expect volatility levels to be highly accurate with market's future expectations (U. Wystup, 2006, p. 31).

The implied volatility is deducted from the option price traded in the market. The implied volatility can be lower or higher than the historical one. We can refer to the implied volatility as a forward looking and to a historical as to a backward looking value (Internal material of Citi Bank, p. 52).

In order to receive an implied volatility from the Black-Scholes Model, one has to use the option price, or premium, as one of the known parameters, by replacing the volatility of the underlying. The output after the modification is the implied volatility. Following exhibits describe the deduction of the implied volatility by the above mentioned transformation.

Figure 2: Calculation of Implied Volatility

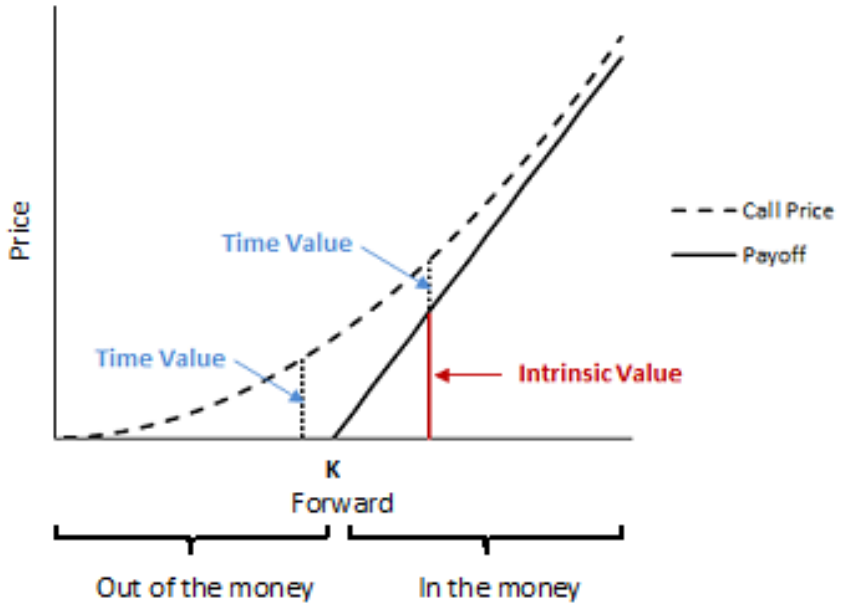


2.1.5. Intrinsic Value and Time Value

In order to understand the value of an option we have to decompose the price to an intrinsic value and a time value. The first part of this chapter discusses the price of a Call option and the second part shows the diagram of a Put option. Intrinsic value is the value that the buyer could extract from the option, if he or she exercises the option immediately. For a call option it equals *Max (0, Underlying Asset – Strike)*. For the put option it equals *Max (0, Strike – Underlying Asset)*. The remaining value of the option is called the time value. It reflects the possible additional payoff from the underlying asset, if the price of asset moves higher and causes option to be more in-the-money before the expiration (Internal material of Citi Bank, p. 9).

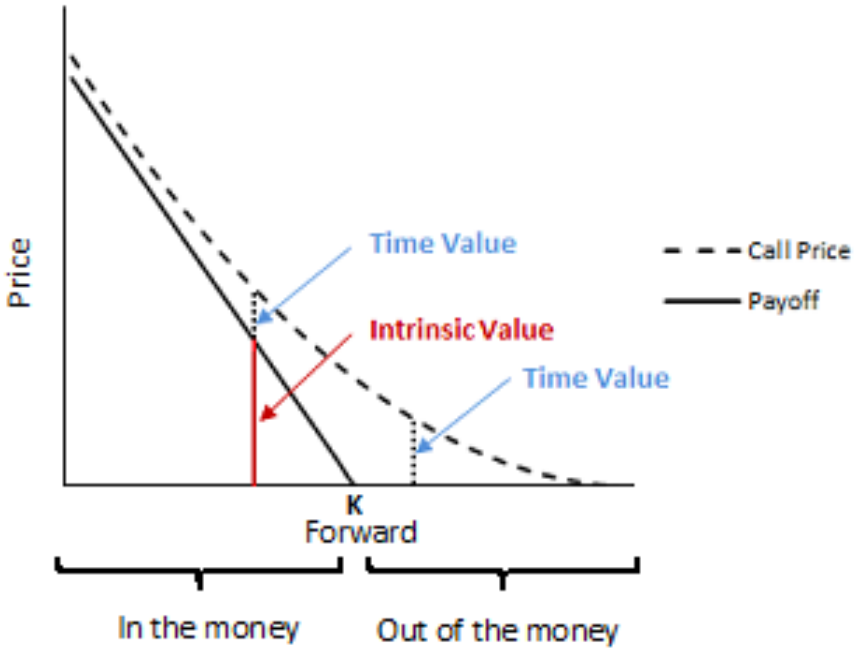
FX option with a positive intrinsic value is called *in-the-money* option. If the FX option's intrinsic value is equal to zero, the option is *out-of-the-money*. In a special scenario, when strike price K equals the underlying asset, we say the option is *at-the-money* (Brown & Reilly, 2006, p. 812). The following graph describes the call price and the payoff of a call option with Strike K, as the function of the forward rate. When the call is out-of-the-money, forward is less than strike K, and the price of the call is made only from the time value. On the other hand, when the call is in-the-money, the forward is greater than strike K, the call price equals to the sum of the time value and the intrinsic value (Internal material of Citi Bank, p. 9).

Figure 3: Call Price - Intrinsic Value & Time Value



The second graph below shows the payoff for a put option with strike K, as the function of the forward rate. When the put is out-of-the-money, the forward is higher than strike K. The price of the put is made only from the time value, and the intrinsic value is set to zero. On the other hand, when the put is in-the-money, the forward is smaller than strike K, the put price equals to the sum of the time value and the intrinsic value (Internal material of Citi Bank, p. 10).

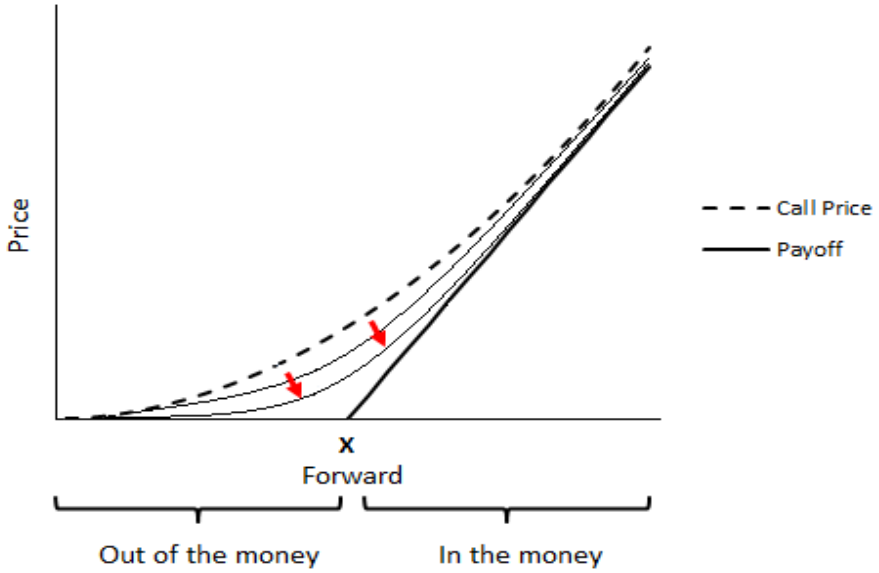
Figure 4: Put Price - Intrinsic Value & Time Value



2.1.6. Intrinsic Value and Time Depreciation

As the time to maturity decreases, the call price approaches the payoff function: Max (0, Underlying Asset – Strike). The same dynamics works for the put option price graph, where the option price approaches: Max (0, Strike – Underlying Asset).

Figure 5: Call Price - Time Decay vs. Option's Value



2.1.7. Put-call Parity

The relationship between holding the underlying asset and a portfolio combination of a European call and European put option, with the same strikes and expiration dates, is called a Put-Call Parity rule. The Put-Call Parity rule is easily derived by comparing two equivalent portfolios. This rule is used to test whether the option pricing model works. If an option pricing model doesn't hold the Put-Call Parity rule, an arbitrage opportunity exists. We can use the Put-Call Parity to compute the option value, too. If this parity doesn't hold an arbitrage opportunity occurs.

A combination of portfolios made of American puts and calls does not work. The American call option value is equal to the value of the European call option with identical parameters. Problem occurs, when we compare the American put with the European put option. Despite the same option parameters, the American put is more valuable because the right to exercise the option at any time of the option life adds to the value of the option. Portfolios that have the same value at the expiration time must also have the same value at present. Left side of the equation, Call & Cash, and right side of the equation, Put +

Underlying Asset, must be equal. Following the European Put-Call Parity relationship holds (Company Finance Trainer International, p. 26):

$$C + PV(K) = P + S \tag{8}$$

C = European Call Option Value

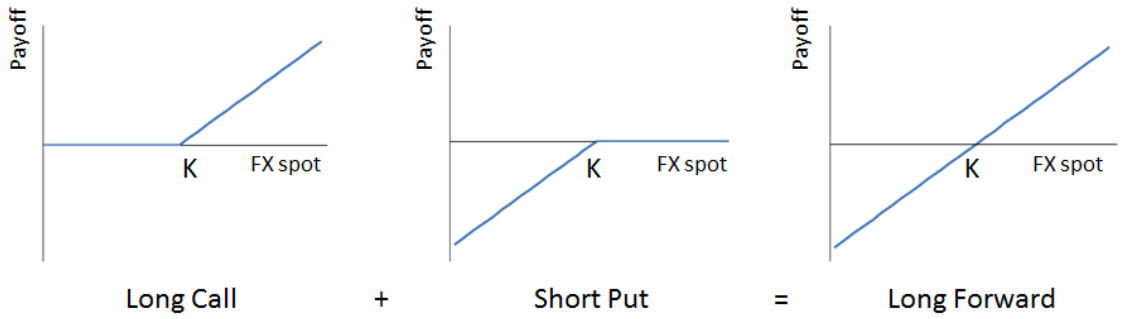
P = European Put Option Value

PV (K) = Present value of the strike price K (discounted from the date of expiry date)

S = Spot or currency exchange rate (base over quote)

K = Strike (exchange rate)

Figure 6: Put- Call Parity Relationship (Internal Material of Citi Bank)



The Graph above can be mathematically derived as:

$$C - P = S - PV(K) \tag{9}$$

Portfolio made of a bought call option and a sold put option with the same expiration date and a strike K equals to a portfolio made of a forward with the same underlying, the same time, and the same strike. At the expiration date, the first portfolio and the second portfolio are equal at any change of the underlying asset. The Put-Call Parity relationship works for many portfolio variations. The combination of selling a put and buying a call is much cheaper than buying the underlying asset. Therefore, it creates for portfolio managers a leveraging opportunity.

2.2. The Greeks and Risk Parameters

It is very important to consider risk parameters when trading options. The inability to read risk alerts can sink a trader's portfolio into red numbers. Understanding the risk parameters allows traders to determine the profit & loss ratio. Using a correct computation of risks one can avoid losses and increase chances of getting to green numbers. The value of a European option changes during the entire life of the option. As the price of the underlying asset, the volatility, the time, or the interest rate change so does the intrinsic and the time value of the option.

Delta, Gamma, Theta, Rho, Phi, and Vega (Kappa) are risk parameters, collectively named the Greeks. In the following paragraphs, every Greek parameter is individually explained.

2.2.1. Delta

Delta (Δ or δ) is the first partial derivative of the option price with respect to the underlying asset's price. Therefore it measures the rate of change of an option price to a unit change of the underlying asset's price. The Delta of the European call option is (Stoll, 1969):

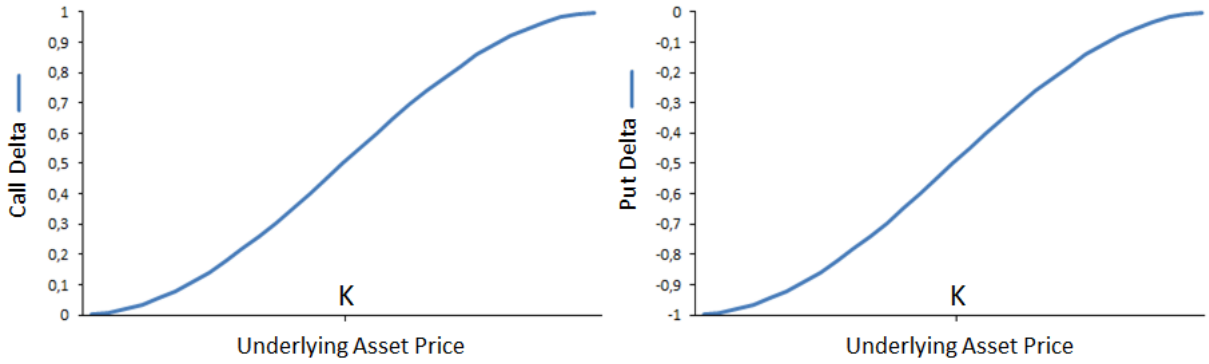
$$\delta_c = e^{-qt}N(d_1). \quad (10)$$

The Delta of the European Put option equals to:

$$\delta_p = e^{-rt}[N(d_1) - 1]. \quad (11)$$

The following picture demonstrates the Delta dynamics of a put and a call option, with respect to the change of the underlying asset. The Delta parameter is very sensitive around the strike area. The Delta sensitivity is the same for a call and a put option (Sorensen, Miller & Cox, 1998, p. 61).

Figure 7: Delta Dynamics and Underlying Asset Price



Market quotes Delta in an absolute percentage terms. Delta values range from -1 to 1 (-100% to 100%). The higher the absolute Delta value is, the more the option is in-the-money. Analogously, the smaller the absolute Delta value is, the more the option is out-of-the money. An option is called to be at-the-money, when the absolute Delta equals 50%. If the absolute Delta of an option equals 1, it implies that the option price increases by one unit of the underlying asset's price. From the derivation we can clearly see, that the Delta of a call option has positive values and The Delta of a put option has negative values. This is an important rule, which is very useful for the option portfolio managers. In order to find out the Delta of the entire Vanilla option portfolio they simply sum up Deltas that are multiplied by the appropriate quantities of each option's notional. The result reveals if the portfolio is Delta positive (long on the underlying), Delta negative (short on the underlying) or Delta neutral (no position in the underlying) (Schlessinger, 2011, p. 2).

Creating a Delta neutral option portfolio is simple, but it is much more complicated to sustain it this way as the other risk parameters (the effect of a constantly changing volatility, the rate of a change of the Delta, etc.) influence the equation (Schlessinger, 2011, p. 2).

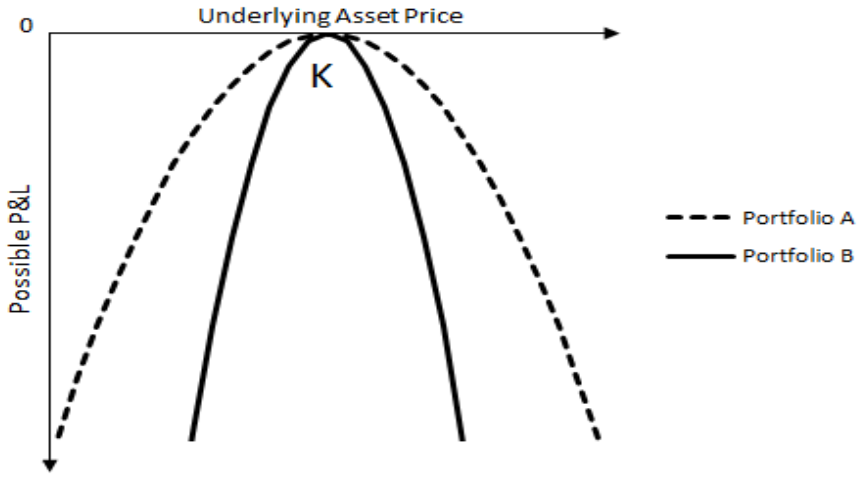
2.2.2. Gamma

Gamma (Γ or γ) is the second partial derivative of the option price with respect to the underlying asset price. Gamma for a call and a put (with the same parameters) is the same. A Gamma position can be increased by buying straddles (long put and call). An underlying asset has zero Gamma value. The higher the Gamma is the bigger the change of the Delta (Δ) is. Garman and Kohlhagen define Gamma as (1983):

$$\Upsilon = \Upsilon_c = \Upsilon_p = \frac{N(d_1)e^{-qt}}{S\sigma\sqrt{t}} \qquad (12)$$

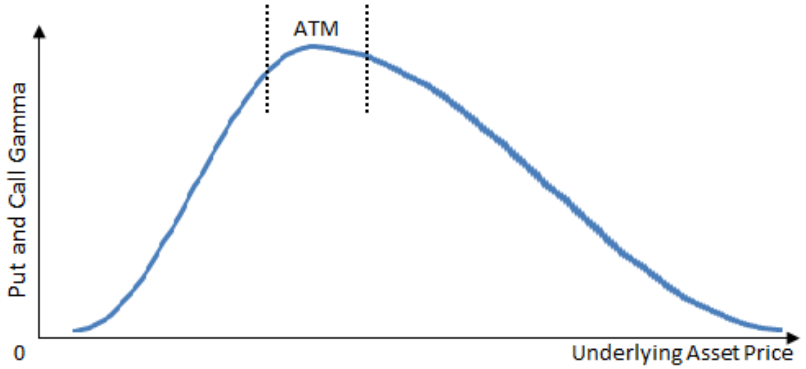
Following graph compares the theoretical profit & loss of a portfolio A and a portfolio B, which consist of Short Straddle positions. The portfolio A is more Gamma negative than the portfolio B. Picture below demonstrates, that any change in the price of the underlying causes a bigger loss to the portfolio B than to the portfolio A (Schlessinger, 2011, p. 2).

Figure 8: Short Straddle has a Negative Gamma



We can compare Delta to the speed and Gamma to the acceleration. A long (positive) Gamma is created by buying long puts and calls. A negative Gamma can be done by the exact opposite, selling puts and calls. The Gamma is the strongest at the place, where the option is at-the-money area (50% Delta) or if it is very close to the expiration date. The value of the Gamma depreciates in both directions from the at-the-money area. The Gamma of a long position can have any positive value (0, ∞). The dynamics of the log-normal distribution are described on the graph below (Sorensen, Miller & Cox, 1998, p. 75).

