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Financial Management

Option Strategies Based on the CBOE's Commodity Volatility Indices

CBOE:n hyödykkeiden volatiliteetti-indekseihin perustuvat optiostrategiat

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ABSTRACT

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The commodity volatility indices of the Chicago Board Options Exchange (CBOE) measure the market's expectation of the 30-day volatility of the commodity in question. The Connors VIX Reversal (CVR) 1, 3 and 9 strategies have clear and simple rules that utilize moving averages and mean reversion to create signals for the buying and selling of S&P 500 index futures and options. In this thesis the strategies have been adapted to use the CBOE's commodity (crude oil, gold, silver) volatility indices and the CBOE's options on the commodity ETFs on which the indices are based. The risk-adjusted returns of the CVR strategies have been compared to the risk-adjusted market return. The market return has been represented by the return from the buy-and-hold strategy which uses shares of the commodity ETF on which the options are based. The studied period was 6.7 years. Generally Connors VIX Reversal strategies can be successfully utilized with the CBOE's commodity volatility indices to create excess returns. The CVR 3 and 9 strategies create returns much more uniformly than the CVR 1. Put options clearly perform better than call options on average. Strategies differ in their performance according to the ETF on which the options are based. The effect of transaction costs depends on the option type and the underlying ETF in question and also on the length of the period of trading rules. Of all the strategies, the CVR 3 is least sensitive to the effect of transaction costs.

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Hakusanat: volatiliteetti, indeksi, optio, pörssinoteerattu rahasto, hyödyke, markkinoiden ajoitus, Connorsin VIX-käännös, liukuva keskiarvo, palautuminen keskiarvoon

Chicago Board Options Exchange (CBOE) -arvopaperipörssin hyödykkeiden volatiliteetti-indeksit mittaavat markkinoiden odotusta kyseessä olevan hyödykkeen tulevasta 30:n päivän volatiliteetista. Connorsin VIX-käännös (CVR) 1, 3 ja 9 -strategiat koostuvat selkeistä ja yksinkertaisista säännöistä, jotka hyödyntävät liukuvia keskiarvoja sekä palautumista keskiarvoon synnyttämään signaaleja S&P 500 -indeksifutuurien ja -optioiden ostamiseen ja myymiseen. Tässä työssä edellä mainitut strategiat on sovitettu käyttämään CBOE:n hyödykkeiden (raakaöljy, kulta, hopea) volatiliteetti-indeksejä sekä CBOE:n optioita pörssinoteeratuista hyödykerahastoista, joihin indeksit perustuvat. CVR-strategioiden riskikorjattuja tuottoja verrattiin riskikorjattuun markkinatuottoon. Markkinatuottoa edustaa tuotto osta-ja-pidä -strategiasta, joka käyttää osakkeita pörssinoteeratusta hyödykerahastosta, johon optiot perustuvat. Tarkasteltu ajanjakso oli 6,7 vuotta. Yleisesti ottaen Connorsin VIX-käännös -strategioita voidaan onnistuneesti käyttää CBOE:n hyödykkeiden volatiliteetti-indeksien kanssa ylituottojen saavuttamiseksi. CVR 3 ja 9 -strategiat synnyttävät tuottoja huomattavasti tasaisemmin kuin CVR 1. Myyntioptiot suoriutuvat keskimäärin selvästi paremmin kuin osto-optiot. Strategioiden suorituskyky vaihtelee riippuen pörssinoteeratusta rahastosta, johon optiot perustuvat. Transaktiokustannusten vaikutus riippuu option tyypistä ja sen taustalla olevasta rahastosta sekä myös kaupankäyntisääntöjen ajanjakson pituudesta. CVR 3 on strategioista vähiten herkkä transaktiokustannusten vaikutuksille.

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LIST OF ABBREVIATIONS

CBOE – Chicago Board Options Exchange

CVR – Connors VIX Reversal strategy

ETF – exchange-traded fund

GVZ – CBOE's Gold ETF Volatility Index

JKM – The statistical test of Jobson, Korkie and Memmel

OVX – CBOE's Oil ETF Volatility Index

S&P 500 – Standard & Poor's 500 Index

VIX – CBOE's volatility of index of S&P 500

VXSLV – CBOE's Silver ETF Volatility Index

1 INTRODUCTION

In the following subchapters the fundamental starting points of this bachelor's thesis are explained. This introductory chapter is followed by two chapters that contain the theoretical framework of the thesis which consists of information and studies related to the volatility indices of the Chicago Board Options Exchange and to trading strategies that have been devised by Larry Connors. The theoretical framework is followed by the chapter which contains the empirical study of the thesis that tests the performance of the Connor's trading strategies with the aforementioned volatility indices. The results of thesis are summarized in the final conclusions chapter.

1.1 Background of the research

This thesis studies the application and performance of Connors VIX Reversal (CVR) 1, 3 and 9 strategies on the commodity volatility indices of the Chicago Board Options Exchange (CBOE) (Connors 1999a, 37; Connors 1999b, 38-39; Connors 2002, 46). The background of these commodity volatility indices and strategies is explained in more detail in the chapters 2 and 3. The indices that are studied are Crude Oil ETF Volatility Index (OVX), Gold ETF Volatility Index (GVZ) and Silver ETF Volatility Index (VXSLV) (CBOE 2008; CBOE 2011a; CBOE 2017b). The thesis tests CVR 1, 3 and 9 strategies' capability to generate excess returns by timing correctly the buying and selling of options on commodity ETFs. Excess return is defined as a return that is higher than the return from the buy-and-hold strategy which uses the commodity ETFs on which the CBOE's options are based. The strategies apply few precise and simple rules to time the trading of options based on the development of these indices. The OVX index is used to time the trading of United States Oil Fund options, the GVZ index is used with SPDR Gold Shares options and the VXSLV index is used with iShares Silver Trust options (CBOE 2008; CBOE 2011a; CBOE 2017b). No futures are available for these commodity ETFs in the Chicago Board Options Exchange.

The efficient market hypothesis states the prices of securities reflect all the information available as all the market participants try to gather new information to gain higher investment returns (Bodie et al. 2005, 370-372). The efficiency of markets decreases the possibilities to gain excess returns (Bodie et al. 2005, 370). However, the degree of efficiency may vary across various markets (Bodie et al. 2005, 372). Due to the efficiency of markets it shouldn't be possible to gain excess returns by timing correctly the buying and selling of commodity options. Therefore the capability of CVR strategies to generate excess returns, which has been tested statistically according to Connors (2002, 46), shows that markets haven't been completely efficient. The three aforementioned CVR strategies were published in 1999 and 2002, so it is reasonable to carry out a new study to find out whether these strategies are still able to generate excess returns or whether markets have become more efficient in this respect. The application of CVR strategies has been studied with S&P 500 futures and options, but no studies applying CVR strategies on commodity volatility indices and commodity ETF options currently exist, so there is a clear research gap.

1.2 Research questions

The main research question is:
Can Connors VIX Reversal strategies be applied to the CBOE's commodity volatility indices to create excess returns?

The main research question is answered through three subquestions:
1. Is some CVR strategy generally better than others at creating excess returns?
2. Are there clear differencies in the performance of CVR strategies according to the option of a commodity ETF in question?
3. Can transaction costs significantly erode excess returns?

1.3 Limitations of the research

This thesis studies only the three commodity volatility indices (oil, gold, silver) that have been introduced by CBOE and doesn't consider the other volatility indices of CBOE or indices of other organizations. CBOE's volatility indices are studied because they utilize the VIX methodology on which the Connors VIX Reversal strategies are based. The aforementioned three indices were selected because they are the CBOE's only volatility indices on exchange traded funds which reflect the spot prices of their different respective commodities (CBOE 2008; CBOE 2017b; BlackRock 2017) and are therefore comparable with each other. It is reasonable to concentrate to study commodities as they are clearly a distinct target of investment, compared for instance to the shares of companies. Only CVR strategies are studied and other potential market timing strategies are ignored. The CVR strategies are studied because they were the only published strategies found in the literature search that applied unambiguous rules that allowed the precise realization of the strategies in practice. The limitations are also posed in order to narrow the scope of research into a reasonable and compact whole. The statistical significance of the excess returns of the CVR strategies is evaluated with the Jobson-Korkie-Memmel test (Auer & Schuhmacher 2013, 198), which isn't necessarily most powerful statistical test available and this may create uncertainty in the interpretation of the results. The Jobson-Korkie-Memmel-test is chosen because its test procedure is simple enough to be applied in the Excel spreadsheet and because the test works well with large sample sizes handled in this thesis and also because the corrections of Sharpe ratios for skewness and kurtosis improve the accuracy of the test.

2 VOLATILITY INDICES OF THE CBOE

The Chicago Board Options Exchange (CBOE) is the largest options exchange in the United States by traded value (CBOE 2017a). The CBOE's Volatility Index (VIX) was introduced in 1993 for the quantification of stock market volatility. The VIX measures the market's expectation of the 30-day volatility based on index option prices. Initially, the calculation of the VIX was based on the Standard & Poor's (S&P) 100 index. In the early 2000s, the VIX shifted to options on the S&P 500 index and thus now takes into account significantly more values. (Toplin 2015, 26) The components of the index calculation are put and call options with more than 23 days and less than 37 days until expiration (Toplin 2015, 28).