Figure 9: Gamma Dynamics vs. Underlying Asset Price



The easiest way to sustain a Delta neutral portfolio even, when there is a big price move in the underlying, is by creating a Gamma neutral position. Due to the fact, that long puts and calls increase the gamma level, it can be hedged only by writing options. Traders with negative Gamma bare the price change risk of the underlying asset in order to earn price premiums as time to expiration decreases (Schlessinger, 2011, p. 6).

2.2.3. Theta

Theta (θ) is a risk parameter that measures the rate of a change of an option price to a unit change (minimum one day) of the remaining time to expiration. A portfolio with positive Theta has better option position as time decays. The longer the life of the option, the more expensive it becomes, and the more negative Theta is. Theta of a long call is

$$\theta_c = -\frac{Se^{-qt}N(d_1)\sigma}{2\sqrt{t}} + qSe^{-qt}N(d_1) - rKe^{-rt}N(d_2). \quad (13)$$

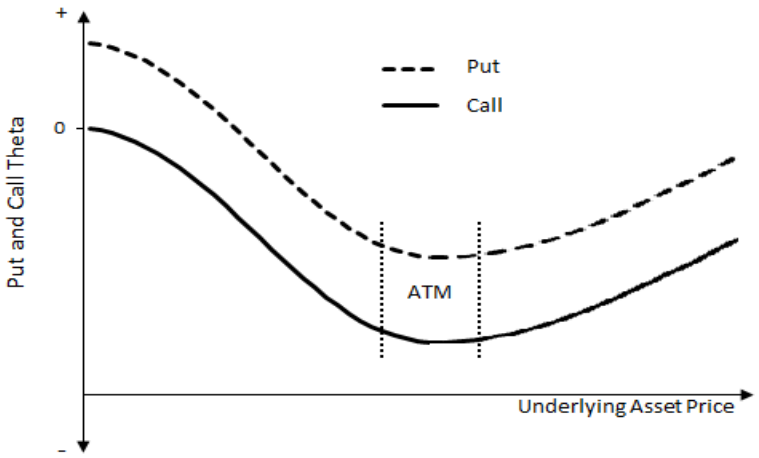
Theta of the European put is defined as (Garman & Kohlhagen, 1983)

$$\theta_p = -\frac{Se^{-qt}N(d_1)\sigma}{2\sqrt{t}} + qSe^{-qt}N(-d_1) + rKe^{-rt}N(-d_2). \quad (14)$$

The European put and the European call options have negative Theta. In other words, an option price decreases as the life of the option shortens (Company Finance Trainer International).

Short-term options and at-the-money options have the most negative Theta. As the price of the underlying asset moves away from the at-the-money area, Theta becomes less negative. The only scenario when Theta is positive is when a put option goes deep in-the-money. As the time depreciates, the volatility has less time to influence the underlying price, hence the option has less time to expire elsewhere than in-the-money (the premium consists mainly of the intrinsic value). The relationship between Theta and the underlying asset price is described in the following picture (Company Finance Trainer International):

Figure 10: Theta Dynamics vs. Underlying Asset Price



Only negative Gamma traders earn bits by having a positive Theta. In other words, they make money on writing options that expire worthless. One of the remaining variables that can affect the option price is the risk-free interest rate, which is discussed in the next paragraph (Schlessinger, 2011, p. 78).

2.2.4. Rho and Phi

Rho (ρ) & Phi (φ) are parameters that measure the sensitivity of the option value to the change of the domestic and the foreign interest rate. A rise or a decrease of a domestic or a foreign interest rate cause change of a forward rate yield curve, and causes a change in the value of an option (Boileau, 2003, p.12).

The risk parameter that measures the change of a domestic currency to the option value is called Rho, and the risk parameter that measures the change of the foreign currency to the option value is called Phi. The Rho of a call option and Phi of a put option are always positive. On the other hand, Rho of a put option and Phi of a call option are always negative.

Rho, the risk factor of the domestic risk-free interest rate for the European call option, is:

$$\rho_c = Kte^{-rt}N(d_2). \tag{15}$$

Rho, the risk factor of the domestic risk-free interest rate for the European put option, is:

$$\rho_p = -Kte^{-rt}N(-d_2). \tag{16}$$

Phi, the risk factor of the foreign risk-free interest rate for the European call option, is:

$$\varphi_c = -Kte^{-qt}N(d_1). \quad (17)$$

Phi, the risk factor of the foreign risk-free interest rate for the European call option, is:

$$\varphi_p = Kte^{-qt}N(-d_1). \quad (18)$$

When domestic interest rates rise, it becomes more expensive to borrow money, thus call options on domestic currency value go up in price. The more in-the-money or less out-of-the-money the call option is, the more expensive it becomes. The longer the time to the expiration, the higher the option's price sensitivity to the change of the domestic currency interest rate and to the foreign currency interest rate is (Boileau, 2003, p.12).

2.2.5. Vega

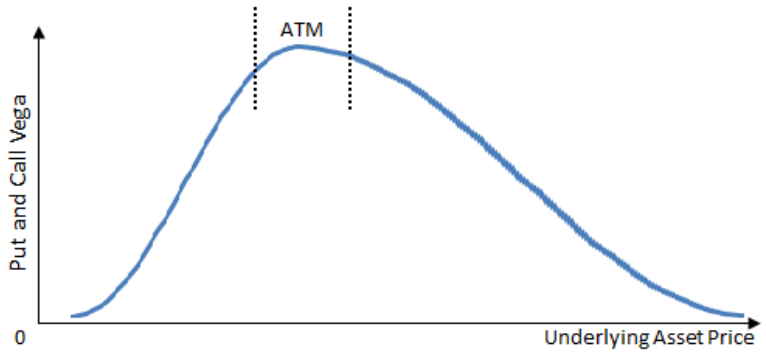
One of the most important risk parameters is named Vega (Kappa in Greek alphabet).Vega or Kappa (K) represents the change of the option price to the change of the volatility of the underlying asset (Sorensen, Miller & Cox, 1998, p.76).

$$\mathrm{K} = \mathrm{K}_c = K_p = Se^{-qt}N(d_1)\sqrt{t} \quad (19)$$

Vega of a long option position can have any positive value (0, ∞). The option with 0.25 Vega has an increase of the option's value by 0.25 unit of the domestic currency, if a one percent increase in the annual volatility of the underlying asset happens.

Increase of volatility makes every option more expensive. A put option and a call option with identical parameters have the same value of Vega. Any increase in the volatility, or the life of the option increases value of Vega. At-the-money and long-life options have the largest Vega. See Picture below (Sorensen, Miller & Cox, 1998, p. 77).

Figure 11: Vega Dynamics vs. Underlying Asset Price



Traders discuss their option strategies in volatility terms. Buying volatility means making money if the volatility value increases. Selling volatility increases profit only if the volatility value decreases (Company Finance Trainer International, p. 33).

2.2.6. The Greeks Summary

As we found out, the risk parameters Delta, Gamma, Theta, Rho, Phi, and Vega (Kappa) play a critical role in the value of the European option. European calls and European puts can have positive but also negative Greeks, depending on whether or not they are written or held. The option portfolio can be expressed in the Greek risk parameters by adding up all risk parameters of every single option. This characteristic makes life of an option trader much easier. Unfortunately, incorrect reading of risk factors or incorrect view of future macro data may still lead to a big loss in the value of the option portfolio. Further below is a comprehensive summary of all risk parameters with respect to the option's position (Sorensen, Miller & Cox, 1998, p. 81).

Table 1: Summary of Exposure Factors

Position	Delta (δ) *Exposure to directional price change*	Gamma (γ) *Exposure to non directional price change*	Theta (θ) *Exposure to time decay*	Rho (ρ) *Exposure to domestic crcy. interest rate change*	Phi (ϕ) *Exposure to foreign crcy. interest rate change*	Vega or Kappa (K) *Exposure to changes in volatility of prices*
Long underlying asset	+					
Short underlying asset	-					
Long Call	+	+	-	+	-	+
Short Call	-	-	+	-	+	-
Long Put	-	+	- (+)	-	+	+
Short Put	+	-	+ (-)	+	-	-

Question arises when looking at signs of Theta. As the dynamics explains, all long option positions depreciate in value as the time to expiry gets shorter. This relationship doesn't hold for the short-time in-the-money put option.

2.3. Exotic Options

Due to options flexibility and applicability in any kind of market, their use grows at a fast rate. The modern option family tree spreads over a wide range of different option types. Apart from the standard European option we recognize groups of Barrier, Digital, Asian, Compound, or Multi-currency options. In the following chapters we will focus on two types of the Exotic options. In the first part we will have a detailed explanation of the Barrier Options and in the second part we will concentrate on the Digital options (Company Finance Trainer International, p.7).

2.3.1. Barrier Options

Barrier options look as standard options with one additional feature. Each barrier option holds a trigger level, which can have two meanings. The barrier option can have either a knock-in or a knock-out barrier. The advantage of the barrier options in comparison to the European options is in their value. Trigger options are always cheaper than plain vanilla (standard put or call) options. This advantage originates from their ability to start or cease to exist only if a certain barrier level is triggered by an actual cross currency spot rate. Barriers could be either American or European. The American barrier can be triggered at any time during the life of the option. The European barrier is compared to a currency spot market only at the expiration date and time. In the following paragraphs the focus will be on Knock-in and Knock-out options with American barriers (Company Finance Trainer International, p. 8).

2.3.1.1. Knock-out Options

A standard Vanilla option with a specified trigger (barrier) called a knock-out (KO) option expiries worthless before expiration, if a currency spot rate is traded at the level of the trigger. Traders say that option is out-the-money (OTM), when the currency spot is at the KO level. In other words, when the barrier is hit by the FX spot, the knock-out option is triggered and ceases to exist.

The down & out call option has an option barrier with a specific (KO) trigger, which is lower than the strike (K). The Up & out put option has an option barrier with a (KO) trigger, which is higher than the strike (K). The maximal profit of a holder is unlimited. The maximal profit of a regular knock-out option is unlimited max= (0, ∞), thus it is the same as a regular Vanilla option with the identical characteristics (Company Finance Trainer International, p. 9).

If the trigger of a barrier option is in the direction, where the option becomes more in-the-money, we call it a reverse knock-out option. Reverse KO options prevent the writer of the option from abnormal losses on the sold option, because the maximal profit of a holder is equal to the absolute difference between the strike (K) and the trigger (KO), max (0, KO-K).

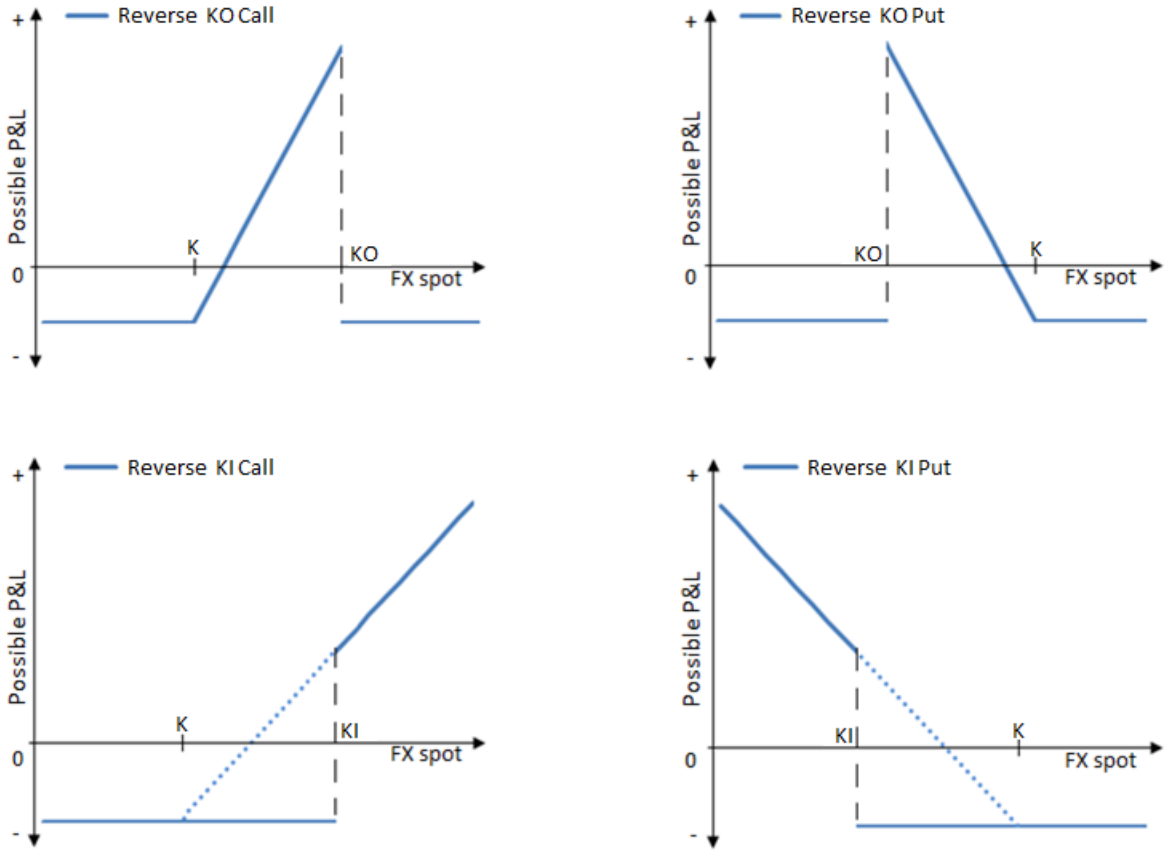
2.3.1.2. Knock-in Options

A standard Vanilla option with a specified trigger (barrier) called a knock-in (KI) option expires worthless at the day of expiration, if a currency spot rate doesn't reach the level of the trigger. On the other hand, if the barrier is hit, the knock-in option changes to a standard Vanilla option. Traders say that the option's barrier is hit, when the currency spot is at the KI level. In other words, when the barrier is hit by the FX spot, the knock-in option flips to a Vanilla option, with the identical strike, expiration date, notional, and direction.

The Down & In call option is specific by a trigger (KI), which is lower than the strike (K). The Up & In put option is specific by a trigger (KI), which is higher than the strike (K). The maximal profit of a holder is unlimited, because the characteristics of a knocked-in option are the same as of the standard Vanilla option. If the trigger of a barrier option is in the direction, where the option becomes more in-the-money, we call it a reverse knock-in option. The maximal profit of a holder is unlimited max= (0, ∞) (Company Finance Trainer International, p. 9).

The following figure summarizes the payoffs at expiry of all four reverse barrier options, which were discussed in the earlier paragraphs. Regular barrier options behave in the same way as Vanilla options; therefore their payoff at expiry is identical, too. The blue line starts below zero, because the paid price premium is added to the Profit & Loss strategy calculation.

Figure 12: Payoffs of Reverse Barrier Options



There exist two more possible alternations of the barrier options, either a Double Knock-Out option, or a Double Knock-In option. These options are specific by having two barriers of the same type (two KO levels or two KI levels). They cease or start to exist when one of the two barriers is triggered. The value of the double barrier options is even smaller than the value of the single barrier options (Company Finance Trainer International, p. 9).

2.3.2. Digital options

A digital option is also called a binary or an all-or-nothing option, which gives the holder a chance to receive a fixed and predetermined amount (payoff) if it expiries in-the-money. In case that the option expiries out-of-the-money or at-the-money, the holder doesn't receive anything.

The trigger of a binary option can watched either only at the expiration date or during the entire life of the option. In other words, it depends on the type of the option, whether the level is watched throughout the entire life of the option or only at its expiration. One Touch, No Touch, Double One Touch, and Double No Touch are the most common digital options ((Sorensen, Miller & Cox, 1998, p. 171).

2.3.2.1. One Touch and No touch

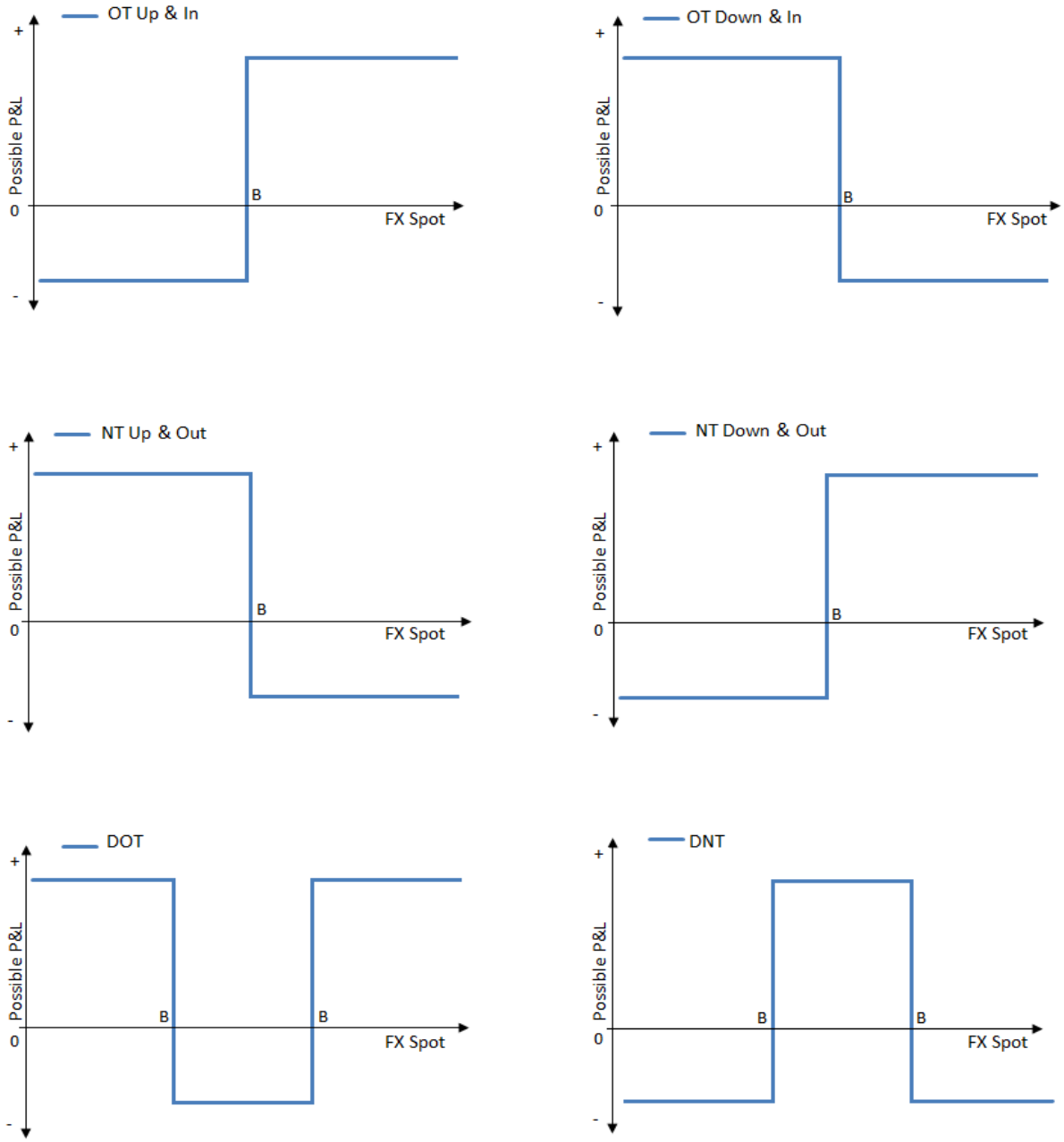
A one touch option is a bet or a transaction, in which at a predetermined expiration date, a trigger, and a payoff the writer receives from the option holder a premium. It is a one-directional strategy. If at any time of the life of the option or at the time of expiration is the level crossed or current cross currency rate is traded exactly on that level, the writer has to pay the holder the entire payoff. Up & In One Touch and Down & In One Touch can occur. The exact opposite bet or transaction is called No Touch, where the holder receives the payoff only if the FX spot doesn't cross or is traded at the specified level. The Touches are either Up & Out or Down & Out (Company Finance Trainer International, p. 10)

2.3.2.2. Double One Touch and Double No Touch

A double one touch option is a transaction or a bet, where the holder of the option receives a specified payoff if any of the two barriers is crossed during the life of the option. A writer receives the premium at the beginning of the agreement. The further away the barrier from the FX spot, the smaller the probability to be triggered is, thus smaller the option premium.

A double no touch option is a transaction or a bet, where the holder of the option receives a specified payoff if none of the two barriers are crossed during the life of the option. The further away the barrier from the FX spot, the smaller the probability to be triggered is, thus smaller the option premium (Company Finance Trainer International, p. 10). The following figure describes all the possible binary options' payoffs at expiration.

Figure 13: Payoffs of Digital Options



2.4. Option Strategies

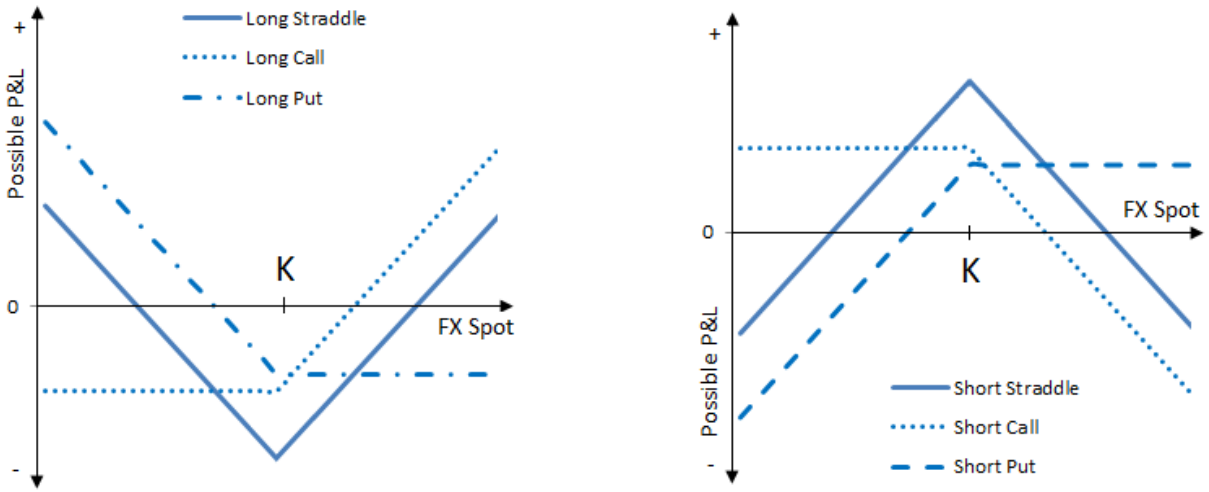
The most often traded strategies are made of buying or selling simple call options or put options. Little more complicated strategies are straddles, strangles, call spreads, and put spreads. The icing on the cake is the butterfly strategy, which is the combination of a strangle and a straddle. The following paragraphs contain a detailed explanation of the above mentioned strategies.

2.4.1. Straddle

A straddle is an option strategy, which consists of a bought put option and a bought call option with the same strike (most of the time ATM), expiration date, and a notional. An owner of this strategy believes in the increase of volatility. In other words if any price action happens and the FX spot moves to a new higher level or a new lower level, the strategy will be profitable.

By selling a straddle strategy the trader receives options' premiums. A short straddle is the same thing as playing short volatility. It is a very risky strategy which might pay off 99% of the time. However, when a sudden big move on the FX market happens, the writer of the put option and the call option will suffer big losses, which can be considerably bigger than all of the profit made in the trades before. The writer of a straddle is positive in Theta. The following figure shows a profitability structure of being long or short on the straddle (Sorensen, Miller & Cox, 1998, p. 125).

Figure 14: Payoffs of a Straddle (Holder and Writer)

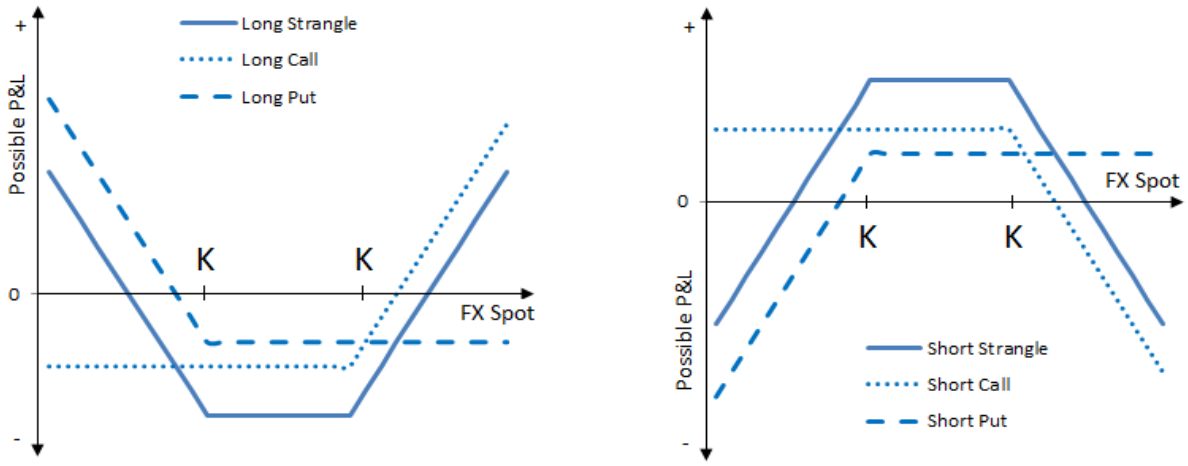


2.4.2. Strangle

An option trader is interested in buying the Strangle, when he believes in the increase of the volatility. In comparison to the Straddle strategy, the Strangle strategy offers a higher leverage. This is possible due to cheaper options, which are usually out-of-the-money. Unfortunately, in order to be profitable, the FX spot fluctuation must be much bigger than at the Straddle strategy (Company Finance Trainer International, p. 19).

Selling the Strangle strategy will make you earn less money on premiums but your Gamma will not be extremely negative, because the risk of the FX spot getting to the out-of-the-money strikes is much smaller. Short strangle offers long Theta. If the spot doesn't fluctuate and as the option's life-time decays, the Short Straddle strategy makes money. The figure below describes a proper way of creating the short Straddle strategy and the long Straddle strategy.

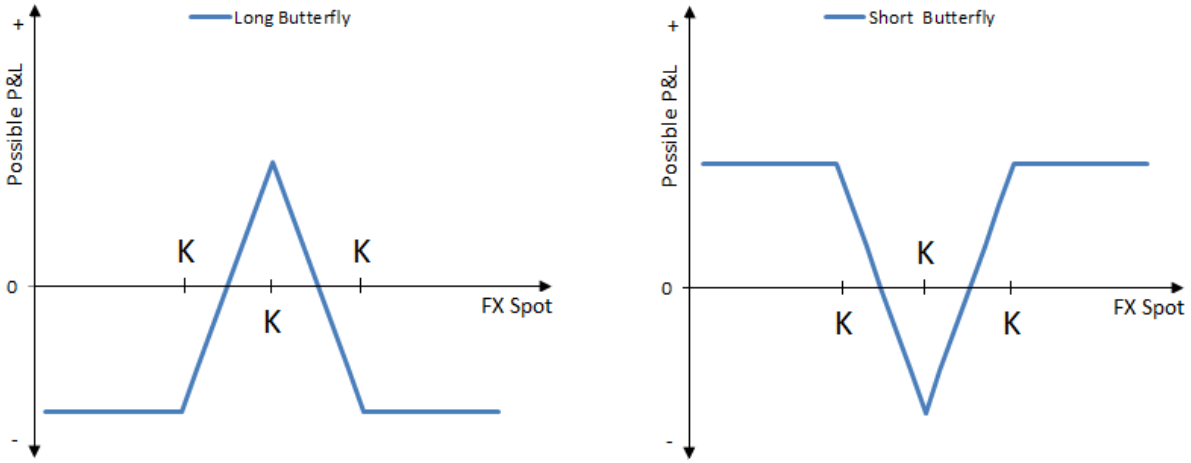
Figure 15: Payoffs of a Strangle (Holder and Writer)



2.4.3. Butterfly

A Butterfly strategy is created by selling the Straddle and buying the Strangle. This strategy offers the holder profitability if there is the FX spot fluctuation. Owner of this strategy believes in the decrease of volatility and has a positive Theta. By buying a straddle, the holder hedges himself from an unexpected increase of volatility, which could cause a great loss. On the other hand, the seller of the butterfly strategy is profiting in the case of an increase of fluctuation on the FX market. The advantage of the strategy consists of a lower net premium he has to pay. The disadvantage is the limited profitability. A detailed P&L is described on the figure below (Company Finance Trainer International, p. 20):

Figure 16: Payoffs of a Butterfly (Writer and Holder)

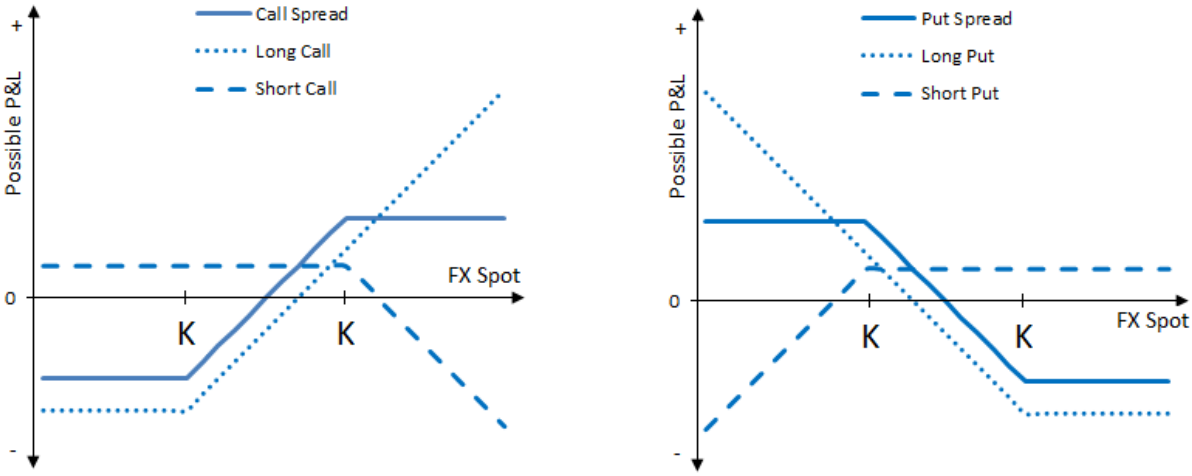


2.4.4. Spread

There exist two types of a spread, either a call spread or a put spread. The call spread is a combination of the bought at-the-money option and the sold out-of-the-money put option. The call spread can also be called a bull spread. The other way of creating a bull spread is by selling the in-the-money put option and buying the out-of-the-money put option. The spread strategy offers the holder a cheaper one-directional trade. The sold option decreases the overall net price of the sold and bought premiums. The bought at-the-money put option and the sold out-of-the-money put option form a bear spread (put spread) strategy.

The bear spread strategy can also be constructed by selling the in-the-money call option and buying the out-of-the-money call option. Both strategies offer the holder a one-directional trade with a limited profit as well as a limited loss. The figure below describes the call spread and the put spread strategy (Company Finance Trainer International, p. 22):

Figure 17: Payoffs of a Spread (Call and Put)



3. TECHNICAL INDICATORS

A technical indicator is nothing else but a mathematical equation, which works with a generic price activity of any asset. Despite the fact that they do not analyze any part of the fundamental data (earnings, revenues, profit margins, and other ratios), the influence of the technical indicators on the market should not be underestimated. They can predict a price direction and even the size of the next move. The main source of the technical indicator is considered to be the historical price. Technical indicators work with any time interval and any price type (open price, close price, interval high, interval low, bid price, ask price, generic middle price). They predict or reveal a good entry level and a convenient exit level for any kind of strategy. The most common technical indicators are the moving averages, the support and resistance levels, the Bollinger Bands, the historical volatility, and the trend lines (StockCharts.com).

3.1. Trends

After removing the upper and lower part of a price cycle, one should be able to see an overall direction of the market at any period of time. This analysis provides the trader with an idea of the future price direction. The trend can go upward, downward or in a sideway direction.

3.2. Moving Averages

An indicator that can follow the trend of the market is called the Moving Average (MA). This indicator is used for smoothing the historical prices, filtering out any kind of noise and creating a trend following line with a lag. Moving averages don't predict any price direction, but can be used to identify the trend with a leg and define the future resistance level and the future support level. Moving averages are very popular technical indicators. They are the linchpins of the other, more complicated technical indicators, such as Bollinger bands or Moving Average Convergence Divergence (MACD). The most often used moving averages are the simple moving average (SMA) and the exponential moving average (EMA) (Walker).

Mathematically, a simple moving average is expressed as the simple (not weighted) mean of the last *n* daily closing prices. A simple or arithmetic moving average is calculated

by the sum of the closing prices of the security for given number of time periods (window lengths). The sum is then divided by the number of the time periods. The equation is

$$SMA(d) = \frac{\sum_{i=1}^{n} p_{(d-i)+1}}{n} \quad n \leq d \tag{20}$$

N = number of days the SMA is computed from

d = day for which the SMA is calculated

p_x = closing price of the given day x

The following picture represents three simple moving averages applied on the EUR/USD cross currency rate for a period of one year. The yellow line is the SMA (200), the green line is the SMA (100), and the purple line represents the SMA (50). These are the most often used simple moving averages, and they are predetermined on many Bloomberg graphs. The future FX spot is very often influenced by their current levels. It is used for indicating the support and resist levels.

Figure 18: EUR/CHF Cross - Simple Moving Averages (200, 100, 50)

3.3. Bollinger Bands

John Bollinger developed Bollinger Bands, which he computed from the standard deviation and the simple moving average. This technical indicator provides a very good overview of the volatility level. Firstly, the simple moving average line is drawn, and then from the SMA line one adds a multiple of the historical volatility. In the end, we receive the upper and the lower bound, which are affected by the price direction and the fluctuation (Bloomberg

Terminal, 2014). Bollinger bands are able to identify a high and a low volatility period and an extreme price movement. The volatility decrease leads to a decrease of the span between the upper and the lower band. The exact opposite happens when the volatility increases (Bloomberg Terminal, 2014). The diagram below shows an application of Bollinger bands on the EUR/USD currency pair during a period of three months. The green line represents a lower band and the purple line represents an upper band of the indicator. The grey line in the middle represents a simple moving average. The Classical set up is made of the simple moving average (21) and the historical volatility (21) (the volatility multiplier equals two).

Figure 19: EUR/USD Cross - Bollinger Bands

4. FX OPTION STRATEGY INDICATOR

The FX option strategy indicator was designed to capture any extreme movements on the FX market. Previous chapters described many FX Option strategies. From the simplest as buying and selling call and put options to creating strategies such as butterfly, spread, strangle, or a straddle. In comparison with the FX spot trading the FX options offer a wide range of advantages, which are not possible when trading only the currency pairs. Very interesting is the possibility to create a one directional trade with no risk of closing a position at stop-loss levels. FX options allow the trader to make a non-directional strategy, where one plays only on the increase or on the decrease of the volatility (strangle, straddle). Last but not least, the FX option offers the leverage with a no extra risk, except of paying the price premium.