Before the introduction of the VIX, Bollinger bands have been used to measure volatility. They are plots of standard deviation placed above and below the moving average of a stock price. The bands widen when the volatility increases and narrow when volatility decreases. Bollinger bands can be also used to complement the VIX to increase an investor's ability to predict the development of stock prices. (Williams 2011, 39)

The VIX index is quoted as a percentage point and it has a roughly inverse relationship to the direction of stock prices. High VIX readings indicate risk that stock prices will move sharply in either direction, whereas low VIX numbers mean there is neither significant risk nor potential. (Toplin 2015, 29) The VIX reacts much more powerfully to negative changes in stock prices than to positive price changes of similar size, and therefore it can be interpreted rather as a gauge of investor fear than positive investor sentiment (Sarwar 2012, 908). When stock prices fall, the VIX rises, reflecting increasing market fear. When the prices rise, the VIX usually declines, which reflects decreased fear. As VIX levels reach short-term extremes, they many times coincide with short-term reversals in the development of prices. (Connors 2002, 47) Volatility is mean reverting, which means that higher-than-normal and lower-than-normal volatility periods eventually return to an average volatility level (Connors 1999a, 36). These volatility reversions are frequently accompanied by reversals from falling prices to rising prices or the other way round (Connors 1999a, 37). In addition, volatility is correlated with its previous values (autocorrelated), so that if the VIX rises today, it is highly probable that it also rises tomorrow (Connors 2002, 47). It can be supposed that the characteristics of mean reversion, autocorrelation and the inverse relationship to the prices of the underlying securities also apply to the CBOE's commodity volatility indices.

The commodity volatility indices of the CBOE measure the market's expectation of the 30-day volatility of the commodity in question by applying the same methodology as the VIX index (CBOE 2008; CBOE 2011a; CBOE 2017b). The CBOE's Gold ETF Volatility Index (ticker GVZ) utilizes options on the SPDR Gold Shares exchange-traded fund (CBOE 2017b). The Crude Oil Volatility Index (ticker OVX), introduced in 2008, utilizes options on the United States Oil Fund ETF (CBOE 2008). In 2011 CBOE published Silver ETF Volatility Index (ticker VXSLV) which utilizes options on the iShares Silver Trust exchange-traded fund (CBOE 2011a; CBOE 2011b). All these exchange-traded funds reflect the spot prices of their different respective commodities (CBOE 2008; CBOE 2017b; BlackRock 2017).

Mensi et al. (2013, 15, 21) has found significant correlation and transmission of volatility among the S&P 500 index and commodity markets. The S&P 500 index correlated especially powerfully with the GOLD index (of gold markets) and the WTI index (of crude oil markets in the USA) (Mensi et al. 2013, 15, 17). Therefore it could be proposed that the CBOE's commodity volatility indices correlate with the VIX. Jubinski and Lipton (2013, 70, 85) found out that gold and silver futures returns have a positive relationship with the changes in the VIX, which supports the idea that investors perceive precious metals as safe havens to be purchased in anticipation of rising equity market volatility. Oil has a statistically negative relationship with the VIX which indicates a reaction to an anticipated decrease in demand (Jubinski & Lipton 2013, 85). Investors incorporate information about equity market changes into their valuation of precious metals and oil (Jubinski & Lipton 2013, 85). So one could propose that the GVZ and the VXSLV correlate negatively with the VIX and that the OVX correlates positively with the VIX. These potential correlations provide support to the idea that Connors VIX Reversal strategies can also be applied to CBOE's commodity volatility indices. It has also been found out that the VXSLV index (which represents the U.S. silver options) is able to predict the volatility changes in the Shanghai silver futures market at daily and weekly horizons (Luo & Ye 2015, 76). This means that the CBOE's commodity volatility indices could possibly be applied to market timing in other futures and options markets than the U. S.

When technical trading rules (like filter, trading-range breakout and moving-average crossover) are calculated by using VIX data, instead of security data, to generate the buy and sell signals, the returns are increased (Kozyra & Lento 2011, 1370). The main principle of the filter rule is to buy when the stock price rises *k* % above its past local low and sell when it falls *k* % from its past local high (Wu et al. 2006, 270). The trading range breakout rule utilizes "resistance" and “support” levels. The resistance (support) level is defined as a local maximum (minimum) price, with a buy (sell) signal generated when the price penetrates the resistance (support) level. (Yu et al. 2013, 359) A moving average shows the average value of a security's price over a period of time. According to moving average crossover trading rules, buy and sell signals are generated by two different moving average periods: a long and a short period. To apply the rules conventionally, an investor should buy (sell) at the closing price of a trading day immediately after the short-term moving average exceeds (falls below) the long-run moving average. (Yu et al. 2013, 358) Copeland and Copeland (1999, 80) have found out that deviations from the moving average of the VIX can be utilized to signal the times to rotate between portfolio strategies to create excess returns. This rotation creates excess returns both with style (value versus growth) and size (large cap versus small cap) portfolios. When volatility increases, value and large-cap portfolios outperform their opposites, and when volatility decreases, growth and small-cap portfolios outperform. (Copeland & Copeland 1999, 80) The next chapter concentrates to explain in detail Connors VIX Reversal trading strategies, of which the CVR 3 strategy utilizes moving averages and the CVR 1 and 9 strategies somewhat employ the principle of trading-range breakout.

3 TRADING STRATEGIES BASED ON VOLATILITY INDICES

A literature search was done when the author began to work on this thesis to find published trading strategies utilizing VIX and other related CBOE's volatility indices. Connors VIX Reversal strategies, in the *Futures* journal, were the only the published strategies which utilized clear and simple rules so that they could be applied in practice according to the description of the articles in which they were published. The other articles explained their strategies so generally that it wasn't possible to determine how the strategies were exactly applied. It can be argued that a strategy, which basically any investor can apply, must have clear rules and operating principles or it isn't a strategy at all. The ten statistically tested CVR strategies, created by Larry Connors, have been used to trade the S&P 500 index futures and options with the VIX (Connors 2002, 46). The CVR 1, 3 and 9 strategies utilize moving averages, mean reversion and autocorrelation to create sell and buy signals (Connors 1999a, 37; Connors 1999b, 38-39; Connors 2002, 46). Connors (1999b, 39) states that options are particularly well-suited to exploiting the market behavior captured by CVR signals. The CVR strategies can be likely applied to the CBOE's commodity volatility indices because the indices utilize the same methodology as the VIX index for which the CVR strategies were originally designed (CBOE 2008, 2011b; 2017b).

In this chapter the three different Connors VIX Reversal strategies, which have been published in the Futures journal, are explained from the simplest to the most complex. These strategies have originally utilized the VIX index and S&P 500 futures, but in this thesis they have been adapted to use the CBOE commodity volatility indices (OVX, GVZ, VXSLV) and the CBOE's options on commodity ETFs (the United States Oil Fund, SPDR Gold Shares and iShares Silver Trust). The trading rules which are explained in the subchapters don't consider protective stops, but Connors (1999a, 37) recommends the use of protective stops in actual trading. Protective stop means that an investment is sold if its value descends to or below a predefined limit (Thachuk 2003, 62).

The Connors VIX Reversal strategy 1 is the simplest of the three CVR strategies. In the list below its buy signal rules (in this thesis named as call signal rules as the signal indicates to use call options) have been modified to use CBOE's commodity volatility indices and the options of their corresponding ETFs. The rules of a call signal are the following:

1. First one must identify when a commodity volatility index reaches the highest value in *n* periods. (*n* can be 5 days, for instance.)
2. When the volatility index reaches an n-period high, it must also close below where it opens.
3. When the 1. and 2. rules are met, the call options of the corresponding commodity ETF (in the Connors' article S&P 500 futures) are bought or put options of the ETF are sold.

The second rule of the CVR 1 strategy implies that volatility may have been pulled too far from its mean, and may have begun to revert back to its mean due to volatility reversing within the day. (Connors 1999a, 37)

According to Connors (2002, 47) the values of the VIX and stock prices are inversely correlated. When the stock prices fall, the values of the VIX increase as they reflect increasing market fear. When the stock prices rise, the values of VIX usually decline, as the market fear decreases. When the VIX reaches short-term extremes, the development of stock prices is often about to reverse (from bearish to bullish or other way around). (Connors 2002, 47) Therefore we can suppose that in the short term also the value of a commodity volatility index and the price of its corresponding commodity ETF are inversely correlated. When the commodity volatility index reaches the high point before its reversal to the mean, also the price of the corresponding ETF will reach its lowest point before the reversal.

As a call option gives its holder the right to purchase an asset for a specified price (strike price) on or before some specified expiration date (Bodie et al. 2005, 698), one should purchase the at-the-money call option when the price of its ETF reaches the lowest point before the bearish market changes to bullish. By selling this option later before the market turns from bullish to bearish one can attain significant returns. Following the same reasoning, as a put option gives its holder the right to sell an asset for a specified strike price on or before some expiration date (Bodie et al. 2005, 699), one should sell the at-the-money put option when the price of its ETF reaches the lowest point before the bearish market changes to bullish. When the trader has purchased the at-the-money put option at the time when the market has changed from bullish to bearish, significant returns can be gained by selling this option when the price of the ETF reaches its short term lowest point. From the reasoning presented above in this paragraph, buying call options and selling put options in the 3. rule of the call signal can be understood.

The rules for a put signal are the reversion of the call rules:
1. First it is identified when a commodity volatility index reaches the lowest value in *n* periods.

2. When the volatility index reaches an n-period low, it must also close above where it opens.
3. When the 1. and 2. rules are met, the call options of the corresponding commodity ETF are sold or put options of the ETF are bought. (Connors 1999a, 37) As also the call and put signal rules of the CVR 3 and 9 strategies are reversions of each other, the explanations of these both signals have been combined into a single explanation in the following paragraphs.

The Connors VIX Reversal strategy 3 is somewhat more complex than the CVR1 strategy. The rules for the call/put signal are the following:
1.Today's lowest/highest value of a commodity volatility index must be above/below the 10-day moving average of the lowest/highest index values.
2. Today the commodity volatility index must also close at least 10% above/below the 10-day moving average of the closing values.
3. If the 1. and 2. rules are met the call/put options of the corresponding commodity ETF are bought.
4. The day the commodity volatility index trades below/above yesterday's 10-day moving average of closing values during the day is the signal that volatility has reverted to its mean and the call/put options are sold. (Connors 1999b, 38)

The rules for the signals of the Connors VIX Reversal 9 strategy are probably the most complex of the three presented CVR strategies. The call/put signal is based on the following rules:
1. Today the highest/lowest value of a commodity volatility index during the day must be the highest/lowest value in 10 days and the close value of the index must be lower/higher than the opening value.
2. Yesterday the close value of the commodity volatility index must have been greater/lower than the opening value.
3. Today's range of the commodity volatility index (the difference between the highest and lowest values) must be the largest of the ranges in the last three days.
4. If the 1.-3. rules are met, the call/put options of the corresponding commodity ETF are bought on the market close and sold after three days. (Connors 2002, 46)

4 RESEARCH METHOD AND SOURCE DATA

This chapter explains generally the utilized research method and the mathematical background behind the applied statistical test. The empirical part which is presented in the following chapter 5 is quantitative as it analyzes the historical data of the three commodity volatility indices and the historical prices of their respective options. All the historical data which has been used in the empirical part has been obtained from the Datastream-database. For the three commodity volatility indices daily opening, closing, highest and lowest prices have been downloaded. As these commodity volatility indices have been introduced quite recently, historical data on them is limited, but still abundant enough to enable reasonable analyses. Daily data for the OVX is available from 10/5/2007, for the GVZ from 3/6/2008 and for the VXSLV from 16/3/2011.

The options for the United States Oil Fund started trading on 16/2/2011, options for SPDR Gold Shares on 16/7/2009 and options for iShares Silver Trust on 24/3/2011. The daily market prices of the at-the-money call and put options of the three commodity ETFs were also downloaded from Datastream. All the options have started trading after the introduction of their respective commodity volatility indices. As the latest date of introduction for a commodity option is 24/3/2011, the performance of all the different commodity volatility indices with the CVR strategies is compared between 24/3/2011 and 31/11/2017. This leads to a study period of about 6.7 years for every ETF option, which is long enough time for a comprehensive study. The utilization of the same study period ensures the comparability of the performances of different indices and strategies.

The daily closing prices of the three ETFs (the United States Oil Fund, SPDR Gold Shares and iShares Silver Trust) were retrieved from the Datastream database (for the calculation of the returns of the buy-and-hold strategy, i.e. market return). The interest rate of the U. S. treasury bill with a 3-month maturity (issued by the Federal Reserve) was chosen to represent the risk-free interest rate as the short-term nature of the U. S. treasury bill makes its value insensitive to interest rate fluctuations (Bodie et al. 2005, 200). The maturity of three months had to be chosen as this was the only type of Treasury Bill for which continuous data was available in the Datastream. The separate time series of the different aforementioned variables were assembled to the same table in the Microsoft Excel program. There were several dates when the values of the volatility indices were unavailable. These dates were obviously days when the U. S. stock markets were closed, like the 4th July (Independence Day) and Thanksgiving Day. The dates when the index values were unavailable were removed from the dataset.

In the Excel model it is supposed that a certain sum of money is invested at the beginning of the studied period and the success of the strategy is based on how this investment has increased or decreased during the studied period. Based on the trading signals of a CVR strategy all the money is either moved from United States Treasury Bills, which serve as a risk-free rate, to call or put options of an ETF or the other way around, so that all options are sold and Treasury Bills are bought instead. When similar trading signals (e. g. consecutive buy signals) are given on consecutive days, only the first signal is taken into account, as on the following days the action necessitated by the signals has already been carried out. Call and put options are studied separately, which means that one scenario of the study uses either call or put options. This way it is possible to identify if one of the options types is generally more capable to generate significant excess returns than the other.

The risk-adjusted returns of the CVR strategies are compared to the risk-adjusted market return (of the buy-and-hold strategy) by testing the equality of the strategies' Sharpe ratios with the Jobson-Korkie-Memmel (JKM) -test. The specifics of the Sharpe ratio and JKM-test will be explained in the following subchapters. A large set of equations in an Excel spreadsheet has been used to generate signals for option buying and selling based on the historical data of the indices and to calculate the excess returns, Sharpe ratios and the values of the JKM-test. The call and put signals have been created automatically through the utilization of IF-, AND- and OR-functions in the Excel. After the signals have been identified, the return or loss during every period when an option was owned by the investor was calculated separately.

Transaction costs of trading are taken into account by assuming them to be constant per trade over time. Transaction costs vary among different types of traders (CBOE 2017c, 1). Transaction costs may have increased or decreased during the history of the CBOE's options on commodity ETFs, but in this thesis the transaction costs are assumed to be constant over time. Protective stops aren't used as they can reduce both losses and profits and therefore hinder the evaluation and comparison of the performance of different strategies. In this kind of study it is rather reasonable to aim to exaggerate differences between the strategies than to lessen them.

4.1 Sharpe ratio

The Sharpe ratio, which measures the relationship between the mean and standard deviation of excess returns, is a widely used metric to measure and compare investment performance (Auer & Schuhmacher 2013, 196). The Sharpe ratio, η_i, divides the average portfolio excess return over the sample period by the standard deviation of the returns over that period. It can be said to measure the reward to volatility trade-off. (Bodie et al. 2005, 868)

$$\eta_i = \frac{\bar{r}_i - \bar{r}_f}{\sigma_i} \tag{1}$$

$\bar{r}_i$ = the mean actual rate of return on a risky asset over the sample period

$\bar{r}_f$ = the mean risk-free rate of return over the sample period

σ_i = the standard deviation of returns on a risky asset over the sample period

(Bodie et al. 2005, 144, 868)

Various degrees of skewness and kurtosis can make traditional mean-variance measures of performance, like the Sharpe ratio, inadequate. The adjusted Sharpe ratio , $\eta_{i,A}$ incorporates penalty factors for negative skewness and excess kurtosis and is expressed as the following equation:

$$\eta_{i,A} = \eta_i \left[1 + \left(\frac{\mu_3}{6}\right)\eta_i - \left(\frac{\mu_4}{24}\right)\eta_i^2\right] \tag{2}$$

μ_3 = the skewness parameter

μ_4 = the kurtosis parameter

(Pézier & White 2008, 42)

The equation for skewness is provided below:

$$\mu_3 = \frac{1}{T}\sum_{s=1}^{T}\left(\frac{r_i(s) - E_i(r)}{\sigma_i}\right)^3 \tag{3}$$

T = the number of returns

$r_i(s)$ = the value of the return in the scenario s

$E_i(r)$ = the expected value of return

(Pätäri 2011, 73; Bodie et al. 2005, 174)

The equation for kurtosis is the following one:

$$\mu_4 = \frac{1}{T}\sum_{s=1}^{T}\left(\frac{r_i(s) - E_i(r)}{\sigma_i}\right)^4 - 3 \tag{4}$$

(Pätäri 2011, 73; Bodie et al. 2005, 174)

The expected return can be calculated with the following formula:

$$E_i(r) = \sum_{s=1}^{T} \Pr_i(s)\, r_i(s) \tag{5}$$

$\Pr_i(s) = \text{the probability of the scenario } s$

(Bodie et al. 2005, 174)

The standard deviation can be calculated with the following formula:

$$\sigma_i = \sqrt{\sum_{s=1}^{T} \Pr_i(s)[r_i(s) - E_i(r)]^2} \tag{6}$$

(Bodie et al. 2005, 174)

It can be assumed that the probability for a single return is equal for every return of a strategy. If a strategy i leads to T returns, then the probability for a single return is always

$$\Pr_i(s) = \frac{1}{T}. \tag{7}$$

The expected return can be then expressed as the following equation:

$$E_i(r) = \sum_{s=1}^{T} \frac{r_i(s)}{T}$$

The standard deviation can be written as the equation below:

$$\sigma = \sqrt{\sum_{s=1}^{T} \frac{1}{T}\left[r_i(s) - \sum_{s=1}^{T} \frac{r_i(s)}{T}\right]^2}$$

4.2 Jobson-Korkie-Memmel -test

The test of Jobson and Korkie (1981) and Memmel (2003) (JKM-test) has been the most frequently used test for the equality of the Sharpe ratios of two investment strategies. The null hypothesis of the JKM test is that H_0: $\Delta = \eta_i - \eta_j = 0$, where η_i and η_j are the Sharpe ratios of two investment strategies. (Auer & Schuhmacher 2013, 198) In this thesis η_i is the Sharpe ratio of a CVR strategy and η_j is the Sharpe ratio of the buy-and-hold strategy. Therefore if the difference between these two Sharpe ratios is positive, the CVR strategy is able to generate positive excess returns compared to the buy-and-hold strategy. If the Sharpe ratio difference is negative, the buy-and-hold strategy outperforms the CVR strategy. The sample size of excess returns (T) should be at least 36 for a single strategy (Jobson & Koerkie 1981, 905). At the significance level of α the null hypothesis is rejected if the hypothetical value of zero for the Sharpe ratio difference lies outside the confidence region

$\Delta \pm z\left(1-\frac{\alpha}{2}\right)s(\Delta).$

$$\Delta = \eta_i - \eta_j \tag{8}$$

$z\left(1-\frac{\alpha}{2}\right)$ = the (1-α/2)-quantile of the standard normal distribution

(Auer & Schuhmacher 2013, 198)

$z\left(1-\frac{\alpha}{2}\right)$ is calculated with the function NORMSINV(probability) in Excel.

The statistical significance of the Sharpe ratio difference is tested only when the difference between two Sharpe ratios is positive. In the cases of negative difference the statistical test can only show that the buy-and-hold strategy very likely outperforms a CVR strategy or that the two strategies likely perform equally well. This isn’t useful information when the specific goal is to identify CVR strategies which are able to generate excess returns.