4.1. Assumptions

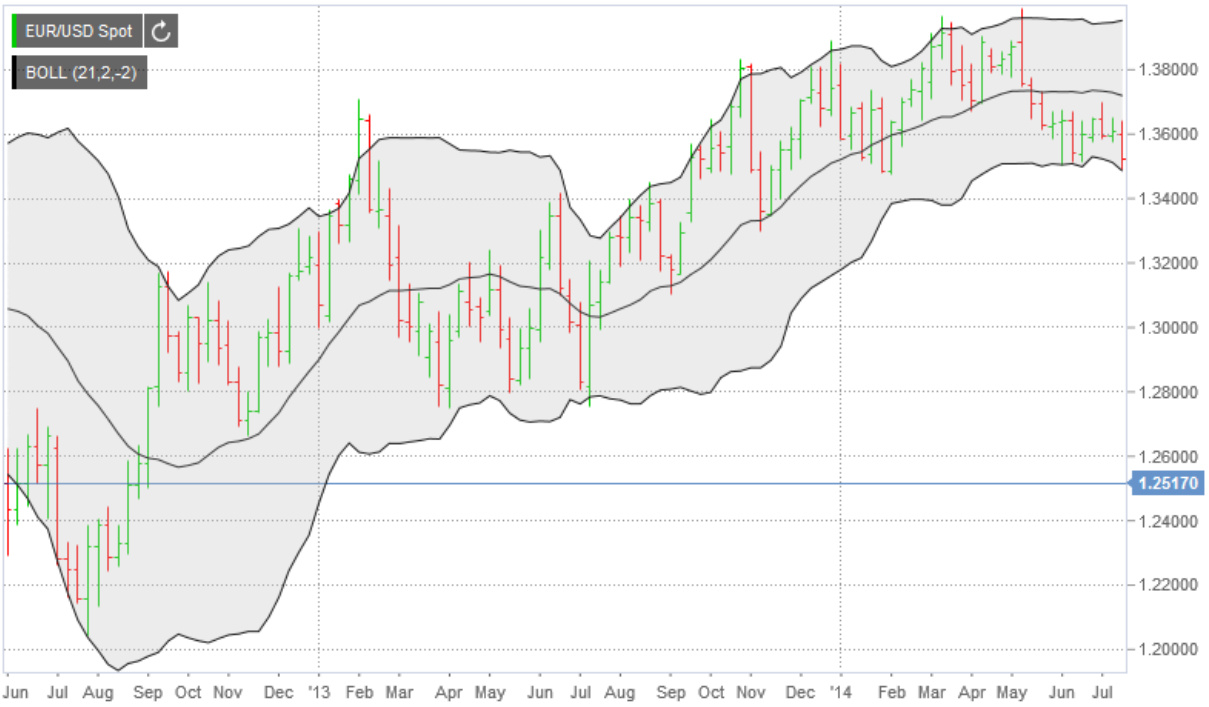
The FX option strategy indicator has two main assumptions that need to be satisfied. The first assumption is the ability to indicate when an extreme increase or decrease of the price occurs. For the first assumption to work a technical indicator Bollinger band was used. The Bollinger band indicator creates an alert if either the upper or the lower band is crossed. This alert is the second very important assumption, which has to hold. If a spot goes below lower Bollinger band an alert to buy a long delta option is triggered. If the cross currency price goes above the upper band it indicates a strategy to buy a short delta options. These options should be as cheap as possible but not too much out-of-the-money (OTM). The aim of the strategy is to buy a cheap option at an efficient level, hold it to the maturity and exercise it with the highest possible profit (Spot-K or K-Spot). A more detailed explanation of the FX option strategy indicator is elaborated in the following chapter.

4.1.1. Model Identification

For a proper functionality of the model's first assumption, a classical Bollinger band indicator was chosen. It computed the moving average from the last 21 days. The same amount of days in a row was used to compute the standard deviation in other words, the 21 days volatility. The more days used to calculate the standard deviation, the smaller the sensitivity of the indicator. On the other hand, if the monitored period is shorter, it misleads the bands ranges due to a sudden extreme increase of the volatility. In other words, the model would be too sensitive and would not reflect the historical range trend. Due to the

monthly lifetime of the option, the 21 days range is the best setup. The most difficult is the proper pick of the Bollinger bands' multiplier value. If the bands were too narrow, it would cause frequent signals for buying options. If the range was too wide, it would create a model with only a small number of signals. Therefore, the multiplier's parameter number two was chosen. The following graph represents the EUR/USD currency cross with the Bollinger band (21, 2, -2) in use:

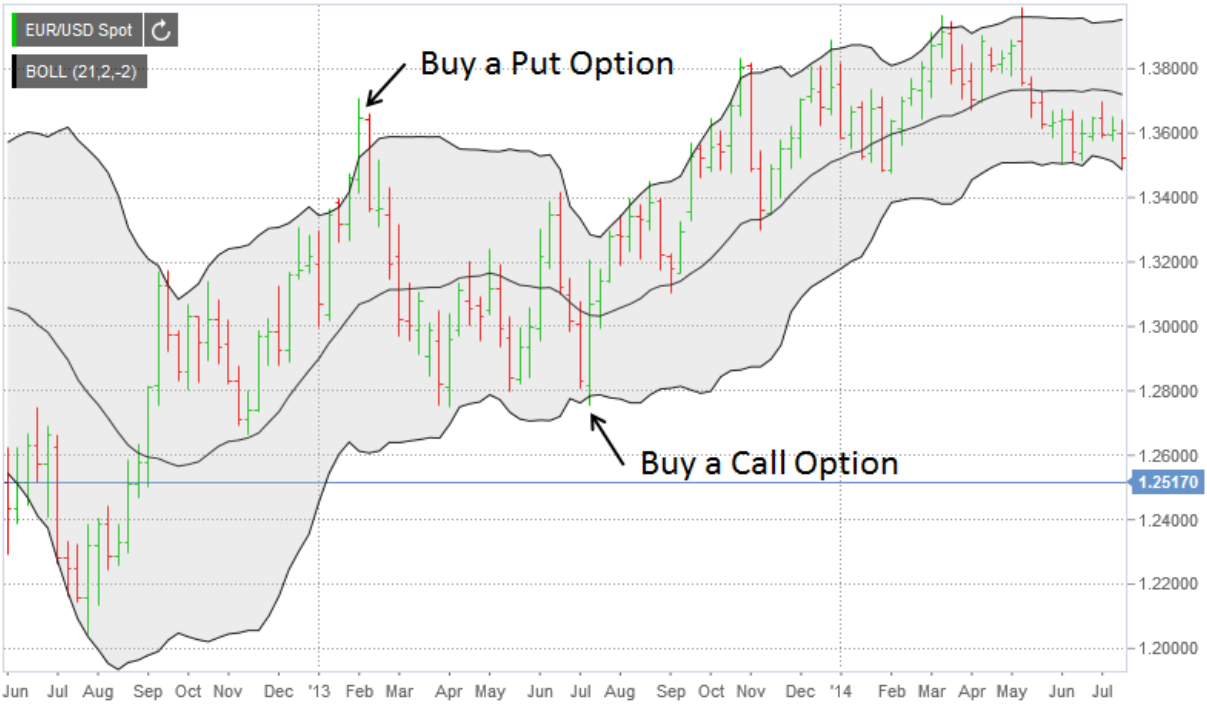
Figure 20: EUR/USD Cross - Bollinger Bands (21, 2, -2)



On the graph above, one can see moments when the spot price was above as well as below the Bollinger bands. In those situations, the FX option strategy indicator should alert one to an extreme jump or drop of the price with respect to the upper and the lower range. If the price crosses the lower boundary, the model sends a signal to buy the long delta option. If the price crosses the upper band, the model sends a signal to buy the short delta option. The cheapest one, which is available on the market and has high Delta sensitivity, is a call option with the ATM strike. The strategy is based on buying a cheap call option with the ATM strike, as it has a high probability of being exercised at the end of the holding period. The scenario, where one buys the ITM option, is not appropriate. The price premium would be too expensive, thus the risk one beard would be too big. The other extreme is the OTM option, the strike of which is very far away from the current spot level. The OTM option strategy would not work, because the owner of the option has a negative Theta, which makes the option less valuable as the time passes by and the probability of a successful exercise of the option is very low. Therefore, holding either the call or the put ATM option is the best strategy

for entering the long Delta, or the short Delta trade. When the spot moves in the bands' range, there is no need for entering any kind of trade. If the FX option strategy indicator sends alerts about a break through with a proper direction of a trade, the second assumption of the model holds. The graph below demonstrates the importance of the second assumption.

Figure 21: EUR/USD Cross - Signal to Purchase the Option



4.1.2. Option's Input Parameters

In order to buy an option, one has to write all the important inputs. Only after writing the inputs, one can receive a proper price premium. The following paragraphs explain the inputs that were chosen for either a call or a put strategy in a more detailed way.

When the cross currency rate breaks through the lower Bollinger band, a signal to buy a call option is shown. When it breaks through the upper band, a signal to buy put option is generated. The FX option strategy indicator is not a fully automatized algorithm, because it needs human intervention. The over-the-counter ATM call options have too many inputs. As a consequence, it takes the trader several minutes to actually receive a fair price from the market. Sometimes this process takes even a quarter of an hour. Therefore, the FX option strategy indicator only sends a signal or an alert to inform the trader about a good opportunity to make a trade. By the time the trader receives the price, the FX spot could have moved, therefore the strike is always at-the-money and the option's price premium is calculated at the current spot price.

Back-testing is a very difficult and time consuming activity, because every trade entry has to be done manually by looking at the graph and selecting the proper spot level with respect to the technical analysis. A possibility that a trader opens a position right at the moment, when FX OSI sends an alert, is impossible. Therefore, the short time spikes were removed from the back-testing, and a stabilized spot level was chosen to set the strike and the option premium instead.

To make the strategy even simpler, let's assume that the trader holds the European option until the expiration date. If the spot moves in the direction of the trade and crosses the break-even point, the options are exercised otherwise they are worthless. The lifetime of the option is set to be one month. An option with a longer life span is too expensive, and a shorter option doesn't provide enough time for price to reverse from its current level, despite the fact that break-even point is much closer when options have a shorter life span.

The profitability of any trade is calculated from the difference between the strike and the spot at the time of expiration, from which the option's price premium in PIPs is subtracted. It is very easy to compute the price in PIPs or in the percentage, thus the option notional can be neglected. In real life, a too small option's notional can skew the option's price. In addition to the volatility, the price also includes the banks' or the brokers' transaction costs (margin). If the notional is too big, the banks have a problem to hedge this option due to the insufficient liquidity on the given market, thus the option becomes more expensive. The prices of the premium are expressed in the PIPs or the percentages.

4.1.3. Option's Premium Calculation

In a phase, when every option input is known, one can compute a price premium. At the beginning of the back-testing, the bank's option database was used to collect options' prices. The advantage of using the bank's database was in the realistic prices, which its clients traded on daily bases. Unfortunately, after a few tries to look up an option with particular parameters, the database was found insufficient. Therefore, another source had to be used.

A time consuming yet an effective way of getting a precise price premium was the Bloomberg's OVML function, which calculated the option's price premium after plugging all the necessary inputs. The calculator uses the Black-Scholes model to compute the price premium. The option premium of underlying currency cross was always calculated in the domestic currency PIPs (EUR or USD). This technique allowed computing the options

strategy in PIPs, which could be easily converted to absolute values or percentages. A figure below describes the Bloomberg's OVML function.

Figure 22: Bloomberg's Vanilla Options Pricing Function

The Bloomberg's OVML function is widely used by the sales and trading department in almost every bank in the world. It provides employees with very precise and widely used outputs. The disadvantage of the OVML calculator is its inability to use the bank's implied volatility, therefore enabling the possibility that the OVML price would differ from the traded price on the financial market. When the market knows about a big event, the spreads between bids and offers widen. This is one of the reasons why the OVML calculator might be mispriced. Nevertheless, it is a very precise option calculator, which is used by many bank departments. Its use for computing options' premiums is therefore sufficient.

4.1.4. Strategy Limitations

The FX option strategy indicator suggests buying only one directional trade, which is either Delta negative or positive. During a period, when portfolio has an option, there is no need for buying another option. This rule has more reasons. The portfolio is already oriented in one direction and the resources have been spent on the price premium. Even if the indicator alerts the trader about another extreme cross currency move, the portfolio already

contains an option and no extra purchase needs to be done. Buying another the option during a period when option is already in the portfolio causes increase of costs (paid premium), hence a bigger risk is involved. The FX option strategy is based only on technical analysis. No fundamental factors are applied into the evaluation process.

4.1.5. Maturity Date

On the date of the European option maturity, the trader can either exercise or let the option expire worthless. The FX option strategy indicator has options with a monthly duration. In case of holding a call option until the expiration date, an investor compares spot to the strike price. If the strike is below the current spot, the investor has interest in exercising the option at a more convenient currency cross level. Positive net profit is realized if the difference between the spot and the strike is bigger than the price premium paid at the beginning, when the option was purchased. The net profit from exercising the European call option is:

$$NP = Spot - K - Price\,premium \tag{21}$$

The European put option has a negative Delta, therefore it profits from cross currency rate depreciation. If the strike is above the spot, the option is exercised. The net profit is calculated by subtracting the spot and the price premium from the strike. The following equation computes the net profit of the European put option:

$$NP = K - Spot - Price\,premium \tag{22}$$

Options that are exercised below the break-even point have not covered the cost of the premium. The worst scenario is when the option is expired. In this situation, the strategy doesn't earn any money and the investor is left with a loss of the entire price premium.

4.1.6. Strategy Performance

The performance of any strategy is often expressed in the annual data. Due to the monthly expirations condition, one can assume that the FX option strategy indicator has in maximum twelve trades per year. The net profit of a traded option is computed from the difference between the exercised profit and the paid option premium. The net profit of every option trade is added together and divided by the sum of the annual purchase costs. The following equation calculates the annualized yield of the FX option strategy indicator.

$$Y_a = \frac{\sum_{n=1}^{k} NP_n}{\sum_{n=1}^{k} OP_n} \quad (23)$$

k = number of trades per year

NP = net profit

OP = option premium

4.2. Data Sets

For a proper functioning and the ability to back-test the FX OSI model, three databases had to be used. Each contained different time intervals but all had the same currency crosses.

The first set of the data contains three currency crosses with the daily open, high, low, and close prices, which are used for computing the moving average, standard deviation, and upper and lower Bollinger band. The database starts from the 16th of November 2011 until the 12th of August 2014. The back-testing was conducted on EUR/PLN, USD/PLN, and EUR/USD crosses. The role of the Excel's if-function was to generate two types of signals, which had to fulfil a condition of the price being either above or below the Bollinger bands indicator.

The second database contains options that were traded in the bank. The database included 30 currency crosses and contained strike, maturity, spot, notional, date, option's type, direction, and a currency pair. Unfortunately, none of these crosses had sufficient number of options that were supposed to be used for calculating the option premiums. Due to an excessive number of option combinations, another alternative to compute price premium had to be found. The Bloomberg's OVML function effectively substituted the downloaded historical database of traded options. It provided a precise price premium at any moment in the back-tested history.

The third database was used to compute the net profit of every purchased option. EUR/USD options expire every banking day at 16:00 CET. EUR/PLN and USD/PLN crosses expire every banking day at 11:00 CET. The first database contained only the daily data, and therefore a more detailed database with opening prices at 11:00 and at 16:00 had to be used. This condition was fulfilled by the hourly database with two years' history.

Without the OVML calculator and the two data sets, the FX OSI model could not have been back-tested. The next section discusses the simulations' results.

5. RESULTS

The FX option strategy indicator was back-tested during a period of two years on three currency pairs. The pre-determined life of the option was set to one month, 3 weeks, and 2 weeks. The notional of every option was set to 100.000,- of the domestic currency (EUR or USD). The option strikes were set above or below the Bollinger bands. Every option had at-the-money strike, thus the spot at the time of the trade had to be out of the Bollinger bands range. If an extreme move lasted only a very short time, no option was bought.

In reality, entering an option trade lasts several minutes, and therefore it cannot be traded automatically. Before trading an option a lot of inputs must be selected, which is another reason, why this model is only an indicator and cannot be converted into a fully automatized trading system. Many of the FX options are traded on the over-the-counter market, where making a trade lasts even longer than the above mentioned several minutes. Due to all of these factors, a fully automatized system is almost impossible. Only the strategy indicator to give an advice can be automatized.

5.1. Results of Monthly Options

The first back-tested set of the data was the EUR/PLN cross. During the last two years of the monitored period, 17 trades were executed. Out of the 17, eight options were calls and nine options were puts. On the day of the expiration, only four options had expired worthless. Another four options have not reached a break-even point. None of the nine profitable options made an extraordinary yield. At the end of the watched period, the FX OSI model made the net profit of 49 EUR, with 14 950 EUR paid in premiums. The following table describes every trade on the EUR/PLN cross in detail.

Table 2: EUR/PLN Cross - Purchased Monthly Options

EUR/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	31.7.2012	4,1838	4,106	31.8.2012	CALL	1 334	1 860	525	525	4%
2	31.8.2012	4,1099	4,199	2.10.2012	PUT	1 037	2 168	1 131	1 656	11%
3	24.10.2012	4,1142	4,15	22.11.2012	PUT	701	870	169	1 825	12%
4	19.12.2012	4,1293	4,07	18.1.2013	CALL	908	1 436	528	2 353	16%
5	18.1.2013	4,1604	4,15	20.2.2013	PUT	735	Expired	-735	1 619	11%
6	25.2.2013	4,1588	4,143	25.3.2013	CALL	974	380	-594	1 025	7%
7	8.4.2013	4,1424	4,123	8.5.2013	CALL	878	468	-410	615	4%
8	15.5.2013	4,2682	4,185	13.6.2013	PUT	632	Expired	-632	-17	0%
9	20.6.2013	4,2296	4,321	22.7.2013	PUT	1 171	2 161	990	973	7%
10	22.7.2013	4,2463	4,214	22.8.2013	CALL	1 054	761	-293	680	5%
11	28.8.2013	4,2246	4,282	26.9.2013	PUT	899	1 359	459	1 140	8%
12	15.10.2013	4,1889	4,17	14.11.2013	CALL	972	451	-520	619	4%
13	19.12.2013	4,16	4,169	17.1.2014	CALL	717	Expired	-717	-98	-1%
14	24.1.2014	4,1582	4,21	26.2.2014	PUT	800	1 246	446	348	2%
15	7.3.2014	4,1684	4,203	9.4.2014	PUT	765	830	65	413	3%
16	23.4.2014	4,1523	4,1947	23.5.2014	PUT	591	1 021	430	843	6%
17	23.5.2014	4,1435	4,154	25.6.2014	CALL	793	Expired	-793	49	0%

The second back-tested dataset was the EUR/USD currency pair. The two-years-long period was monitored, during which 19 trades were executed. Out of the 19 executed trades, 13 trades were put options. Seven options expired worthless and another four did not reach a break-even point. This leads to a very insufficient number of successful option trades. Fortunately, three trades made an extraordinary profit, which made a net profit of 2.392 EUR. Cumulated costs of premiums added up to a sum of 16.901 EUR. The two years performance made a 14% yield. The table below offers a detailed description of every trade on the EUR/USD cross.