A confidence region widens when α decreases. This is because α depicts certainty about the magnitude of the Sharpe ratio difference. When certainty decreases, less narrowly we can define the region within which the accurate Sharpe ratio difference is located. The highest possible value of α for which the null hypothesis remains true is the value for which the lower bound of a confidence region equals to 0. This value of α is the p-value of the JKM-test. If this p-value is less than the chosen significance level (0.05 in this thesis), the null hypothesis is rejected and the Sharpe ratios of two strategies differ. The value of α (which functions as the p-value) is solved by formulating the aforementioned lower bound of a confidence region into an equation:

$$\Delta - z\left(1 - \frac{\alpha}{2}\right) s(\Delta) = 0$$

$$\rightarrow z\left(1 - \frac{\alpha}{2}\right) = \frac{\Delta}{s(\Delta)}$$

$$\rightarrow z^{-1}\left(\frac{\Delta}{s(\Delta)}\right) = 1 - \frac{\alpha}{2}$$

$$\rightarrow \alpha \ = 2 - 2z^{-1}\left(\frac{\Delta}{s(\Delta)}\right)$$

z^{-1} is the inverse function of z and it returns the cumulative percentage of the standardized normal distribution that is accumulated up to $\Delta/s(\Delta)$. These percentages of the standardized normal distribution are obtained with the function NORMSDIST(z) in Excel. For the sake of clarity, p is substituted for α in the final equation:

$$p = 2 - 2z^{-1}\left(\frac{\Delta}{s(\Delta)}\right) \tag{9}$$

The standard error of the difference is expressed with the following equation:

$$s(\Delta) = \left[T^{-1}\left\{2 - 2\rho_{ij} + \frac{1}{2}\left(\eta_i^2 + \eta_j^2 - 2\eta_i\eta_j\rho_{ij}^2\right)\right\}\right]^{\frac{1}{2}} \tag{10}$$

$T =$ the number of returns for each strategy

$\rho_{ij} =$ the correlation between the excess returns of the strategies i and j

(Auer & Schuhmacher 2013, 198)

The correlation between the excess returns is calculated by using the equation:

$$\rho_{ij} = \frac{\sigma_{ij}}{\sigma_i\sigma_j} \tag{11}$$

(Leung & Wong 2008, 20)

$\sigma_i =$ the standard deviation of the returns of the strategy i

$\sigma_j =$ the standard deviation of the returns of the strategy j

$\sigma_{ij} =$ the covariance of the returns of both strategies

(Leung & Wong 2008, 18)

When two risky assets with variances σ_i^2 and σ_i^2 are combined into a single portfolio with portfolio weights w_1 and w_2, respectively, the portfolio variance σ_P^2 is given by

$$\sigma_P^2 = w_i^2\sigma_i^2 + w_j^2\sigma_j^2 + 2w_iw_j\sigma_{ij} \tag{12}$$

(Bodie et al. 2005, 177-178)

From the equation above the covariance can be solved. If there are no reasons for specific weights (as aren't in this study), it can be assumed that the weights are equal, in other words $w_i = 0.5$ and $w_j = 0.5$.

$$\sigma_{ij} = \frac{\sigma_P^2 - w_i^2\sigma_i^2 - w_j^2\sigma_j^2}{2w_iw_j} = \frac{\sigma_P^2 - 0.5^2\sigma_i^2 - 0.5^2\sigma_j^2}{2 \times 0.5 \times 0.5} = 2\sigma_P^2 - \frac{1}{2}\sigma_i^2 - \frac{1}{2}\sigma_j^2 \tag{13}$$

The rejection of the null hypothesis of equal risk-adjusted performance means that one of the investment strategies performs better than the other (Auer & Schuhmacher 2013, 198). The skewness- and kurtosis-adjusted Sharpe ratio and the JKM-test are used in this thesis to compare the performance between the a CVR strategy in question and the buy-and-hold strategy of the corresponding commodity ETF. It has been noted that the statistical power of the JKM-test is low especially for small sample sizes (Auer & Schuhmacher 2013, 198), but the test is utilized in this bachelor's thesis as the sample sizes (numbers of returns) are quite high (nearly two thousand returns for a strategy) and the power of the test is amplified with the aforementioned adjustments for skewness and kurtosis. The null hypothesis is rejected at the nominal level $\alpha = 0.05$.

A statistical test is carried out only when a CVR strategy is able to generate excess return during the studied period of 6.7 years. When a CVR strategy performs worse than the buy-and-hold strategy, the statistical test is not performed as the CVR strategy obviously isn't capable to generate higher return than the buy-and-hold strategy and therefore isn't useful. The success differences between the CVR strategies is not tested statistically as their rates of return generally differ considerably. In addition, the similar length of period, for instance, is not an adequate premise to compare strategies, as the strategies as a whole are considerably different from each other, and therefore the only way to compare strategies reasonably would be to test each strategy against every other. As there are 6 option types and the three strategies employ 7, 9 and 10 different periods respectively, the number of statistical tests comparing performances between two CVR strategies would be 6×(7×9+9×10+10×7) = 1338. This amount of testing is simply too excessive to be carried out in the scope of this thesis and its fluent execution would require an application with more advanced programming capabilities than those of Excel. In addition, the success of the strategies is mainly dependent on the ability to uniformly create excess returns with different lengths of period and this is not directly revealed with statistical tests.

5 EMPIRICAL ANALYSIS ON THE PERFORMANCE OF THE STRATEGIES

In this section of the thesis the applicability of the Connors VIX Reversal trading strategies to the CBOE's commodity volatility indices and their underlying options is tested empirically. The beginning of this chapter explains some more specific assumptions and characteristics of the empirical study which hold for all the tested CVR strategies and the following three sub-chapters explain and illustrate the results of each CVR strategy in turn. The final subchapter explains differences in the ability of call and put options to generate excess returns.

The transaction costs of buying and selling options are subtracted from the invested sum and therefore they reduce its amount and the number of purchased options or Treasury Bills. It is supposed that buying or selling Treasury Bills doesn't involve any transaction costs. The shares of the commodity ETFs (used in the buy-and-hold strategy) are sold in the NYSE Arca exchange and according to its fee schedule, its transaction cost is on average 0.003 US dollars per share (NYSE Arca Equities 2017), so this amount is used as the transaction cost for buying and selling shares. In the model it is supposed that the transactions take place at the end of a trading day which means that the daily interest of Treasury bills or the change in an option's value during the day is incorporated to the total value of investment before the transaction. In real life, transactions of course cannot take place at the very end of the trading day (as trading stops at that moment) but instead they must happen few moments before the end of the trading. However, this temporal difference is so small that it doesn't likely affect the return of an investment significantly.

It is supposed that all the options have a position limit of 250,000 contracts on the same side of the market (i. e. call or put options) (CBOE 2017d). When the value of an investment enables the purchase of more than 250,000 contracts, only 250,000 contracts are bought and rest of the money is kept invested in Treasury Bills. The aforementioned position limit means that the amount of invested money affects the rate of return of the investment if the invested sum is high enough. Therefore it is supposed that the invested amount is U$ 10,000 (when there are no transaction costs). The model doesn't take into account the margins which must be deposited into to the traders account in the CBOE as collaterals before buying or selling options as it is supposed that options are not exercised, in other words underlying stocks are not bought or sold, but instead the options are only sold or bought before their expiration date (Bodie et al. 2005, 88; CBOE 2017d). Due to the need for collaterals the actual amount of money needed to implement CVR strategies in practice can be higher than the sum that is used to buy options or Treasury Bills. However, when a volatility index correctly predicts the development of an ETF's price, exercising options allows the investor to gain excess returns.

Transaction costs are evaluated according to the cost categories for a regular customer in the CBOE's fee schedule (CBOE 2017c, 1). Customer is a party which gives buy and sell orders and is not a broker or dealer (CBOE 2013). There are also several other types of parties which can give orders, according to the CBOE's fee schedule, but the exact nature of these parties is rather complicated and is not clearly explained in the fee schedule or in the list of origin codes (CBOE 2017c, 1; CBOE 2013). Therefore only customers are considered in the analysis of this thesis. Transaction costs are also generally lowest for a customer and therefore it is useful for a party who gives orders to be in this role (CBOE 2017c, 1). For the evaluation of the applicability of the CVR 1, 3 and 9 strategies when the order is placed by some other party than a regular customer, the maximum transaction costs for the generation of minimal excess return have been provided in the appendices.

Customer orders can be given manually, electronically, with the Automated Improvement Mechanism and with the CFLEX system (CBOE 2017c, 1). The Automated Improvement Mechanism (AIM) is the CBOE's automated process for crossing orders of any origin type. The AIM provides potential for price improvement and a participation right through an auction process. (CBOE 2018a) CFLEX is an internet-based system for trading the CBOE's FLEX options (FLexible EXchange options) (CBOE 2018b). FLEX options enable the customization of the terms of an option contract (CBOE 2018c). For a customer, the transaction costs are zero for all the aforementioned methods to enter an order, with the exception of placing the order electronically (CBOE 2017c, 1).

When an order has been placed electronically, there are no transaction costs if the order size is 249 contracts or less. When the order size is 250 contracts or greater, the transaction costs are U$ 0.18 per contract. (CBOE 2017c, 1) In the case of an order that consists of more than 3,000 ETF options, only the transaction costs of first 3,000 options are charged and the remainder options in the order are free of transaction costs (CBOE 2017c, 5). In addition to the aforementioned position limit, also the three previously mentioned rules mean that the amount of invested money can affect the rate of return of the investment. In the case of electronically placed orders the effect of transaction costs on the rates of return is examined with the investments of U$ 10,000 and 100,000.

In should be noted that during the studied period of about 6.7 years, the performance of every commodity ETF in question has been declining. The rate of return for the buy-and-hold strategy of the United States Oil Fund has been -72.74 %, in the case of SPDR Gold Shares it has been -13.02 % and for iShares Silver Trust the rate has been -57.08 %. The decline of these stocks increases the likelihood that the CVR strategies won't lead to positive returns.

5.1 CVR 1

The guidelines of the Connors VIX Reversal 1 strategy encourage the trader to test periods of different length for the first rule of the call or put signal in order to find out the optimal length of this period. In this thesis the strategy was tested with periods between 1-7 days. When the period is just one day this practically means that the first rule is ignored and just the second rule was applied. In other words the trading signal is defined just based on whether the volatility index closes above or below where it opens. This also means that the strategy creates a signal every day as the volatility index always closes either above or below the opening price. However, the transaction is carried out only when the type of the signal changes (e. g. from call to put).

In the table 1 we see the number of times when the option type in question was owned by the investor (after buying options and before selling them). In other words, the table doesn't list the number of generated signals (which is greater than the values in the table). The table differentiates the lengths of the first rule's period. One can see that the number of option owning times increased as the length of a period in the first rule shortened because trading was more frequent. The number of holding periods is almost similar for both the call and put options of a commodity ETF. As the options of the SPDR Gold Shares had most option owning times in the scenario of the one-day period where the first rule was ignored, one can conclude that the direction of the Gold ETF Volatility Index changed most often among the studied indexes from a rise to a fall or the other way around. In other words, the gold volatility index experienced most short term fluctuation which CVR strategies exploit.

Table 1. The number of option owning times when the period of the CVR 1 strategy's 1. rule has varied lengths

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)	373	372	424	425	347	348
2	131	132	138	139	145	145
3	89	89	84	85	96	96
4	71	71	77	78	76	76
5	59	59	62	63	57	57
6	50	51	52	53	45	45
7	44	45	47	48	38	38

In the table 2 we see the rates of return (as percentages) of the CVR 1 strategy with the different commodity ETF options and lengths of the first rule's period. In the table it is assumed that transaction costs are zero. The green color in a cell means that the strategy leads to a positive return and the beige color means that the strategy generates excess return compared to the buy-and-hold strategy but doesn't lead to positive return. One can observe that for the commodity volatility indices and their options the CVR 1 strategy works best with short lengths of period, from one to three days. It also seems the that the period of one day generally leads to highest returns. Indeed, trading gold puts by applying just the second and third rules seems to lead to a staggering return which would mean that the investment of U$ 10,000 would transform into the profit of U$ 861,259. However, this is the situation only when there are no transaction costs at all, which occurs when the order is placed manually, with the Automated Improvement Mechanism or with the CFLEX system. The shorter length of the period means that there are more transactions as the shorter period loosens up the requirements for the trading signals. In the case of electronically entered orders, more frequent trading leads to higher transaction costs which dramatically affect the value of invested money. Therefore it is likely that such high returns won't be acquired in electronically placed orders. However, it is surprising how accurately just following whether a volatility index closes above or below its opening price can lead to very high returns.

Table 2. Rates of return (%) when the period of the CVR 1 strategy's 1. rule has varied lengths (zero transaction costs)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)	-100.00	427.98	-99.78	8,612.59	172.74	-99.93
2	-94.62	-90.57	-98.26	170.49	-92.08	1,567.31
3	-70.85	-96.75	-99.05	95.82	-95.25	154.44
4	-87.86	-97.66	-95.18	-65.79	-98.40	-3.65
5	- 91.25	-98.12	-97.13	-36.5	-91.88	-90.85
6	-91.82	-94.81	-97.57	-65.74	-96.20	-95.23
7	-87.33	-89.51	-97.86	-21.96	-93.74	-89.64

The table 3 depicts the differences between the modified Sharpe ratios of the CVR 1 strategy and the buy-and-hold strategy of the respective ETF in the cases of excess returns. The modified Sharpe ratio and the calculation of the difference between two ratios have been explained in the subchapters 4.1 and 4.2. Because all the differences are positive, the CVR 1 strategy performs better than the buy-and-hold strategy in all cases in which excess return was created during the studied period. Therefore all these cases merit further examination. The bigger the difference between the ratios, the larger the capability of the CVR strategy to outperform the buy-and-hold strategy. The put options of the United States Oil Fund have the largest difference when the length of the period is one day. Also the put options of iShares Silver Trust perform consistently well.

The p-values of the JKM-tests have been provided in square brackets. The expression ">0.0001" means that the p-value is some number which is less than 0.0001. The p-values have been calculated with the procedure that was explained in the subchapter 4.2. From the table 3 one can see that all the p-values are below the significance level 0.05, and therefore all the excess returns from the CVR 1 strategy differ statistically significantly from the returns of the buy-and-hold strategy of the corresponding ETF.

Table 3. Sharpe ratio differences when the period of the CVR 1 strategy's 1. rule has varied lengths

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)		3.0324 [>0.0001]		1.6122 [>0.0001]	2.6281 [>0.0001]	
2				0.8242 [>0.0001]		2.3856 [>0.0001]
3	1.8427 [>0.0001]			0.9524 [>0.0001]		2.0719 [>0.0001]
4						2.1156 [>0.0001]

In those scenarios in which the CVR 1 strategy created excess returns with zero transaction costs the table 4 presents the percentages of days when the cumulative return from the CVR 1 strategy has been higher than the cumulative return from the buy-and-hold strategy (in other words, when excess return has been obtained). The cumulative return is the return from the start of the investment period to the particular day in question, which can be any day during the studied period. In other words, it doesn't mean just increase in return that is acquired during a single day. The table depicts the probability that an investor loses the invested money if this person wants to stop obeying the strategy before the end of the investment period and to use the money in some other way. The lower the value, the more likely the loss of money is. The loss is more likely than excess return if a percentage is less than 50. These too low values have been marked with the strikethrough in the table and the options and periods that lead to them are omitted from the subsequent analysis.

Table 4. Percentages of days when the CVR 1 has led to higher cumulative returns than the buy-and-hold strategy (the period of the strategy's 1. rule has varied lengths)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)		99.70		98.34	78.58	
2				59.05		83.32
3	~~30.39~~			65.40		69.91
4						85.10

In the tables 5 and 6 those scenarios in which the CVR 1 strategy created excess returns with no transaction costs are examined when the transaction cost is U$ 0.18 per contract (in the situation when the order is placed electronically). The maximum transaction costs for the generation of minimal excess return with the CVR 1 have been provided in the appendix 1. The table 5 shows the rates of return when the amount of invested money is U$ 10,000. In this situation the transaction costs completely erode the excess returns.

Table 5. Rates of return (%) when the period of the CVR 1 strategy's 1. rule has varied lengths (the investment of U$ 10,000, the transaction cost U$ 0.18 per contract)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)		-99.90		-98.70	-99.94	
2				-97.94		-99.38
3				-97.66		-99.27
4						-99.78

When the amount of invested money is increased to U$ 100,000 (table 6), the CVR 1 strategy still isn't able to generate excess return (when transaction costs are present). Therefore the CVR 1 generates excess returns only when orders are entered manually, with the Automated Improvement Mechanism or with the CFLEX system.

Table 6. Rates of return (%) when the period of the CVR 1 strategy's 1. rule has varied lengths (the investment of U$ 100,000, the transaction cost U$ 0.18 per contract)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)		-99.96		-99.87	-99.99	
2				-99.78		-78.50
3				-76.39		-99.96
4						-91.75

In general it seems that the put option of SPDR Gold Shares would be excellent to trade with just the second and third rules of the CVR 1 strategy. It has a very high rate of return (table 2), a remarkable positive Sharpe ratio difference (table 3) and it is unlikely that the trader would lose the original invested money (table 4). However, the creation of excess return requires that orders are entered otherwise than electronically, in order to avoid the effect of transaction costs.

5.2 CVR 3

Although the guidelines of the Connors VIX Reversal 3 strategy don't encourage to variate the period in the rules of the strategy's signals, the variation of the period in the rules 1, 2 and 4 was carried out in this study. The minimum period was chosen to be two days as choosing one day would have meant abandoning the rules 1, 2 and 4 and therefore actually the whole strategy. In the variation it was supposed that the same length of period is implemented in the rules 1, 2 and 4.

From the table 7 one can notice that the number of times when an investor owns options increases as the period of the strategy's rules lengthens. This is inverse to the behavior of the CVR 1 and shows that the CVR 3 is clearly its own distinct strategy. This inverse relationship is probably due to the fact that the CVR 3 is the only one of the three studied CVR strategies which utilizes moving averages. Call options have consistently greater numbers of option owning times than put options. In the case of shortest periods (2-3 days) the numbers of option owning times are often so small that the correct or wrong timing of trading signals which leads to either high or low rates of return may be purely a result of coincidences. This weakens the reliability of results with the shortest period lengths.

Table 7. The number of option owning times when the period of the CVR 3 strategy's 1., 2. and 4. rules has varied lengths

Period (days)	**Oil call**	**Oil put**	**Gold call**	**Gold put**	**Silver call**	**Silver put**
2	5	2	6	2	6	1
3	13	3	19	8	18	3
4	25	8	27	10	23	5
5	30	12	41	19	36	6
6	34	17	42	25	37	15
7	38	21	46	31	39	23
8	37	28	49	34	37	25
9	37	32	51	34	38	26
10	43	32	50	35	38	30

According to the table 8 the CVR 3 strategy was more uniformly successful in terms of rates of return than the CVR 1 as different lengths of period generally created excess returns. The put options the United States Oil Fund created excess returns with all the tested period lengths. On the other hand, the highest returns weren't as high as with the CVR 1 strategy. The performance of the CVR 3 strategy is clearly less sensitive to the length of the period, especially when using put options, but the strategy doesn't likely create as high returns as CVR 1. In the case of put options the highest returns were gained when the period was 9 days long. However, call options acquired their greatest returns when the period was 2 or 3 days. It may be that call options generally require shorter periods for their signals which could mean that the mean reversions of their volatilities take place much faster than with put options. It could be that the values of volatility indices should be monitored constantly within the trading day in order to time the trading of call options speedily enough. Put options are somewhat more successful with the CVR 3 strategy as they more often lead to excess returns and positive returns than call options.

Table 8. Rates of return (%) when the period of the CVR 3 strategy's 1., 2. and 4. rules has varied lengths (zero transaction costs)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
2	-16.56	127.12	-23.24	1.92	209.07	-21.69
3	-62.76	82.57	-50.27	-31.51	123.54	-40.09
4	-91.08	155.47	-13.31	-35.01	-6.64	-42.05
5	-74.95	85.86	-76.06	-34.65	-48.46	2.91
6	-87.08	-54.36	-41.91	-16.99	-84.27	-58.13
7	-91.35	-10.05	-78.77	59.97	-89.93	-42.86
8	-66.79	-20.85	-60.38	63.65	-85.99	64.43
9	-96.42	168.55	-65.67	82.46	-78.68	390.65
10	-97.46	99.57	-83.97	76.19	-50.43	185.72

In the table 9 we see the differences between the modified Sharpe ratios of the CVR 3 strategy and the buy-and-hold strategy of the respective ETF in the cases of excess returns. Some of the differences are negative and these differences have been underlined in the table. In the cases of negative difference, the buy-and-hold strategy is better at creating returns than the CVR 3 strategy and therefore these cases should be excluded from further analysis. Compared to the CVR 1, the CVR 3 has noticeably larger variation in the magnitude of Sharpe ratio differences. The call options of the United States Oil Fund traded with the period of two days and the put options of iShares Silver Trust with the period of four days have an exceptionally substantial Sharpe ratio difference. All the p-values are below the significance level 0.05, and therefore all the examined excess returns from the CVR 3 strategy differ statistically significantly from the returns of the buy-and-hold strategy of the corresponding ETF.