Table 3: EUR/USD Cross - Purchased Monthly Options

EUR/ USD	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	6.8.2012	1,2579	1,24	6.9.2012	PUT	1 104	Expired	-1 104	-1 104	-7%
2	7.9.2012	1,292	1,279	9.10.2012	PUT	1 023	Expired	-1 023	-2 127	-13%
3	17.10.2012	1,2779	1,311	15.11.2012	PUT	970	2 590	1 620	-507	-3%
4	30.11.2012	1,3256	1,302	2.1.2013	PUT	859	Expired	-859	-1 366	-8%
5	11.1.2013	1,348	1,335	13.2.2013	PUT	935	Expired	-935	-2 301	-14%
6	21.2.2013	1,2905	1,318	21.3.2013	CALL	1 041	Expired	-1 041	-3 342	-20%
7	25.3.2013	1,3015	1,287	25.4.2013	CALL	1 133	1 114	-18	-3 360	-20%
8	1.5.2013	1,3032	1,322	30.5.2013	PUT	925	1 443	517	-2 843	-17%
9	6.6.2013	1,2868	1,32	8.7.2013	PUT	1 003	2 580	1 577	-1 266	-7%
10	8.7.2013	1,3371	1,2818	8.8.2013	CALL	1 051	4 136	3 085	1 819	11%
11	8.8.2013	1,3261	1,339	10.9.2013	PUT	884	973	89	1 908	11%
12	20.9.2013	1,3755	1,3456	22.10.2013	PUT	848	Expired	-848	1 060	6%
13	18.10.2013	1,3532	1,378	20.11.2013	PUT	827	1 833	1 006	2 066	12%
14	5.12.2013	1,3622	1,366	7.1.2014	PUT	833	279	-554	1 511	9%
15	6.1.2014	1,3605	1,358	6.2.2014	CALL	733	184	-550	962	6%
16	18.2.2014	1,3891	1,376	18.3.2014	PUT	716	Expired	-716	246	1%
17	3.4.2014	1,3875	1,371	5.5.2014	CALL	740	1 189	449	695	4%
18	6.5.2014	1,3583	1,393	5.6.2014	PUT	627	2 555	1 928	2 623	16%
19	10.6.2014	1,3602	1,3545	10.7.2014	CALL	650	419	-231	2 392	14%

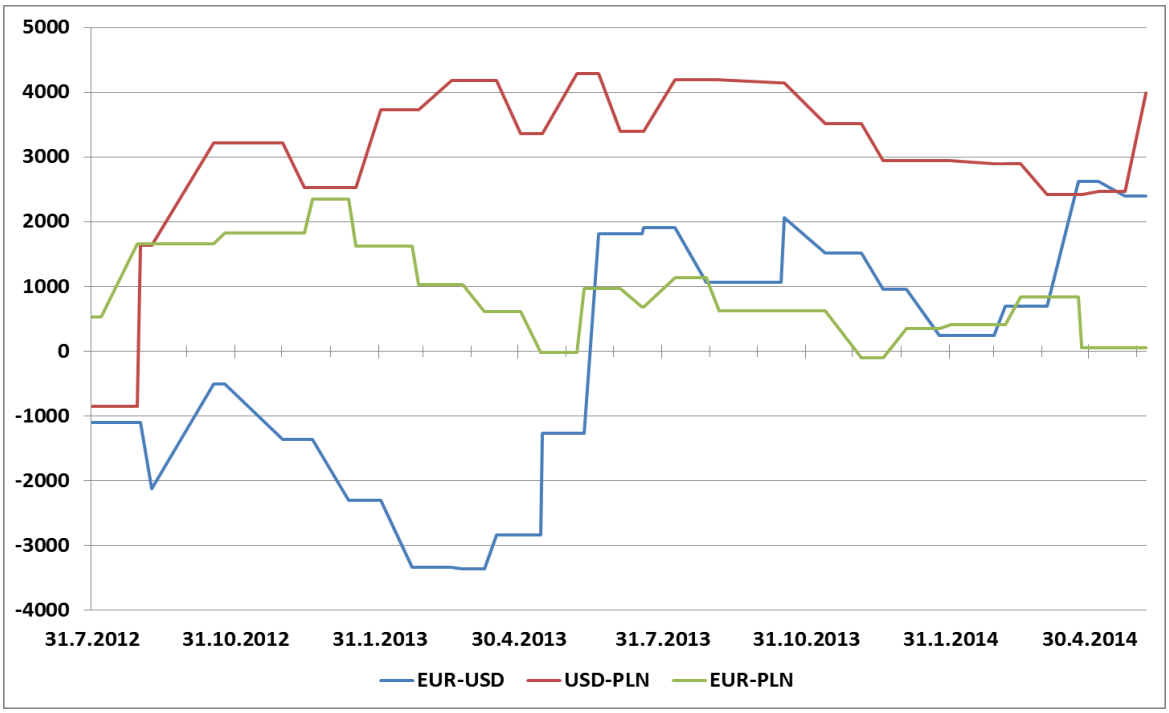
The third currency pair used for the simulation was the USD/PLN cross. During the last two years 18 trades were executed, out of which ten were call options. Four trades expired worthless and another four options have not crossed the break-even point. The maturity of every option was one month, and the notional was 100.000 USD. The strategy had four very profitable exercises, which lead to the profit of 7.237 USD. For option premiums 24.201 USD was paid, which created a two-year performance of plus 30%. The following table describes every traded option on the USD/PLN cross.

Table 4: USD/PLN Cross - Purchased Monthly Options

USD/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in USD	Profit at EXP	Net profit per EXP	Yield in USD	Yield in %
1	2.8.2012	3,3275	3,3	4.9.2012	CALL	2 211	826	-1 385	-1 385	-6%
2	5.9.2012	3,1695	3,36	8.10.2012	PUT	1 882	6 010	4 129	2 744	11%
4	17.10.2012	3,2671	3,119	15.11.2012	CALL	1 684	4 533	2 849	5 593	23%
5	14.12.2012	3,1085	3,1	16.1.2013	CALL	1 457	273	-1 184	4 410	18%
6	1.2.2013	3,1765	3,055	1.3.2013	CALL	1 497	3 825	2 328	6 738	28%
7	18.3.2013	3,1538	3,21	18.4.2013	PUT	1 252	1 782	530	7 268	30%
8	10.5.2013	3,201	3,2	12.6.2013	PUT	1 440	Expired	-1 440	5 828	24%
9	11.6.2013	3,3211	3,205	11.7.2013	CALL	1 763	3 496	1 733	7 561	31%
10	19.7.2013	3,1692	3,222	21.8.2013	CALL	1 643	Expired	-1 643	5 917	24%
11	28.8.2013	3,1259	3,22	26.9.2013	PUT	1 449	3 010	1 561	7 479	31%
12	17.10.2013	3,0923	3,05	19.11.2013	CALL	1 373	1 368	-5	7 474	31%
13	5.12.2013	3,0686	3,068	7.1.2014	CALL	1 135	20	-1 116	6 359	26%
14	6.1.2014	3,095	3,071	6.2.2014	PUT	1 044	Expired	-1 044	5 314	22%
15	17.3.2014	3,0314	3,07	17.4.2014	PUT	1 228	1 273	45	5 360	22%
16	25.4.2014	3,0534	3,044	27.5.2014	PUT	913	Expired	-913	4 447	18%
17	5.6.2014	3,0498	3,008	7.7.2014	CALL	1 354	1 371	17	4 464	18%
18	9.7.2014	3,1396	3,025	7.8.2014	CALL	877	3 650	2 773	7 236	30%

During the monitored period the best performing strategy was found on the EUR/USD cross. Unfortunately, a detailed analysis of every single trade showed that this strategy performed well only because of the second and the third very successful trade, which generated a profit of 10.500 USD. The least performing cross was the EUR/PLN, which made no profit, but was a very stable strategy. The first half of the simulation performed on the EUR/USD cross had a very unstable performance. It made a loss of 3.360 EUR that was later replaced by four profitable trades and created a profit of 2.392 EUR.

Figure 23: Yield Curves of Monthly Simulations



5.2. Implementation of Monthly Options' Results

Overall, the FX OSI model with a monthly maturity had a profitable performance. A detailed look at the performance of every trade has revealed that the strategies are unstable and stayed in green numbers only due to a couple of very profitable trades in each of the three currency pairs traced. The first advantage of these strategies was based on a very small number of trades that had to be executed throughout the watched period. The second advantage of the strategy is its ability to calculate the maximum loss, which equals to a sum invested into the price premium. If a trade went the opposite direction no additional loss was created.

5.3. Results of Three-Week Options

The first currency pair back-tested on a strategy with the three-week-long option was the EUR/PLN cross. 18 trades were executed during the two-year period. Six of them expired worthless and another nine options had not crossed the break-even point. Therefore, the majority of trades made a loss. Only three trades were profitable. The overall cost of premiums summed up to 11.632 EUR. At the end of the watched period, a strategy made a net loss of 5.769 EUR. Losing 50% of the portfolio in two years is a very risky strategy.

Table 5: EUR/PLN Cross - Purchased Three-Week Options

EUR/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	31.7.2012	4,0877	4,106	15.8.2012	CALL	932	Expired	-932	-932	-8%
2	29.8.2012	4,1152	4,16	13.9.2012	PUT	682	1 089	406	-526	-5%
3	24.10.2012	4,1586	4,15	8.11.2012	PUT	560	Expired	-560	-1 086	-9%
4	19.12.2012	4,0758	4,07	3.1.2013	CALL	606	142	-464	-1 550	-13%
5	16.1.2013	4,1872	4,15	31.1.2013	PUT	540	Expired	-540	-2 090	-18%
6	25.2.2013	4,1491	4,143	12.3.2013	CALL	704	147	-557	-2 647	-23%
7	8.4.2013	4,1284	4,123	23.4.2013	CALL	701	131	-570	-3 217	-28%
8	15.5.2013	4,2485	4,185	30.5.2013	PUT	578	Expired	-578	-3 794	-33%
9	20.6.2013	4,2812	4,321	5.7.2013	PUT	687	930	243	-3 552	-31%
10	18.7.2013	4,2553	4,24	2.8.2013	CALL	818	360	-459	-4 011	-34%
11	28.8.2013	4,2232	4,282	12.9.2013	PUT	702	1 392	690	-3 321	-29%
12	15.10.2013	4,1865	4,17	30.10.2013	CALL	676	394	-281	-3 602	-31%
13	12.11.2013	4,2037	4,217	27.11.2013	PUT	527	316	-211	-3 813	-33%
14	19.12.2013	4,1644	4,169	3.1.2014	CALL	471	Expired	-471	-4 284	-37%
15	24.1.2014	4,1823	4,21	10.2.2014	PUT	716	662	-53	-4 337	-37%
16	7.3.2014	4,1985	4,203	24.3.2014	PUT	555	107	-448	-4 785	-41%
17	23.4.2014	4,1866	4,195	8.5.2014	PUT	650	193	-457	-5 242	-45%
18	23.5.2014	4,0993	4,154	9.6.2014	CALL	528	Expired	-528	-5 769	-50%

The second currency pairs back-tested on the three-week option was the EUR/USD cross. During the simulation, 21 trades were executed, of which nine expired worthless, and another three had not crossed the break-even point. The strategy had eight profitable trades, which earned the most of the 19% yield. The maximal net loss of the portfolio was 25%, which represents a very big risk. The table below contains a detailed description of every trade on the EUR/USD pair.

Table 6: EUR/USD Cross - Purchased Three-Week Options

EUR/ USD	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	6.8.2012	1,247	1,24	21.8.2012	PUT	781	Expired	-781	-781	-5%
2	7.9.2012	1,2913	1,278	24.9.2012	PUT	754	Expired	-754	-1 535	-11%
3	17.10.2012	1,2964	1,311	1.11.2012	PUT	708	1 126	418	-1 117	-8%
4	30.11.2012	1,3173	1,301	17.12.2012	PUT	664	Expired	-664	-1 780	-12%
5	11.1.2013	1,3766	1,335	18.12.2013	PUT	948	Expired	-948	-2 728	-19%
6	21.2.2013	1,2976	1,32	8.3.2013	CALL	858	Expired	-858	-3 586	-25%
7	25.3.2013	1,3047	1,286	9.4.2013	CALL	849	1 433	585	-3 002	-21%
8	1.5.2013	1,2902	1,321	16.5.2013	PUT	740	2 387	1 647	-1 354	-9%
9	6.6.2013	1,3164	1,324	21.6.2013	PUT	768	577	-191	-1 545	-11%
10	4.7.2013	1,3121	1,29	19.7.2013	CALL	813	1 684	872	-673	-5%
11	8.8.2013	1,3349	1,339	23.8.2013	PUT	616	307	-309	-982	-7%
12	5.9.2013	1,3528	1,313	20.9.2013	CALL	735	2 942	2 207	1 225	8%
13	17.10.2013	1,3503	1,378	1.11.2013	PUT	606	2 051	1 445	2 670	19%
14	5.12.2013	1,3675	1,366	20.12.2013	PUT	669	Expired	-669	2 000	14%
15	3.1.2014	1,356	1,36	20.1.2014	CALL	694	Expired	-694	1 307	9%
16	31.1.2014	1,3704	1,35	17.2.2014	CALL	675	1 489	814	2 120	15%
17	28.2.2014	1,3928	1,381	17.3.2014	PUT	621	Expired	-621	1 499	10%
18	3.4.2014	1,3819	1,371	18.4.2014	CALL	562	789	227	1 726	12%
19	6.5.2014	1,366	1,393	21.5.2014	PUT	460	1 977	1 517	3 243	22%
20	5.6.2014	1,3583	1,352	20.6.2014	CALL	527	464	-63	3 179	22%
21	16.7.2014	1,3387	1,353	31.7.2014	CALL	379	Expired	-379	2 800	19%

The last currency pair that was back-tested was the USD/PLN. Despite a shorter maturity of the option, only 16 trades were executed. Every trade had a notional of 100.000,- USD and not EUR as in last two tests. Five trades had expired and four had not crossed the break-even point on the expiration day. Due to the smaller number of executed trades and two very profitable options, the strategy based on the FX OSI model made a profit of 78%. The total cost of premiums equalled to 20.091 USD. The net profit was 15.651 USD, which puts this simulation to the first place in the profitability. The table below contains a detailed description of every trade on the USD/PLN pair.

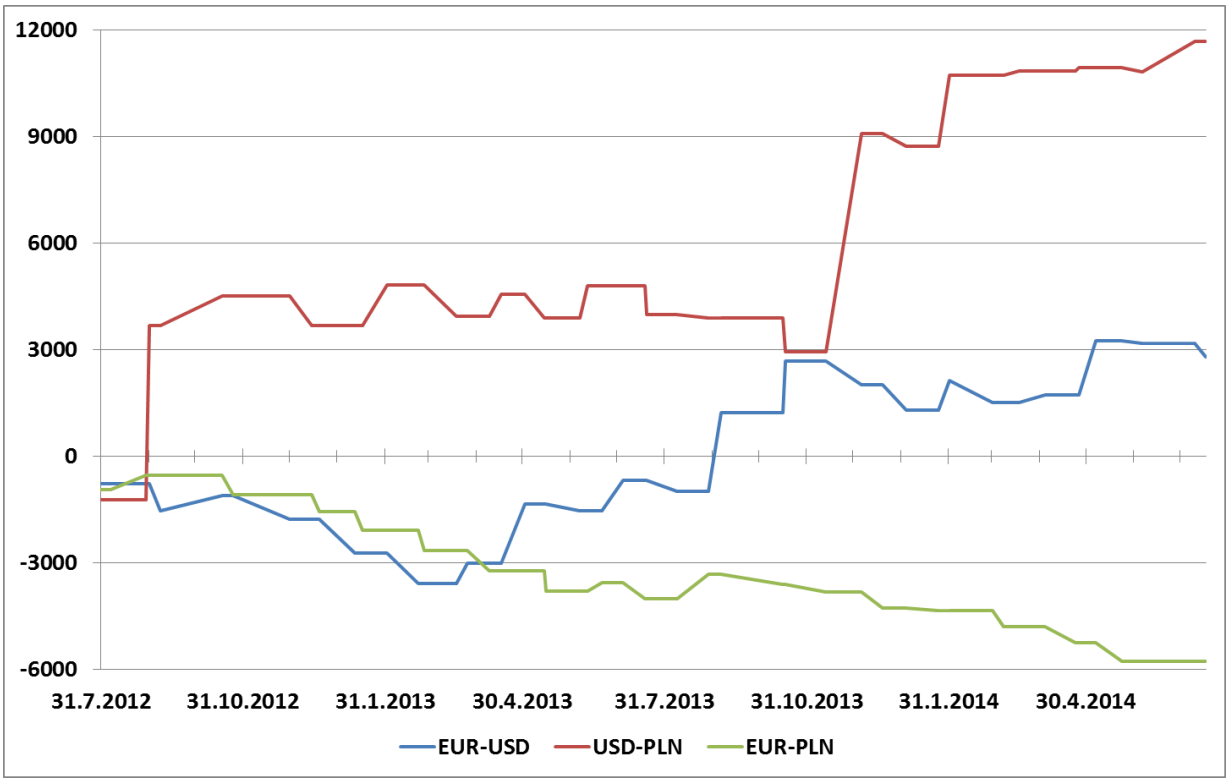
Table 7: USD/PLN Cross - Purchased Three-Week Options

USD/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in USD	Profit at EXP	Net profit per EXP	Yield in USD	Yield in %
1	2.8.2012	3,288	3,3	17.8.2012	CALL	1 518	Expired	-1 518	-1 518	-8%
2	31.8.2012	3,1205	3,36	17.9.2012	PUT	1 445	7 675	6 230	4 712	23%
3	17.10.2012	3,1933	3,119	1.11.2012	CALL	1 185	2 327	1 142	5 854	29%
4	14.12.2012	3,0996	3,1	31.12.2012	CALL	992	Expired	-992	4 862	24%
5	1.2.2013	3,1403	3,055	15.2.2013	CALL	1 069	2 716	1 647	6 509	32%
6	18.3.2013	3,2641	3,21	1.4.2013	PUT	1 445	Expired	-1 445	5 064	25%
7	16.4.2013	3,1728	3,114	30.4.2013	CALL	996	1 853	857	5 921	29%
8	14.5.2013	3,2461	3,22	28.5.2013	PUT	869	Expired	-869	5 052	25%
9	11.6.2013	3,2834	3,202	25.6.2013	CALL	1 185	2 470	1 285	6 337	32%
10	19.7.2013	3,2197	3,222	2.8.2013	CALL	999	Expired	-999	5 338	27%
11	28.8.2013	3,194	3,22	11.9.2013	PUT	1 030	814	-216	5 122	25%
12	17.10.2013	3,0506	3,05	31.10.2013	CALL	1 129	20	-1 109	4 013	20%
13	5.12.2013	3,4087	3,068	19.12.2013	CALL	1 595	9 995	8 400	12 412	62%
14	3.1.2014	3,0596	3,068	17.1.2014	PUT	767	275	-492	11 920	59%
15	31.1.2014	3,033	3,15	14.2.2014	PUT	1 071	3 858	2 787	14 707	73%
16	17.3.2014	3,0348	3,07	31.3.2014	PUT	890	1 160	270	14 976	75%
16	25.4.2014	3,0246	3,044	9.5.2014	PUT	609	641	33	15 009	75%
16	5.6.2014	3,0217	3,008	19.6.2014	CALL	722	453	-269	14 740	73%
16	9.7.2014	3,0706	3,025	23.7.2014	CALL	575	1 485	910	15 651	78%

5.4. Implementation of Three-Week Options' Results

The graph below represents the simulation results of the three currency pairs, which were used to test the FX OSI model. During the period of two years, the Foreign Exchange Options Strategy Indicator with options of the three-week maturity had the same profitability order of currency crosses as the test of options with a monthly maturity. The most profitable currency pair was USD/PLN, the second, which made no change in profit, was EUR/USD, and the last place belongs to the EUR/PLN cross with a total loss of almost 6.000 EUR. The USD/PLN simulation was the most profitable back-test, because two trades made an extreme profit. The goal of every technical indicator is to provide an investor with a continuous profit while allowing only a small chance of drawbacks. Unfortunately, the strategy with the shorter life of the option doesn't provide the investor with a satisfying result.

Figure 24: Yields of Three-Week Options



5.5. Results of Two-Week Options

During the last two years, an option strategy with two-week-life span was back-tested. The first currency pair, of which a detailed explanation is shown in the table below, had 24 executed trades on the EUR/PLN cross. Precisely 50% of trades had expired worthless, and another 5 options had not crossed the break-even level. In total, 14.715 EUR was paid for option premiums. After two years of testing, the strategy ended with a loss of 27%. At one point, the loss on the strategy was almost 35%. Only three trades had a higher profitability. Overall, the strategy was consistently losing money on option premiums.

Table 8: EUR/PLN Cross - Purchased Two-Week Options

EUR/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	31.7.2012	4,0879	4,106	14.8.2012	CALL	899	Expired	-899	-899	-6%
2	29.8.2012	4,0808	4,16	12.9.2012	PUT	666	1 941	1 275	376	3%
3	24.10.2012	4,1122	4,15	7.11.2012	PUT	556	919	363	739	5%
4	13.11.2012	4,1006	4,18	27.11.2012	PUT	531	1 936	1 405	2 145	15%
5	19.12.2012	4,0665	4,07	2.1.2013	CALL	566	Expired	-566	1 579	11%
6	4.1.2013	4,2741	4,125	6.6.2013	PUT	491	Expired	-491	1 088	7%
7	23.1.2013	4,179	4,175	6.2.2013	PUT	551	Expired	-551	537	4%
8	25.2.2013	4,1391	4,143	11.3.2013	CALL	671	Expired	-671	-134	-1%
9	20.3.2013	4,1905	4,175	3.4.2013	PUT	459	Expired	-459	-594	-4%
10	8.4.2013	4,1036	4,123	22.4.2013	CALL	573	Expired	-573	-1 167	-8%
11	15.5.2013	4,2311	4,185	29.5.2013	PUT	481	Expired	-481	-1 648	-11%
12	3.6.2013	4,2313	4,279	17.6.2013	PUT	655	1 127	473	-1 175	-8%
13	20.6.2013	4,3195	4,321	4.7.2013	PUT	920	35	-886	-2 061	-14%
14	16.7.2013	4,2197	4,254	30.7.2013	CALL	778	Expired	-778	-2 839	-19%
15	28.8.2013	4,2396	4,282	11.9.2013	PUT	681	1 000	319	-2 520	-17%
16	16.9.2013	4,2155	4,193	30.9.2013	CALL	767	534	-234	-2 754	-19%
17	15.10.2013	4,1872	4,17	29.10.2013	CALL	442	411	-31	-2 785	-19%
18	7.11.2013	4,1923	4,16	21.11.2013	CALL	612	770	159	-2 626	-18%
19	18.12.2013	4,1578	4,169	1.1.2014	CALL	459	Expired	-459	-3 085	-21%
20	24.1.2014	4,1866	4,21	7.2.2014	PUT	594	559	-35	-3 119	-21%
21	7.3.2014	4,1975	4,203	21.3.2014	PUT	622	131	-491	-3 610	-25%
22	23.4.2014	4,2004	4,1947	7.5.2014	PUT	755	Expired	-755	-4 365	-30%
23	23.5.2014	4,1209	4,154	6.6.2014	CALL	498	Expired	-498	-4 864	-33%
24	10.6.2014	4,1578	4,1015	24.6.2014	CALL	488	1 354	866	-3 998	-27%

The second back-tested currency cross was the EUR/USD pair. The simulation showed that during the time of the test, 31 trades were executed, out of which 10 had expired out-of-the-money and another seven trades had not crossed the break-even point. This means that 17 out of 31 trades were not profitable. Out of 14 options, which were above the break-even point only two yielded an extra profit. That means almost no option picked the proper direction of the trend. The amount paid for options was 19.308 EUR. The maximal drawdown of the portfolio was more than 26%. The strategy made a profit of 1.752 EUR in two years, which is the smallest absolute profit out of the three types of option strategies.

Table 9: EUR/USD Cross - Purchased Two-Week Options

EUR/ USD	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	6.8.2012	1,2314	1,24	20.8.2012	PUT	732	698	-33	-33	0%
2	23.8.2012	1,28	1,256	8.9.2012	PUT	703	Expired	-703	-737	-4%
3	11.9.2012	1,2944	1,28	25.9.2012	PUT	742	Expired	-742	-1 479	-8%
4	17.10.2012	1,2971	1,311	31.10.2012	PUT	669	1 072	403	-1 076	-6%
5	5.11.2012	1,2786	1,278	19.11.2012	CALL	665	47	-618	-1 694	-9%
6	30.11.2012	1,3087	1,301	14.12.2012	PUT	651	Expired	-651	-2 344	-12%
7	19.12.2012	1,3256	1,328	2.1.2013	PUT	518	181	-337	-2 681	-14%
8	11.1.2013	1,3473	1,335	25.1.2013	PUT	641	Expired	-641	-3 322	-17%
9	30.1.2013	1,348	1,356	13.2.2013	PUT	637	593	-44	-3 366	-17%
10	21.2.2013	1,3099	1,32	7.3.2013	CALL	818	Expired	-818	-4 184	-22%
11	19.3.2013	1,2825	1,284	2.4.2013	CALL	822	Expired	-822	-5 006	-26%
12	9.4.2013	1,302	1,309	23.4.2013	PUT	641	538	-104	-5 110	-26%
13	1.5.2013	1,2869	1,321	15.5.2013	PUT	713	2 650	1 936	-3 173	-16%
14	20.5.2013	1,2973	1,283	3.6.2013	CALL	654	1 102	448	-2 725	-14%
15	6.6.2013	1,3194	1,324	20.6.2013	PUT	728	349	-380	-3 105	-16%
16	4.7.2013	1,3077	1,29	18.7.2013	CALL	774	1 354	580	-2 525	-13%
17	25.7.2013	1,3371	1,328	8.8.2013	PUT	704	Expired	-704	-3 229	-17%
18	20.8.2013	1,3155	1,34	3.9.2013	PUT	563	1 862	1 300	-1 929	-10%
19	6.9.2013	1,3528	1,311	20.9.2013	CALL	642	3 090	2 447	518	3%
20	17.10.2013	1,3617	1,378	31.10.2013	PUT	579	1 197	618	1 136	6%
21	7.11.2013	1,3453	1,336	21.11.2013	CALL	628	691	63	1 200	6%
22	5.12.2013	1,3666	1,366	19.12.2013	PUT	642	Expired	-642	558	3%
23	27.12.2013	1,3676	1,381	10.1.2014	PUT	635	980	345	902	5%
24	17.1.2014	1,3487	1,354	31.1.2014	CALL	569	Expired	-569	334	2%
25	18.2.2014	1,3757	1,376	4.3.2014	PUT	482	22	-460	-126	-1%
26	7.3.2014	1,3807	1,39	21.3.2014	PUT	514	674	159	33	0%
27	3.4.2014	1,3835	1,371	17.4.2014	CALL	535	904	369	402	2%
28	6.5.2014	1,37	1,393	20.5.2014	PUT	446	1 679	1 233	1 635	8%
29	5.6.2014	1,3636	1,352	19.6.2014	CALL	500	851	350	1 985	10%
30	30.6.2014	1,3618	1,369	14.7.2014	PUT	383	529	145	2 131	11%
31	17.7.2014	1,3387	1,352	31.7.2014	CALL	379	Expired	-379	1 752	9%

The last back-tested currency cross was the USD/PLN cross. During the two years, 26 options were bought, out of which 9 expired worthless and another 6 had not crossed the break-even level. In total, more than 50% of the purchased options expired worthless. Due to two options, which in sum made a profit of 17.874 USD, the strategy ended with a profit of 44%. 24.775 USD was spent on bought options. Despite the fact that this strategy made a profit of 44%, it is not considered to be a satisfying result, because the strategy was losing money most of the time, and only two trades made an extra profit. The table below sums up all trade details of the 26 bought options with the two-week maturity.

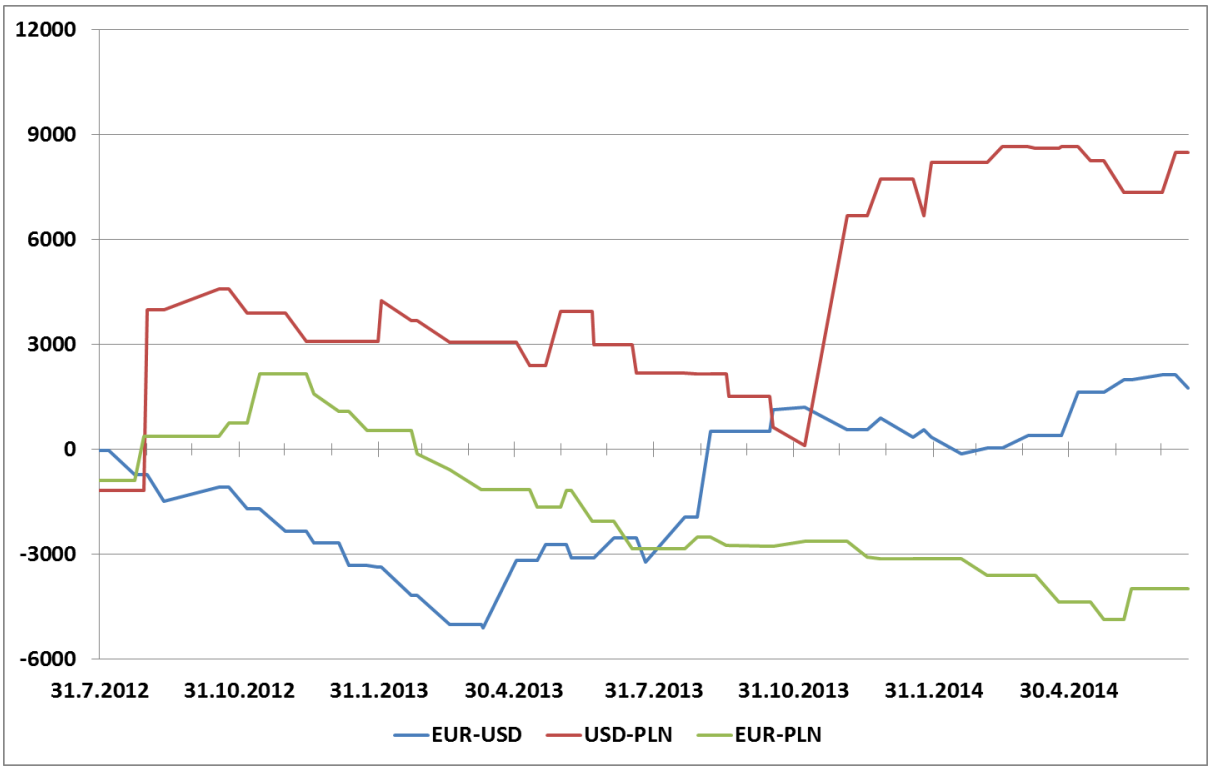
Table 10: USD/PLN Cross - Purchased Two-Week Options

USD/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in USD	Profit at EXP	Net profit per EXP	Yield in USD	Yield in %
1	2.8.2012	3,288	3,3	17.8.2012	CALL	1 452	Expired	-1 452	-1 452	-6%
2	31.8.2012	3,1129	3,36	14.9.2012	PUT	1 378	7 938	6 560	5 108	21%
3	17.10.2012	3,1813	3,119	31.10.2012	CALL	1 123	1 958	835	5 944	24%
4	5.11.2012	3,2473	3,227	19.11.2012	PUT	936	Expired	-936	5 008	20%
5	14.12.2012	3,0895	3,1	28.12.2012	CALL	930	Expired	-930	4 078	16%
6	1.2.2013	3,1403	3,055	15.2.2013	CALL	1 069	2 716	1 647	5 725	23%
7	21.2.2013	3,1809	3,158	7.3.2013	PUT	916	Expired	-916	4 809	19%
8	18.3.2013	3,2641	3,21	1.4.2013	PUT	899	Expired	-899	3 910	16%
9	9.4.2013	3,1798	3,147	23.4.2013	CALL	976	1 032	56	3 966	16%
10	10.5.2013	3,2399	3,195	24.5.2013	PUT	895	Expired	-895	3 072	12%
11	30.5.2013	3,1998	3,3	13.6.2013	PUT	1 122	3 131	2 009	5 081	21%
12	21.6.2013	3,3236	3,32	5.7.2013	PUT	1 162	Expired	-1 162	3 919	16%
13	19.7.2013	3,2197	3,222	2.8.2013	CALL	999	Expired	-999	2 920	12%
14	28.8.2013	3,194	3,22	11.9.2013	PUT	1 030	814	-216	2 704	11%
15	18.9.2013	3,1216	3,11	2.10.2013	CALL	1 089	372	-717	1 987	8%
16	17.10.2013	3,0506	3,05	31.10.2013	CALL	1 159	20	-1 139	848	3%
17	7.11.2013	3,1216	3,127	21.11.2013	PUT	876	173	-703	145	1%
18	5.12.2013	3,4087	3,07	19.12.2013	CALL	952	9 936	8 985	9 130	37%
19	27.12.2013	3,069	3	10.1.2014	CALL	810	2 248	1 438	10 568	43%
20	29.1.2014	3,0553	3,1	12.2.2014	PUT	992	1 463	471	11 039	45%
21	17.3.2014	3,0348	3,07	31.3.2014	PUT	890	1 160	270	11 309	46%
22	8.4.2014	3,0341	3,018	22.4.2014	CALL	664	531	-133	11 175	45%
23	25.4.2014	3,0246	3,045	9.5.2014	PUT	609	674	65	11 241	45%
24	14.5.2014	3,0599	3,055	28.5.2014	PUT	550	Expired	-550	10 691	43%
25	5.6.2014	3,0217	3,02	19.6.2014	CALL	725	56	-669	10 022	40%
26	9.7.2014	3,0706	3,025	23.7.2014	CALL	575	1 485	910	10 933	44%

5.6. Implementation of Two Weeks Options' Results

The graph below describes the simulation results of the two-week option strategy, which was back-tested on the three currency pairs. The best performing currency cross was USD/PLN. The EUR/PLN cross ended in the third place with a total loss of almost 27%. None of the profit diagrams showed a continuous increase of profit, rather a continuous loss. A continual depreciation of the portfolio value was caused by purchasing options, which either expired or were exercised below the break-even point. Due to the options' leverage ability and extreme moves in the direction of the Delta, the portfolio improved its performance. The best result would be a continual profitability with small drawdowns.

Figure 25: Yield Curves of Two-Week Simulations



5.7. Re-evaluation

The back-tested strategies provided sufficient information about the overall performance of the indicator. In general, shorter the option's maturity was, the more expensive the executed were. Unfortunately, the overall cost of the strategy was not directly dependent on the life span of the option. The results showed that investing into options strategy is very expensive. Moreover, it doesn't provide consistent increase of profitability, but rather consistent expenses, which are covered by a rare number of very profitable trades. The results of the trades also showed that the market trend and the behaviour of the currency pair havw a big impact on the overall performance. The change of the maturity had a small impact on the change of the overall profit. In general, the strategies tested on the USD/PLN cross made the highest yield, all strategies back-tested on EUR/PLN cross had negative yield and the strategies tested on the EUR/USD cross ended up with a small profit. The advantage is the ability to compute the maximal potential loss, which equalled to the average cost of the price premium multiplied by the average number of the executed trades during the watched period. The maximal measured drawdown was -45%, thus no investor would ever put money on this kind of strategy.

5.8. Modification of the Model

There was one more experiment conducted in order to improve the tested results. The previous calculations reveal that the time period has nothing to do with the profitability of the strategy. This could be possible due to a lengthy option life span or to a technical indicator, which is not suited for trading options. The Bollinger bands provide information about extreme move on the market, and thus the strategy for trading this kind of event should be much shorter than the one set for the previous calculations. Trading simply Forex is very difficult at extreme levels, because no one knows how much more the spot will go in the direction of the extreme move. This might cause a big loss. Therefore, it is very convenient to limit the loss by buying an option, where the maximal loss equals to the paid premium. In order to minimize the options price, a one-week maturity was chosen. The net cost of the strategy should decrease and make the total performance more efficient, too.