Table 9. Sharpe ratio differences when the period of the CVR 3 strategy's 1., 2. and 4. rules has varied lengths

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
2	39.7473 [>0.0001]	3.5584 [>0.0001]		0.9046 [>0.0001]	2.8111 [>0.0001]	-0.0381
3	1.1482 [>0.0001]	-5.8510			2.1603 [>0.0001]	-0.1145
4		3.3456 [>0.0001]			1.6503 [>0.0001]	11.6400 [>0.0001]
5		1.7542 [>0.0001]			1.3725 [>0.0001]	0.4660 [>0.0001]
6		1.3078 [>0.0001]				
7		2.1598 [>0.0001]		1.1261 [>0.0001]		-0.1874
8	0.8467 [>0.0001]	2.9227 [>0.0001]		0.5360 [>0.0001]		2.2177 [>0.0001]
9		4.0242 [>0.0001]		0.5268 [>0.0001]		2.7572 [>0.0001]
10		3.3847 [>0.0001]		0.4572 [>0.0001]	2.0214 [>0.0001]	2.9642 [>0.0001]

From the table 10 we see that the percentages of days, when the cumulative returns from the CVR 3 have been greater than the cumulative returns of the buy-and-hold strategy, were higher than 50 for most of the studied periods and options. Therefore it is more likely that the trader will gain excess return than lose to the buy-and-hold strategy. Again the options and periods with percentages lower than 50 are excluded from further analysis.

Table 10. Percentages of days when the CVR 3 has led to higher cumulative returns than the buy-and-hold strategy (the period of the strategy's 1., 2. and 4. rules has varied lengths)

Period (days)	**Oil call**	**Oil put**	**Gold call**	**Gold put**	**Silver call**	**Silver put**
2	66.88	98.46		69.02	94.96	
3	~~49.67~~				94.42	
4		98.52			93.59	63.80
5		81.54			72.82	94.66
6		78.93				
7		97.63		70.74		
8	63.03	98.52		~~46.59~~		82.97
9		99.94		~~38.58~~		97.74
10		99.94		~~40.24~~	94.72	97.74

In the tables 11 and 12 those scenarios in which the CVR 3 strategy has created excess returns with zero transaction costs are examined when the transaction cost is U$ 0.18 per contract (in the situation when the orders are placed electronically). The maximum transaction costs for the generation of minimal excess return with the CVR 3 have been provided in the appendix 2. The rates of return when the amount of invested money is U$ 10,000 have been presented in the table 11. If the rate of return from the CVR 3 is higher than the rate of return from the buy-and-hold strategy, the Sharpe ratio difference between the CVR 3 and buy-and-hold has been presented in the parenthesis. If the Sharpe ratio difference is positive, the statistical significance of this difference has been tested with the JKM-test. The p-value of this test has been presented in square brackets. If the p-value is less than the significance level 0.05, the CVR 3 generates significant excess return. These significant rates of return have been bolded in the tables 11 and 12. According to the table 11, with the investment of U$ 10,000, the CVR 3 is able to generate excess returns when the orders are placed electronically. Excess returns are acquired when the length of the period is two days or when the put options of the United States Oil Fund are used. Therefore, logically, the highest rate of return is obtained with the United States Oil Fund put options by using the period of two days.

Table 11. Rates of return (%) when the period of the CVR 3 strategy's 1., 2. and 4. rules has varied lengths (the investment of U$ 10,000, the transaction cost U$ 0.18 per contract)

Period (days)	**Oil call**	**Oil put**	**Gold call**	**Gold put**	**Silver call**	**Silver put**
2	**-65.42** (28.7764) [>0.0001]	**94.06** (3.4548) [>0.0001]		-19.94	**67.60** (2.4064) [>0.0001]	
3					-99.05	
4		**-2.95** (1.6074) [>0.0001]			-99.42	-87.08
5		-98.99			-99.65	-75.10
6		-99.14				
7		-99.00		-96.76		
8	-99.50	-99.23				-99.00
9		**-67.98** (2.8941) [>0.0001]				-99.47
10		-98.72			-99.76	-99.02

When the invested amount is increased to U$ 100,000 (table 12), the cases of excess returns become more common and the excess returns from the previous table increase. The period of two days again leads to the largest excess returns. The put options of the United States Oil Fund are able to generate excess returns with almost all the lengths of the period. Also the calls and puts of iShares Silver Trust generate excess returns with several different period lengths. It seems that rates of return generally decrease when the period lengthens, but this pattern is ambiguous.

Table 12. Rates of return (%) when the period of the CVR 3 strategy's 1., 2. and 4. rules has varied lengths (the investment of U$ 100,000, the transaction cost U$ 0.18 per contract)

Period (days)	**Oil call**	**Oil put**	**Gold call**	**Gold put**	**Silver call**	**Silver put**
2	**-21.45** (37.3472) [>0.0001]	**123.81** (3.5517) [>0.0001]		**-0.27** (0.6990) [>0.0001]	**194.92** (2.7989) [>0.0001]	
3					**0.28** (1.5341) [>0.0001]	
4		**35.44** (3.5744) [>0.0001]			**-31.54** (1.2196) [>0.0001]	**-47.05** (8.7963) [>0.0001]
5		**-14.40** (1.3158) [>0.0001]			-71.53	-4.89 (0.0196) [0.5852]
6		**-67.46** (1.1906) [>0.0001]				
7		**-28.86** (1.9634) [>0.0001]		**12.15** (0.3952) [>0.0001]		
8	-86.98	**-59.78** (2.4467) [>0.0001]				**26.01** (1.7573) [>0.0001]
9		**-39.20** (2.5131) [>0.0001]				**-49.17** (2.3825) [>0.0001]
10		**-0.56** (2.5998) [>0.0001]			-84.05	-77.72

In summary, it can be concluded that one of the best options to trade with the CVR 3 strategy are the put options of the United States Oil Fund with the period of 9 days as they have very good rates of return (tables 8 and 11-12), a relatively high Sharpe ratio difference (table 9) and they are very likely to create excess return (table 10). These options generate excess returns with all the possible ways to enter an order (including electronically) as the transaction costs don’t completely erode excess returns. Based on the values of the tables there are other very potential options types but their low numbers of option owning times make these options too unreliable to be recommended for practical usage as the good values may be just results of coincidences.

As both the length of a period and transaction costs affect the performance of CVR strategies, this is next highlighted with a series of line graphs. In the figure 1 the blue graph is the value of the money (as a function of time) that is invested in the put options of the United States Oil Fund by utilizing the CVR 3 and the orange graph is the value in the buy-and-hold strategy that uses the shares of the same exchange-traded fund. The period in the CVR 3 is ten days and it is assumed that transaction costs are not charged when buying or selling put options. The initial value of the investment is U$ 10,000 in both cases. One notices from the graphs that after beginning of the studied period the investment value of the CVR 3 stays higher than the value of the buy-and-hold for the rest of the time. With the CVR 3, the value of the investment varies very much in the long run, rising and descending intermittently, whereas the value of the buy-and-hold decreases steadily.

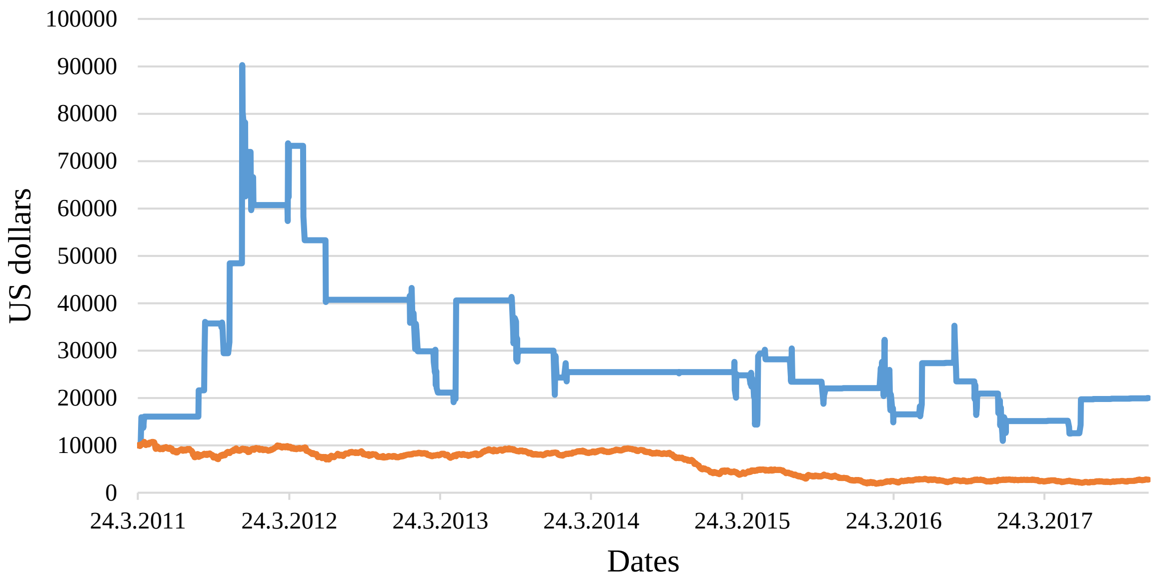

Figure 1. The value of the invested money (U$ 10,000) with the CVR 3 and oil puts (a 10-day period, no transaction costs) and with the buy-and-hold in oil shares

In the figure 2 the period of the previous graph (and of the same CVR strategy and option type) is shortened to nine days. Compared to the figure 1, we can observe that the volatility of the investment value seems to be clearly greater in the figure 2 (and with the 9-day period) as during the bullish periods the value of the investment rises more powerfully and during the bearish periods it also falls more powerfully. The final value of the investment at the end of the study period is much higher (with the CVR 3), because in comparison to the previous scenario the increase in rises during the bullish periods is somewhat greater than the increase in the falls during the bearish periods. Changes from a bullish to a bearish period (or the other way around) seem to take place almost at the same times, but in this scenario the timing is now better enough (compared to the figure 1) to enable the creation of higher excess return.