The second modification of the model is based on the idea of capturing only rare and very extreme price actions. In order to be able to measure this event, the Bollinger bands had to be widened. That can be achieved by increasing the parameter that multiplies the standard deviation, which is then subtracted or added to the moving average. By resetting the parameter from two to three, we were able to capture only very big price actions and reduce the number of generated alerts to buy an option.

5.9. Results after the Modification

The modified FX option strategy model was tested on three currency pairs again. With a shorter option life and wider Bollinger bands we were able to reduce the number of alerts and also emphasize only extreme moves. The first tested currency pair was EUR/PLN.

The first calculations after the modification on the EUR/PLN cross reveal that the number of executed trades in comparison with two week options has declined to 18 trades only. Out of 22 trades, seven expired worthless and another six trades had not crossed break-even point. This is a very disappointing number, which puts the entire strategy into a bad position. Only five trades made profit, and this was not big enough to cover the costs spent on purchasing the options. The total cost was 8.320 EUR and net yield was –1.966 EUR, which equals to a loss of 24% of the portfolio during the entire watched period. The biggest drawdown of the portfolio was 1.967 EUR. Overall, the strategy can be considered as inefficient with an excessive risk and a small profitability. The table below shows details of every single trade executed on the EUR/PLN cross during the watched period.

Table 11: EUR/PLN Cross - Purchased Weekly Options

EUR/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	6.8.2012	4,081	4,031	13.8.2012	Call	580	1 225	645	645	8%
2	29.8.2012	4,213	4,149	5.9.2012	Put	500	Expired	-500	145	2%
3	18.1.2013	4,19	4,15	25.1.2013	Put	420	Expired	-420	-275	-3%
4	4.3.2013	4,139	4,133	11.3.2013	Call	450	145	-305	-580	-7%
5	21.3.2013	4,1866	4,187	28.3.2013	Put	350	10	-340	-920	-11%
6	10.4.2013	4,11	4,1	17.4.2013	Call	420	243	-177	-1 097	-13%
7	29.5.2013	4,234	4,24	5.6.2013	Put	440	142	-298	-1 395	-17%
8	20.6.2013	4,331	4,34	27.6.2013	Put	780	208	-572	-1 967	-24%
9	28.8.2013	4,266	4,293	4.9.2013	Put	530	633	103	-1 865	-22%
10	18.9.2013	4,228	4,177	24.9.2013	Call	590	1 206	616	-1 248	-15%
11	11.11.2013	4,18	4,21	18.11.2013	Put	390	718	328	-921	-11%
12	19.12.2013	4,1445	4,165	26.12.2013	Call	320	Expired	-320	-1 241	-15%
13	24.1.2014	4,237	4,2	31.1.2014	Put	530	Expired	-530	-1 771	-21%
14	31.1.2014	4,1866	4,255	7.2.2014	Put	630	1 634	1 004	-767	-9%
15	25.4.2014	4,198	4,206	2.5.2014	Put	350	191	-159	-926	-11%
16	22.5.2014	4,139	4,158	29.5.2014	Call	310	Expired	-310	-1 236	-15%
17	5.6.2014	4,1087	4,109	12.6.2014	Call	430	Expired	-430	-1 666	-20%
18	31.7.2014	4,199	4,17	7.8.2014	Put	300	Expired	-300	-1 966	-24%

Table 12: EUR/USD Cross - Purchased Weekly Options

EUR/ USD	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in EUR	Profit at EXP	Net profit per EXP	Yield in EUR	Yield in %
1	24.8.2012	1,26	1,255	31.8.2012	Put	475	Expired	-475	-475	-6%
2	14.9.2012	1,299	1,315	21.9.2012	Put	560	1 232	672	197	3%
3	17.10.2012	1,297	1,313	24.10.2012	Put	490	1 234	744	940	13%
4	14.1.2013	1,331	1,339	21.1.2012	Put	490	601	111	1 051	14%
5	26.2.2013	1,302	1,304	5.3.2013	Call	670	Expired	-670	381	5%
6	27.3.2013	1,285	1,277	3.4.2013	Call	530	623	93	474	6%
7	15.5.2013	1,295	1,285	22.5.2013	Call	520	772	252	726	10%
8	6.6.2013	1,33	1,324	13.6.2013	Put	440	Expired	-440	286	4%
9	20.8.2013	1,338	1,344	27.8.2013	Put	490	448	-42	245	3%
10	19.9.2013	1,35	1,355	26.9.2013	Put	480	370	-110	135	2%
11	17.10.2013	1,38	1,364	24.10.2013	Put	420	Expired	-420	-285	-4%
12	27.12.2013	1,361	1,386	3.1.2014	Put	400	1 837	1 437	1 152	15%
13	3.1.2014	1,367	1,3595	10.1.2014	Call	530	549	19	1 170	16%
14	7.3.2014	1,391	1,3905	14.3.2014	Put	360	Expired	-360	810	11%
15	6.5.2014	1,372	1,394	13.5.2014	Put	350	1 603	1 253	2 064	28%
16	14.5.2014	1,366	1,372	21.5.2014	Call	300	Expired	-300	1 764	24%

The table above is a summary of all trades realized on the EUR/USD currency cross. During the tested period, 16 trades were executed, out of which 6 expired out-of-the-money and another 2 had not crossed the break-even point. Eight option trades were exercised with profit. The amount spent on purchasing the options was 7.505 EUR and the maximal

drawdown was –6% percent. At the end of the tested period, the strategy ended up in a positive yield of 24%, which is exactly a gain of 1.764, EUR.

Table 13: USD/PLN Cross- Purchased Weekly Options

USD/ PLN	Trade date	Spot at EXP	Strike	Expiration Date	Type	Price in USD	Profit at EXP	Net profit per EXP	Yield in USD	Yield in %
1	4.8.2012	3,319	3,28	13.8.2012	Call	1 000	1 175	175	175	1%
2	7.9.2012	3,119	3,206	14.9.2012	Call	980	Expired	-980	-805	-6%
3	14.9.2012	3,168	3,09	21.9.2012	Call	970	2 462	1 492	687	6%
4	8.11.2012	3,267	3,275	15.11.2012	Put	740	245	-495	192	2%
5	21.2.2013	3,168	3,17	28.2.2013	Put	710	63	-647	-455	-4%
6	21.3.2013	3,2778	3,247	28.3.2013	Put	710	Expired	-710	-1 165	-9%
7	15.5.2013	3,231	3,25	22.5.2013	Put	660	588	-72	-1 237	-10%
8	14.6.2013	3,274	3,16	21.6.2013	Call	880	3 482	2 602	1 365	11%
9	29.8.2013	3,245	3,235	5.9.2013	Put	890	Expired	-890	475	4%
10	5.9.2013	3,178	3,27	12.9.2013	Put	810	2 895	2 085	2 560	21%
11	19.9.2013	3,126	3,08	26.9.2013	Call	810	1 472	662	3 222	26%
12	17.10.2013	3,032	3,05	24.10.2013	Call	890	Expired	-890	2 332	19%
13	30.1.2014	3,095	3,117	6.2.2014	Put	810	711	-99	2 232	18%
14	10.4.2014	3,0253	3,006	16.4.2014	Call	440	638	198	2 430	19%
15	13.5.2014	3,061	3,053	20.5.2014	Put	430	Expired	-430	2 000	16%
16	6.6.2014	3,038	3,005	13.6.2014	Call	420	1 086	666	2 667	21%
17	18.7.2014	3,083	3,07	25.7.2014	Put	320	Expired	-320	2 347	19%

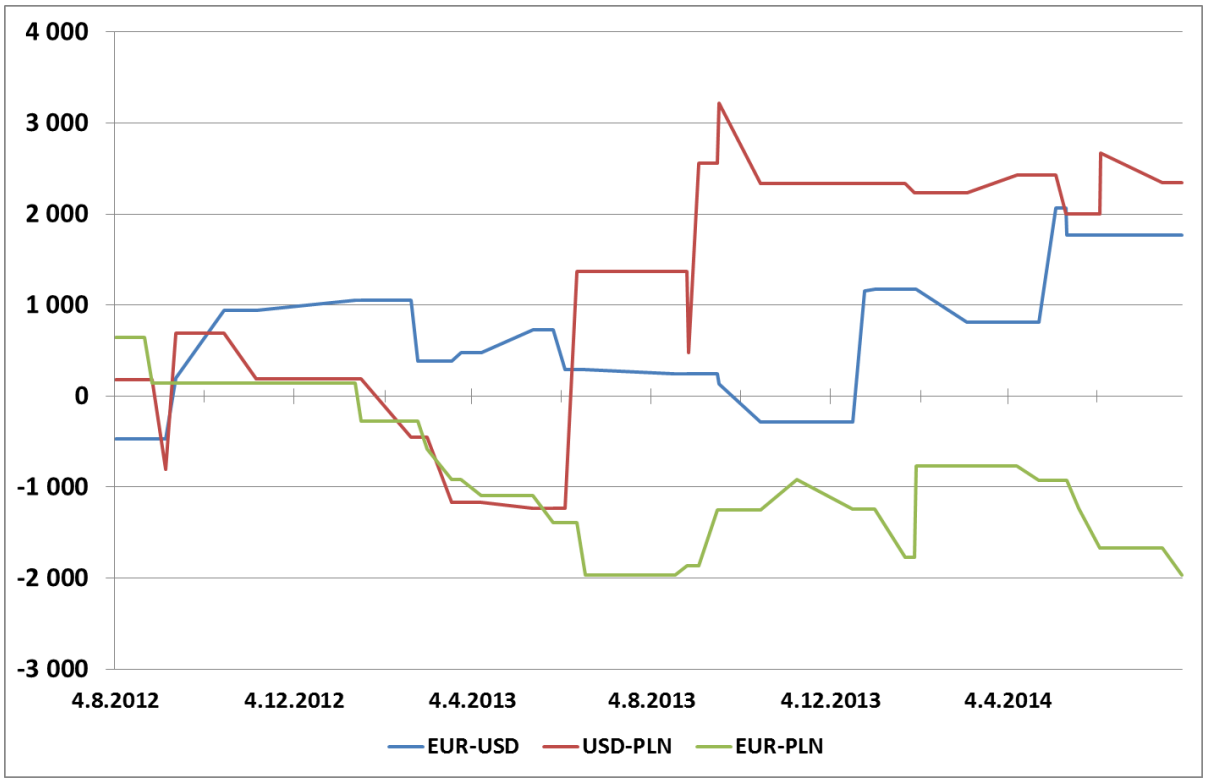
USD/PLN was the last currency pair, which was back-tested within the two-year period. During the test, 17 option trades were executed, out of which six expired worthless and another four were not able to cover the expense of the premiums. The cost of the strategy was 12.470 USD and the net performance yielded a gain of 2.347 USD. This equals to a 19% increase of investment. Out of the three back-tested currency pairs this one made the second highest profit. The table above reports every option trade execution on the USD/PLN pair.

5.10. Implementation of the Results after the Modification

The graph below compares the profitability of a strategy where the life of the option is one week, and the signal to buy occurs when spot crosses the Bollinger band with a standard deviation multiplied by three. The two currency crosses that made a profit in the two-year period were USD/PLN with a net gain of 19% and EUR/USD with a net gain of 24%. EUR/PLN ended in red numbers. Yet, the USD/PLN cross has not gained any profit in the first half of the monitored period. The strategy has not shown any improvement in the continuity of net gains. Due to the expensive price premiums, the portfolio was under continuous depreciation of value with rare but extreme increase of profitability caused by the

exercise of the option with high net profit. Except for the EUR/USD cross, the number of the expired options and the options, which were not able to the cross break-even point during the watched period, has remained high. Overall, more than 50% of all trades were not exercised with profit.

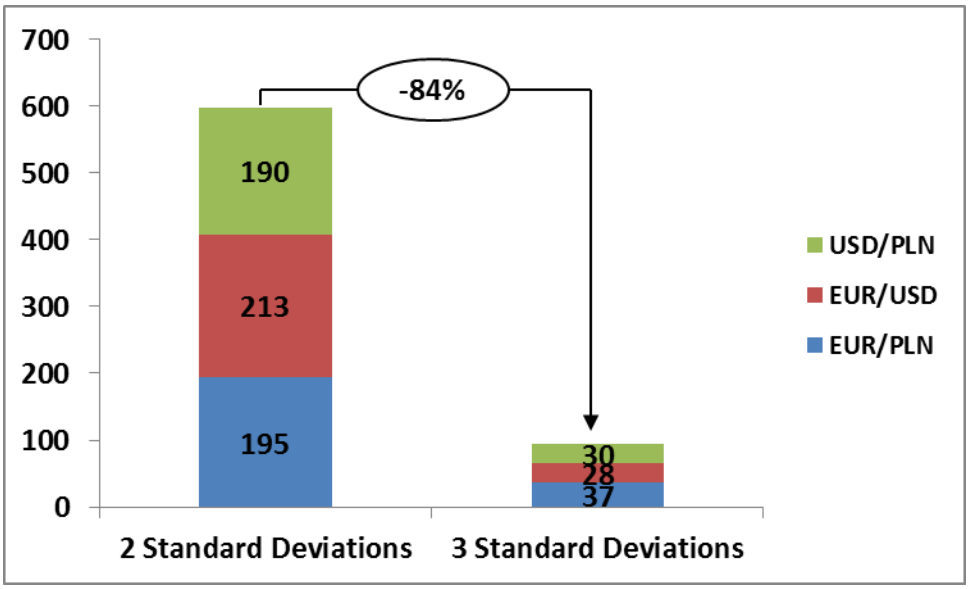
Figure 26: Yield Curves of Weekly Simulations



5.11. Discussion of Results after the Modification

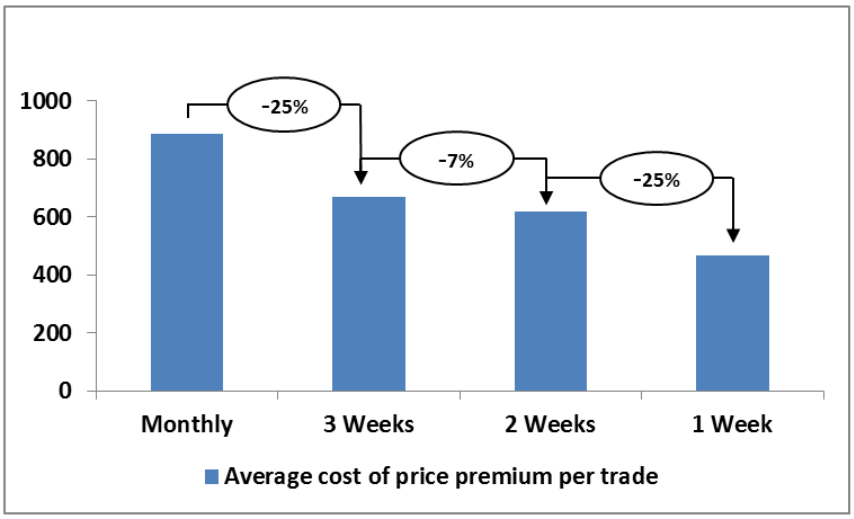
After making the space between the upper and the lower Bollinger Band wider and shortening the option's life, we were able to cut the overall costs of the previous average price to half. The widening of the Bollinger band reduced the number of the trade alerts by 84%. The Bollinger bands, which were set to distance from moving average by two standard deviations, had 598 alerts. After the implementation of the wider bands, the number of alerts dropped to 95. This modification ensured that only the very strong price actions were registered.

Figure 27: Change in the Number of Trade Signals



A shorter life span of the option reduced the price of every traded option. The average cost of a monthly option was 885 EUR, and the average cost of a weekly option was 465 EUR. The implementation of reducing the length of the option from one month to one week lowered the price premium by 47%. The reduction of the option premium's value helped to slow down continuous depreciation of the portfolio's value. The shortening of the life span of the option also shortened the time, during which the spot cold have moved more in the direction of the option. Therefore, one should not expect extreme profits on the day of expiration, rather a continuous stream of small exercises in profit, if the strategy is successful. The disadvantage of shortening the life span and increasing the width of the Bollinger bands is in the reduced number of traded options. The higher number of the trade options could increase the profitability of the strategy.

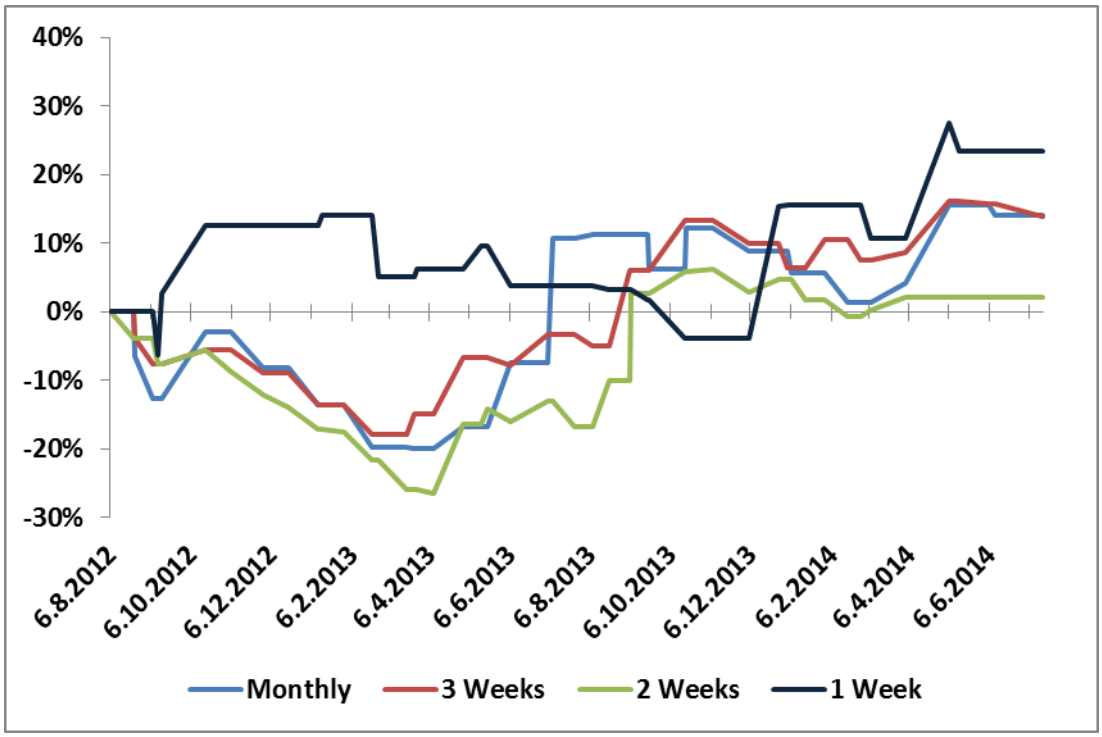
Figure 28: Option's Lifespan vs. Price Premium



5.12. Evaluation of Model before and after the Modifications

The graph below represents the profitability of all fours strategies used on the EUR/USD currency. The blue line represents a strategy, where the option's life span was one month. The red line shows the profitabilily of the strategy tested on three-week options, the green line is the yield curve of two-week options, and the black line represents a net profit of the options with a weekly maturity. Shortening the lifespan of the option prevented the portfolio from investment depreciation. This was done by declining the value of the option and also by reducing the number of the executed trades. The result is represented by the black line, which ended up with the highest profit. The graph also reveals similarity in profitability of options with two-week, three-week, and monthly maturities. Due to the same database of trade alerts, the dates on options with two-week, three-week, and monthly expirations are in many cases identical. The highest portfolio drawdown was recorded for the options with two-week maturity, and the lowest drawdown was calculated for the options with one-week lifespan. Overall, shortening of the life span and increasing the Bollinger bands width led to the highest yield during the back-tested period. The black profitability line shows the best performing strategy, which was measured on the EUR/USD currency cross.

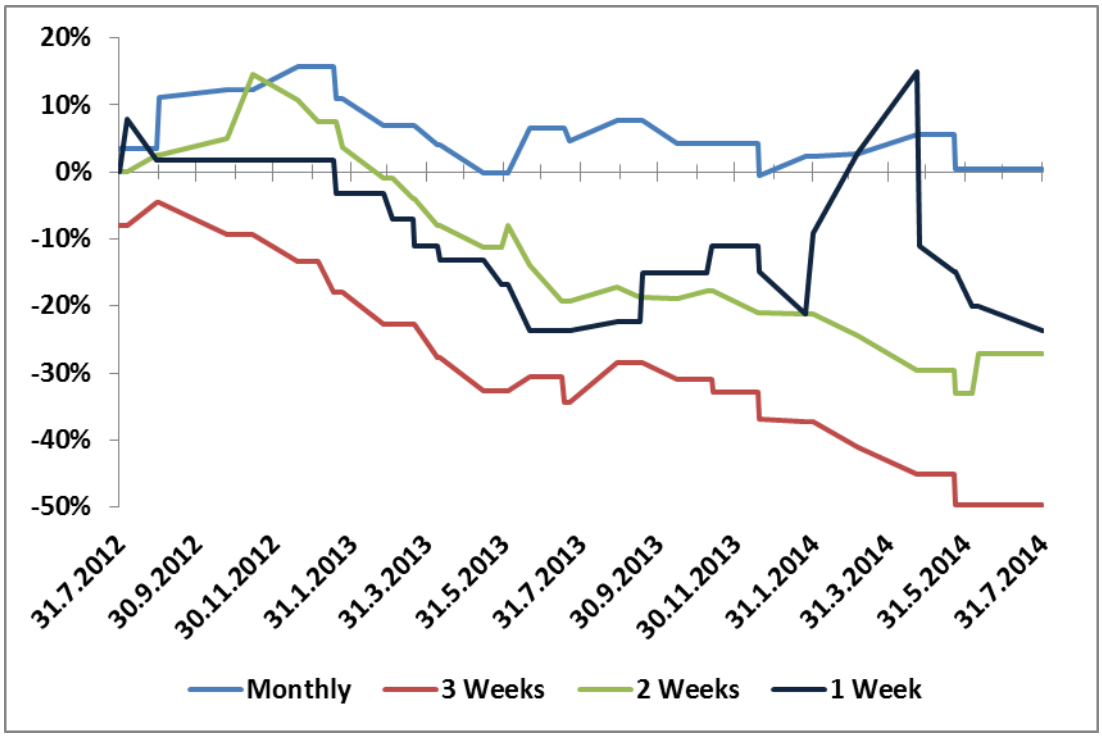
Figure 29: EUR/USD Cross - Simulation's Yield Curves



On the following graph the performance of the option with monthly, three-week, two week, and weekly maturity on the EUR/PLN currency pair is shown. Only the strategy with the weekly maturity was using the signals based on the Bollinger band indicator, which was

widened to three standard deviations. The other strategies used only alerts generated on the width of two standard deviations. Until May 2013, the yield of every strategy was performing with the same pace, except for the strategy with the monthly-maturity options. Those outperformed others and were rarely in negative numbers. On the other hand, the strategies of the options with three-week, two-week, and one-week maturity did not earn any money. They were causing sustaining portfolio depreciation with the exception of the option strategy with weekly maturity, which increased its performance in one trade. Both the EUR/USD and the EUR/PLN option strategies with monthly and three-week maturity had very similar trade dates. This graph shows that none of the four chosen strategies was able to create sustainable and stable profitability curve.

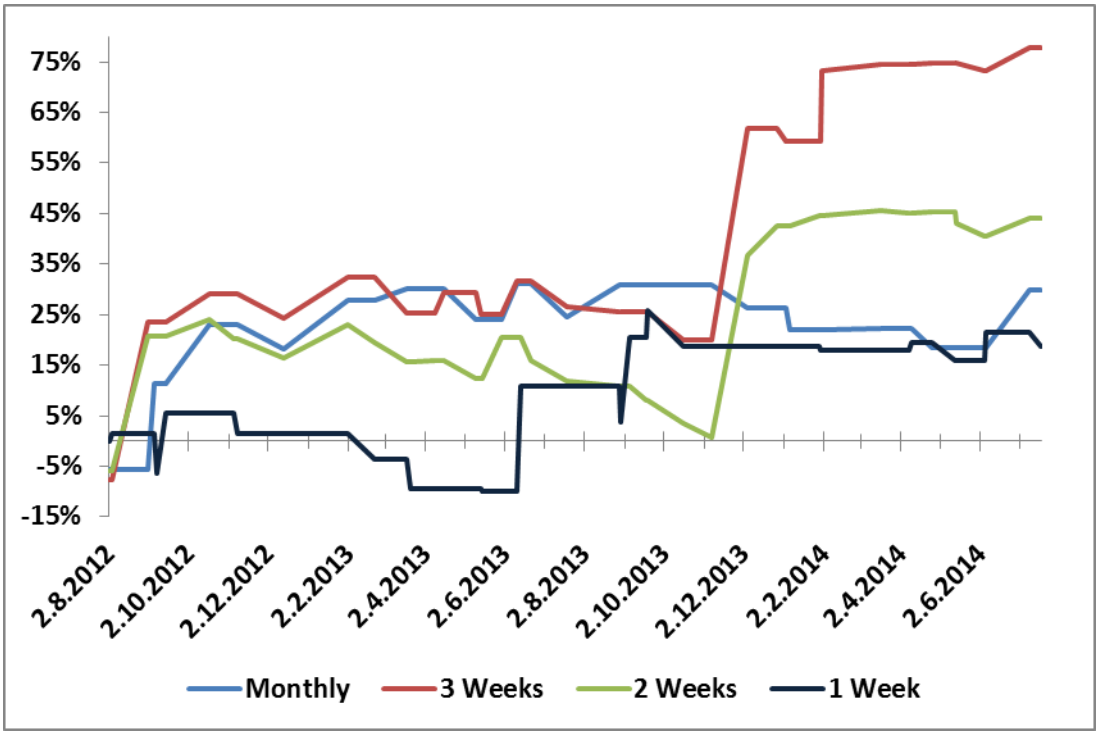
Figure 30: EUR/PLN Cross - Simulation's Yield Curves



The last graph that compares the profitability of the options with different maturities and the Bollinger band width has the currency pair USD/PLN as the underlying. The best performing was the option strategy with three-week options' duration, which after two years of the back-tested period created a yield of more than 75%. The least profitable was the one-week option strategy, which made a yield of almost 20%. All four option strategies ended in positive numbers. The yield curves of the two-week and the three-week options' maturity were very similar. Both made most of their profit in two trades, one in the summer of 2012 and one at the end of the year 2013. Unfortunately, the modified version with the Bollinger band's width of 3 standard deviations and purchased options with only weekly maturity has not performed very well, despite the fact that it was designed to increase the profitability and

decrease the costs. The option strategy with the monthly duration made a significant profit in the first trade. Later on it only made small profits, which were big enough to cover the cost of the premiums. The only satisfying performance was held by the option strategy with three-week maturity.

Figure 31: USD/PLN Cross - Simulation's Yield Curves



In general, the first graph depicted the option strategy with weekly maturity as the most performing and stable. The exact opposite result was shown by the graph of USD/PLN, where the option strategy with weekly maturity made the weakest performance of all, and the same strategy made a negative yield on the EUR/PLN pair. The same thing can be summarized for the option strategy with three-week maturity. During the monitored period it had the best performance on the USD/PLN cross but also ended with the highest negative yield on the EUR/PLN currency pair. The three-week option strategy on the EUR/USD pair had not proved to be efficient, because it had a drawdown of almost 20%.

6. CONCLUSION

The thesis showed an elaborated work focused on developing a foreign currency option strategy indicator, which created proposals for trades on the market purely on the technical analysis. They were based on the evaluation of the extreme price actions occurring in the market. We showed how an extreme move of price can create a trading opportunity on any currency pair. The model incorporated the Bollinger bands indicator into its calculations, which represented the main substance in the process of generating the option trade ideas. The main condition of the option strategy was to decrease the potential risks, to minimize the costs, and to maximize the profits.

The option strategy was based on purchasing a call or a put option with respect to the Bollinger band indicator. The idea behind the indicator was established on the hypothesis that extreme moves tend to return back to their previous positions, and therefore create a speculative investment opportunity, when an option in the opposite direction of the extreme move was bought. By purchasing an option, the investor immediately became the holder of the long Gamma, Vega, and the negative Theta. By a simple rule of holding every option until the expiration, the investor's maximal risk was equal to the value of the purchased option and the effect of any Greek letter was minimized. At the expiration time the value of any vanilla option was equal to the intrinsic value and the potential profit was unlimited and substantially leveraged.

The research was conducted on EUR/USD, EUR/PLN, and USD/PLN currency pairs, where options with different maturities and the Bollinger bands with different band spreads were analyzed. The back-tests were performed on the options with monthly, three-week, two-week, and one-week maturities. The Bollinger band was set to two standard deviations, with an exception of the option strategy with weekly maturity, where the bands spread was widened to three standard deviations. By increasing the spread it was possible to eliminate the less relevant price activities on the market and to primarily focus on the extreme situations.

The back-tested results were analyzed among the three currency pairs, the four types of the options, and the two alternatives of the Bollinger band technical indicator. The results revealed that some strategies were generating continuous depreciation of the portfolio value, which equalled to the amount paid for the purchased option. On the other hand, the back-tested results showed that due to a use of the leveraged product, some high profitability trades occurred.

In general, the best investment possibility is considered to be the trade where the drawdown is minimized and limited, and the potential profit is maximized and unlimited. In theory, this type of investment should generate a continuously increasing yield curve with minimal if none drawdowns. The back-tests showed that the FX option strategy indicator was able to make continuous depreciation of the portfolio with an exception of a few extreme profits, which were big enough to cover the costs of all purchased options and add in some cases an attractive additional yield to the original investment.

The thesis revealed that further emphasis on the market trend must be conducted in order to maximize the profitability curve of the option strategies. Either a combination of the moving averages or other trend indicators would make the entire strategy much more effective. As many extreme price moves are induced by the external factors, which form new market trends opposite to the direction of the purchased option. It also recommends using the foreign currency option strategy indicator in combination with a fundamental analysis.

REFERENCES

Bloomberg Terminal. 2014

Boileau, M. (2003). *Foreign Currency Options.* [Colorado.edu Version]. Retrieved from http://www.colorado.edu/Economics/courses/boileau/4999/sec6.PDF

Finance Trainer International: *Options.* Retrieved from http://is.vsfs.cz/el/6410/leto2012/N_IFS_2/um/Opce_v_pdf.pdf

Garman, Kohlhagen (1983): *Option Pricing Formula.* Retrieved from riskglossary.com: http://www.riskglossary.com/link/garman_kohlhagen_1983.htm

Guziec, P. (2009). *Morningstar Guide to Equity Option Investing.* Morningstar OptionInvestor. Retrieved from http://option.morningstar.com/OptionReg/Options_Guide.pdf

Internal material of Citi Bank.

Investopedia (2004). *Technical Indicator.* Retrieved from http://www.investopedia.com/terms/t/technicalindicator.asp

The Options Industry Council (Dec. 2009). *Understanding Index Options.* Retrieved from http://www.optionseducation.org/documents/literature/files/understanding-index-options.pdf

The Options Industry Council (Dec. 2011). *The Equity Options Strategy guide.* Retrieved from http://www.optionsclearing.com/components/docs/about/publications/equity_options_strategy_guide.pdf

The Options Industry Council (2013). *Understanding Equity Options.* Retrieved from http://www.optionseducation.org/documents/literature/files/understanding-equity-options.pdf

The Options Industry Council (2013). *Long-Term Equity Anticipation Securities.* Retrieved from http://www.optionseducation.org/documents/literature/files/leaps-english.pdf

Patterson, K. E. (1997): Greed and laziness [Personal webpage post]. Retrieved from http://www.kortexplores.com/node/46

Reilly, F. K. & Brown, K. C. (2006). *Investment Analysis and Portfolio Management* (8th Ed.) Masin, OH: Thomson/South-Western.

Schlesinger, D. (2011). Options Alphabet Soup: Is It All Greek to You? [Scribd.com Version]. Retrieved from https://www.scribd.com/doc/62245581/Options-Alphabet-Soup-is-It-All-Greek-to-You-1

Sorensen, E. H., Miller, K. L. & Cox, D. E. (1998*). The Salomon Smith Barney: Introduction Guide to Equity Options.* Retrieved from http://www.trading-software-collection.com/Free%20Download/Eric%20Sorensen%20-%20The%20Salomon%20Smith%20Barney%20Introductory%20Guide%20to%20Eq uity%20Options/

StockCharts.com – Articles (1999-2004). *Moving Averages- Simple and Exponential.* Retrieved from http://stockcharts.com/school/doku.php?id=chart_school:technical_indicators:moving_averages

Stoll, H. R. (1969): *Put-Call Parity.* Retrieved from riskglossary.com: http://www.riskglossary.com/link/put_call_parity.htm

Unger, S. (2014). Options & Derivatives. Retrieved from University of Vienna, author's own documentation.

Wystup, U. (2006): *FX Options and Structured Products.* Wiley.

Walker, J. (n. d.). *Simple Moving averages.* Retrieved from https://www.fourmilab.ch/hackdiet/www/subsubsection1_4_1_0_8_1.html#SECTION04108100000000000000.

XTB Online Trading. Option Trader. Retrieved from http://www.xtb.sk/trhy/opcie

CURRICULUM VITAE

Personal Details:

Name: **Bc. Martin Ružek**

Education:

2011 – Present	University of Vienna, Master's Degree Program in Quantitative Economics, Management and Finance, Vienna, Austria
2010 – 2011	Clausthal University of Technology, Department of Economics, Program Erasmus in Clausthal-Zellerfeld, Germany
2008 – 2011	Comenius University in Bratislava, Faculty of Math, Physics and Informatics- Applied Mathematics in Management and Finance (graduated and completed Slovakian undergraduate education)
2007 – 2008	Evangelical Lyceum, Vranovská 2, Bratislava (graduated and completed Slovakian high school education)
2006 – 2007	Lisgar Collegiate Institute, Ottawa, Canada (graduated and completed Canadian high school education)
2005 – 2006	Waverly-Shell Rock High School, Waverly, Iowa (foreign exchange student in the United States)
1999 – 2005	Evangelical Lyceum (High School), Palisády Street 57, Bratislava, Slovakia
1997 – 1999	Elementary School Vazovova, Bratislava, Slovakia
1995 – 1997	Elementary School, Moscow, Russia

Subsidiary Education:

2008 – 2009	The Austrian Institute in Bratislava, German Language Educational Program

Professional Work Experience:

7/2013 – present	Fulltime dealer at Tatra Banka (Member of Raiffeisen Group). Responsible for managing FX and FX Options portfolios. Daily tasks include dealing with Bonds, FX, FX Options, Certificates, Banknotes, physical gold, and Stock orders. Work with Bloomberg terminal, Reuters Dealing, Cortex, Marquee, Barx, Velocity, Excel, and other software.

5/2011 – 5/2013	Part-time employee at Adidas Slovakia. Processing and analyzing economic, financial, and sell out data of customers. Work with Excel and software that communicates with SAP.
7/2012 – 10/2012	Internship at Metatron investment fund. I was taught by a cofounder of the fund Juraj Podracky. Job contained analyzing daily stock market data including financial news. During an internship I have conducted a statistical research with a main focus on bonds, stocks and commodities (ETF, certificates). Source of all my data was Bloomberg terminal.
5/2011 – 09/2011	Internship at Tatra Banka Private Banking (affiliated with Reiffeisen Bank). Responsibilities included translation of economical articles from English to Slovak Language, providing clients' services through phone (recording customers buy/sell orders, transferring money from and to accounts, and doing currency exchanges). Weekly tutors introduced financial products such as shares, bonds, warrants, options, investment funds, Government bonds and explained bonus, bonus with cap, turbo, and many different certificates.
5/2010 – 10/2010	Part-time job at First Data. Intranet and networks junior administrator

Skills and Competencies:

Languages:

Slovak-	Native
English-	English – fluent (Final State Examination C1, Canadian Graduation Certificate)
German-	Advanced
Russian-	Intermediate

PC literacy:

C++, R- statistical program, Internet (e-mail, WWW), MS Word, MS Excel, PowerPoint, SAP, Bloomberg, Reuters Dealing