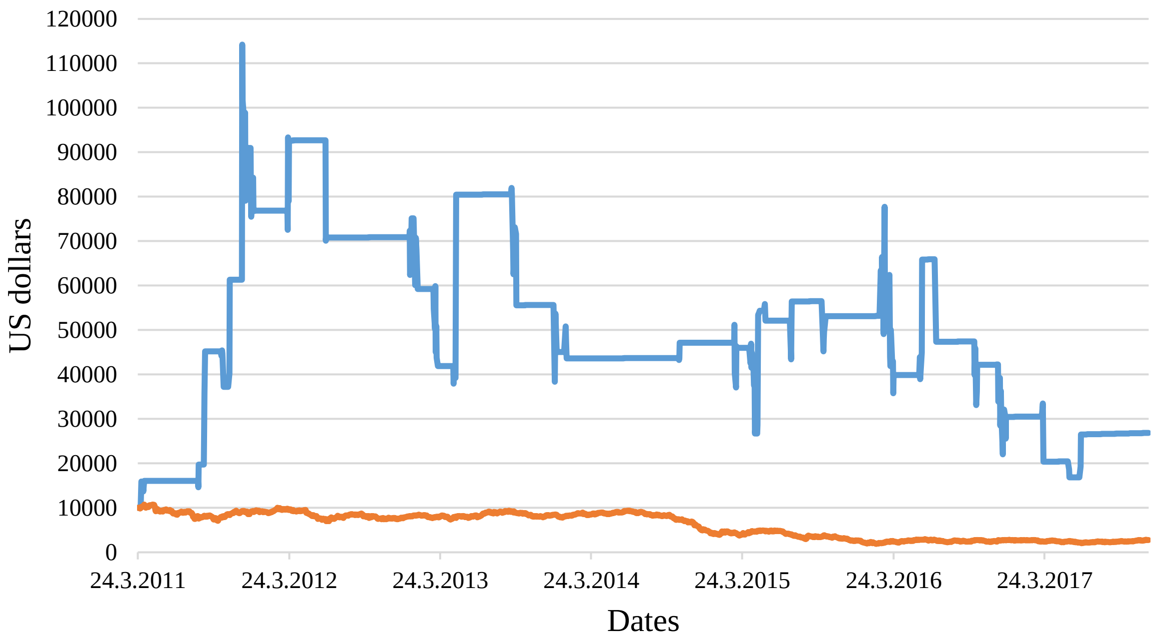

Figure 2. The value of the invested money (U$ 10,000) with the CVR 3 and oil puts (a 9-day period, no transaction costs) and with the buy-and-hold in oil shares

In the figure 3 the transaction costs of U$ 0.18 per option are added to the previous graph when the length of the period, the utilized strategy and the traded option type are kept the same. The main reason for which the final investment value is much worse is that the value drops more continuously than in the previous graph. In other words, there are not as many substantial rises in the investment value that take place during the studied period. Therefore one could hypothesize that high transaction costs especially dampen steep rises of the investment value. The depressing effect seems to get more pronounced as the time passes. At the beginning of the graph values are still somewhat similar to the previous graph, but already in the middle very large differences have shown up.

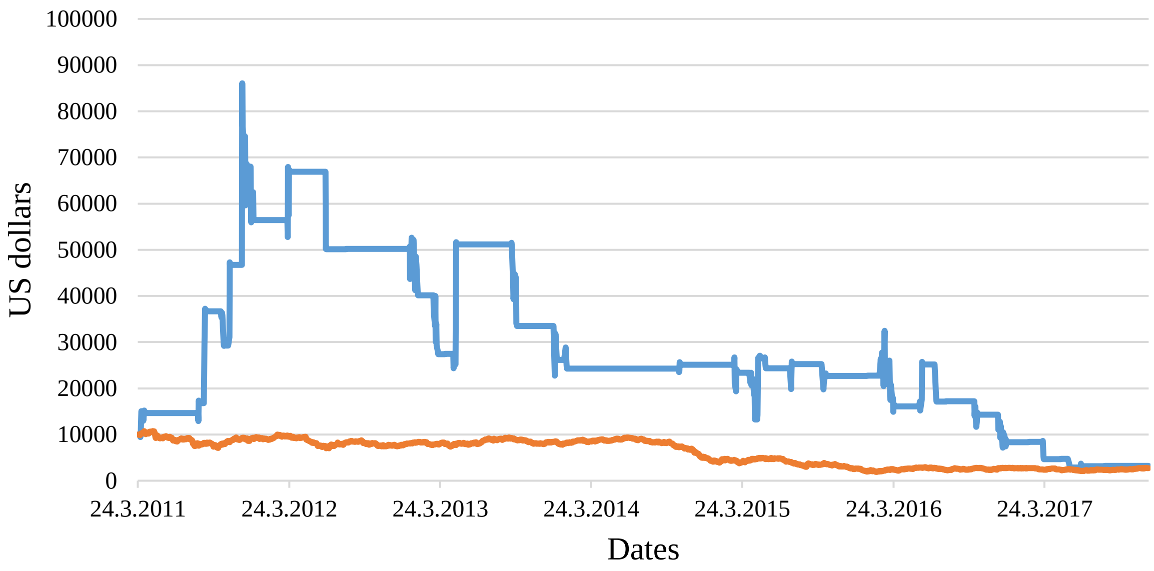

Figure 3. The value of the invested money (U$ 10,000) with the CVR 3 and oil puts (a 9-day period, transaction costs U$ 0.18 per option) and with the buy-and-hold in oil shares

5.3 CVR 9

In the study of the Connors VIX Reversal 9 strategy the period of its first rule was varied. The periods of the third and fourth rule weren't varied as they weren't similar to the first rule and varying them would have added too many new variables to the model. From the table 13 we see that the numbers of times when options were owned by an investor decrease as the period of the CVR 9 strategy lengthens. The CVR 9 strategy is similar to the CVR 1 in this respect and this similarity can be attributed to the fact that both strategies base their rules on the highest or lowest values in the period instead of the moving averages of the period which the CVR 3 utilizes. The numbers of option owning times of the CVR 9 are higher than those of the CVR 3, but not as high as the numbers of the CVR 1. Due to the lower numbers the research results of the CVR 3 are less reliable than the results of the CVR 1 and 9 as the lower numbers increase the risk that the correct timing of the CVR 3 strategy is purely accidental and gained excess returns do not really manifest the goodness of the strategy.

Table 13. The number of option owning times when the period of the CVR 9 strategy's 1. rule has varied lengths

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)	95	126	101	141	93	112
2	62	61	59	62	64	42
3	59	53	51	54	58	36
4	53	44	46	50	49	27
5	46	36	41	42	39	25
6	37	35	36	35	37	23
7	32	35	30	33	30	20
8	31	35	29	33	25	18
9	26	31	24	32	21	16
10	25	29	22	30	20	16

The CVR 9 strategy was uniformly successful with put options but it didn't create excess returns with call options. According to the table 14 the excess returns took place in all the tested periods but the highest returns were gained in the periods of 1-4 days. The put options of iShares Silver Trust created excess returns with all the tested period lengths.

Table 14. Rates of return (%) when the period of the CVR 9 strategy's 1. rule has varied lengths (zero transaction costs)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)	-99.58	-84.67	-98.43	9,094.27	-99.20	243.90
2	-98.77	303.16	-91.24	197.00	-99.52	-39.43
3	-97.93	183.12	88.82	59.38	-99.50	-29.47
4	-94.07	333.36	-91.30	91.86	-98.57	-6.85
5	-97.25	-65.15	-89.75	51.41	-99.35	0.98
6	-88.61	-55.30	-90.20	-85.66	-99.55	47.29
7	-92.63	-55.30	-91.12	-89.75	-99.40	34.82
8	-91.26	-55.30	-94.08	-86.97	-99.75	-0.54
9	-91.87	-67.48	-86.97	-85.52	-99.69	-19.85
10	-91.59	-53.71	-87.43	-88.29	-99.74	-19.85

The table 15 shows the differences between the modified Sharpe ratios of the CVR 9 strategy and the buy-and-hold strategy of the respective ETF in the cases of excess returns. A single negative difference has been underlined in the table and will be excluded from further examination. Higher differences are generally obtained in the cases in which the CVR 9 strategy leads to positive return. The general impression from the table 13 is that the CVR 9 strategy has much less variation in the magnitude of Sharpe ratio differences than the CVR 3 and slightly less variation than the CVR 1. One can state that, in comparison to the CVR 9, the ability of the CVR 3 strategy to lead to excess returns is much more dependent on the length of the period in its trading rules but with certain lengths of the period the CVR 3 is much more likely to generate excess return. The highest Sharpe ratio difference for the CVR 9 is obtained with the put options of the United States Oil Fund traded with the period of four days. All the p-values are below the significance level 0.05, and therefore the examined excess returns from the CVR 9 strategy differ statistically significantly from the returns of the buy-and-hold strategy of the corresponding ETF.

Table 15. Sharpe ratio differences when the period of the CVR 9 strategy's 1. rule has varied lengths

Period (days)	**Oil call**	**Oil put**	**Gold call**	**Gold put**	**Silver call**	**Silver put**
1 (1. rule ignored)				1.4890 [>0.0001]		2.2081 [>0.0001]
2		2.4684 [>0.0001]		1.3093 [>0.0001]		0.2988 [>0.0001]
3		2.5430 [>0.0001]		1.5956 [>0.0001]		0.9675 [>0.0001]
4		2.6433 [>0.0001]		1.5650 [>0.0001]		1.9848 [>0.0001]
5		<u>-0.2441</u>		1.2395 [>0.0001]		2.0679 [>0.0001]
6		0.9371 [>0.0001]				2.5446 [>0.0001]
7		0.9371 [>0.0001]				2.5440 [>0.0001]
8		0.9371 [>0.0001]				1.8378 [>0.0001]
9		0.5064 [>0.0001]				1.0160 [>0.0001]
10		0.8256 [>0.0001]				1.0160 [>0.0001]

From the table 16 one notices that the percentages of days, when the cumulative returns from the CVR 9 have been greater than the cumulative returns of the buy-and-hold strategy, were higher than 50 for all the studied periods and options, so the strategy likely leads to excess returns. The percentages somewhat decrease when the period lengthens.

Table 16. Percentages of days when the CVR 9 has led to higher cumulative returns than the buy-and-hold strategy (the period of the strategy's 1. rule has varied lengths)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)				99.11		92.70
2		81.66		78.52		64.63
3		84.99		78.64		77.51
4		89.50		78.64		97.92
5				78.64		97.92
6		69.50				97.92
7		69.50				97.92
8		69.50				92.58
9		68.61				86.59
10		68.72				86.59

In the tables 17 and 18 those scenarios in which the CVR 9 strategy has created excess returns with zero transaction costs are examined when the transaction cost is U$ 0.18 per contract (as the orders are placed electronically). The maximum transaction costs for the generation of minimal excess return with the CVR 9 have been provided in the appendix 3. The table 17 states that, with the investment of U$ 10,000, the CVR 3 doesn't generate excess returns when the orders are placed electronically.

Table 17. Rates of return (%) when the period of the CVR 9 strategy's 1. rule has varied lengths (the investment of U$ 10,000, the transaction cost U$ 0.18 per contract)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)				-97.48		-98.59
2		-99.49		-97.61		-99.22
3		-99.50		-97.83		-99.52
4		-99.36		-97.67		-99.53
5		-99.49		-97.51		-99.49
6		-99.44				-99.37
7		-99.44				-99.33
8		-99.44				-99.41
9		-99.51				-99.36
10		-99.49				-99.36

As the invested amount is increased to U$ 100,000 (table 18), various cases of excess returns appear. The put options of all the three examined ETFs lead to excess returns with several period lengths. The put options of the United States Oil Fund and SPDR Gold Shares generate excess returns with short period lengths (1-5 days) whereas the puts of iShares Silver Trust generally yield excess returns with longer periods (6-10 days). The highest returns are gained with the put options of SPDR Gold Shares when the period of one or two days is used.

Table 18. Rates of return (%) when the period of the CVR 9 strategy's 1. rule has varied lengths (the investment of U$ 100,000, the transaction cost U$ 0.18 per contract)

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)				**155.61** (1.7656) [<0.0001]		-99.85
2		**-66.22** (1.7270) [>0.0001]		**43.28** (0.6507) [<0.0001]		-88.32
3		**-64.94** (1.8572) [>0.0001]		**-2.60** (1.2657) [<0.0001]		-66.78
4		**-31.18** (2.1727) [<0.0001]		**19.11** (1.2072) [<0.0001]		**-50.52** (1.2799) [>0.0001]
5		-87.21		**-1.93** (0.7470) [<0.0001]		-67.64
6		-77.61				**-27.30** (1.4988) [>0.0001]
7		-77.61				**-48.43** (1.3652) [>0.0001]
8		-77.61				**-46.21** (0.7945) [>0.0001]
9		-84.39				**-36.60** (0.5717) [>0.0001]
10		-73.39				**-36.60** (0.5717) [>0.0001]

When comparing the performance of different options, it seems again, as was also the case with the CVR 1 strategy, that the put option of SPDR Gold Shares would be excellent to trade with just the 2.-4. rules of the CVR 9 strategy. This put option has high rates of return (table 14 and 18), a favorable Sharpe ratio (table 15) and is very likely to create excess return (table 16). The use of this option generates excess return also when the order is entered electronically, if the amount of invested money is high enough, like U$ 100,000, as only the transaction costs of the first 3,000 ETF options are charged, as was mentioned at the beginning of this chapter. Therefore increasing the invested money alleviates the decreasing effect of transaction costs. Still, the orders which are entered manually, with the Automated Improvement Mechanism or with the CFLEX system lead to excess returns also with more modest invested amounts, as there are no transaction costs.

5.4 Better performance of put options

In the following table 19, the performance of the three Connors VIX Reversal strategies with the three commodity exchange-traded funds is summarized and compared based on the rates of return from the previous tables (2, 8 and 14). The numbers present occasions in which the option type in question created excess returns, when there were no transaction costs. Bold numbers present occasions of positive returns and thin numbers present returns that weren't positive but still higher than the returns from the buy-and-hold strategy. From the table we can see that Connors VIX Reversal strategies clearly performed better with put options than with call options.

Table 19. The excess return occasions of put and call options with different CVR strategies

Strategy	CVR 1			CVR 3			CVR 9			Number of excess return occasions
Option type	Oil	Gold	Silver	Oil	Gold	Silver	Oil	Gold	Silver	
Call	1		**1**	3		**2** + 3				**3** + 7
Put	**1**	**3**	**2** + 1	**6** + 3	**5**	**4** + 4	**3** + 6	**5**	**4** + 6	**33 +** 20

One of the most probable explanations for the better performance of put options is that the buyers have bigger demand for put options than for call options so that when the prices of the commodity ETFs fall, the prices of their put options rise more than the prices of call options would rise in the situation where the prices of the ETFs rise equally much. When the prices of ETFs fall the prices of their respective put options rise as the capability of put options to create excess returns increases. Due to buyers' preference for put options they are capable to generate higher returns than call options. The preference of buyers for put options is supported by the existing finding that the VIX index has reacted much more powerfully to negative changes in stock prices than to positive price changes of similar size (Sarwar 2012, 907, 908). The article of Whaley (2009, 99, 11) has attributed the tendency of the VIX to react more powerfully to the price falls (than to price rises) of S&P 500 index to the buyers preference for S&P 500 index put options. The VIX index (as well as the CBOE's commodity volatility indices) estimates expected volatility by averaging the weighted prices of the puts and calls of an ETF over a wide range of strike prices and this information supports the proposition that the prices of puts have a tendency to rise more when the prices of ETFs fall than the prices of calls would rise in the situation where the ETF prices rise equally much (CBOE 2017e).

It could also be that the rise of the commodity volatility indices predicts the decrease in the prices of the ETFs much more accurately than the fall of the index values indicates the rise of the ETF prices. In other words when the index rises the ETF prices likely fall but when the index falls the ETF prices can rise, fall or stay still. This greater uncertainty can weaken the power of the CVR strategies with call options and therefore put options are much more capable to create excess returns. The higher number of buyers for put options leads to the situation where there is much more information in the put market and this can increase the capability of the indices to predict ETF price falls much more accurately. One can also make a further proposition that the prices of call options may not as certainly react in a positive manner to the rise of ETF prices as the prices of put options would react to the price falls of ETFs.

6 CONCLUSIONS

In this chapter the answers to the research questions are summarized and the possible explanations for them, which haven't been presented yet, are outlined. The answer to the main research question is that generally Connors VIX Reversal strategies can be successfully utilized with the CBOE's commodity volatility indices to create excess returns. The CVR 3 and 9 strategies are better than CVR 1 at generating excess returns as they create returns much more uniformly and are therefore less risky. The option type of the commodity ETF in question affects the returns in such a way that put options clearly perform better than call options on average. Strategies differ in their performance according to the ETF on which the options are based but none of the ETFs performed absolutely better with all the three strategies. However, the put options of the United States Oil Fund and iShares Silver Trust generated excess returns uniformly with different period lengths when the CVR 3 and 9 strategies were used. The effect of transaction costs depends on the option type and underlying ETF in question and also on the length of the period in trading rules. Of all the strategies, the CVR 3 is least sensitive to the effect of transaction costs, which however can be possibly attributed to the fact that the strategy leads to fewest instances in which options are bought or sold.

There are several reasons for the identified opportunity to gain excess returns that is contrary to the hypothesis of efficient markets. The success of the strategies is based on applying them in the long term and the majority of investors are not necessarily ready to stick to a single strategy for a long time, especially if the strategy doesn't initially create substantial excess returns. The strategy also requires the continuous daily monitoring of the values of volatility indices. The majority of the investors are not necessarily willing to monitor the values so frequently. The strategies also apply simultaneously several rules and are therefore somewhat complicated. Most of the investors don't necessarily apply strategies which are this complicated, which also creates opportunities to gain excess returns. This is supported by the fact that more complicated CVR 3 and 9 strategies created excess returns much more uniformly than the simpler CVR 1 strategy.

The CBOE's options on the three commodity ETFs have been introduced quite recently (the earliest options, for SPDR Gold Shares, have been introduced in 2009), and therefore it hasn't been possible, until recently, to perform long-term analyses about their performance with different trading strategies. Therefore information which would have made markets more efficient hasn't been available until now. In addition, when the orders to buy or sell options are placed electronically, the amount of invested money affects the rates of return in a complicated manner, as transaction costs are deducted depending on the number of purchased options. The right amount of invested money for the creation of excess return with the CVR strategies can revealed only through detailed analysis (that has been done on a general level in this thesis) and the need for this complicated analysis creates a barrier for potential investors.

Only a limited number of traders may be able to enter their buy and sell orders by accessing the methods that lead to zero transaction costs (manually, with the Automated Improvement Mechanism or with the CFLEX system), and therefore only few able to generate substantial excess returns this way. Also the margins which must be paid as collaterals for the CBOE in order to trade its options can present a barrier for potential investors, as these margins can be large amounts of money, and therefore all willing investors are not capable to continuously trade the options of the commodity ETFs.

The prices of the ETFs and their respective options have been declining for a long time. This may have made these options unpopular with investors and therefore their volatilities and values are not tracked as actively as in the case of rising prices, which opens up opportunities to gain excess returns because the information isn't disseminated completely efficiently in the markets. Especially when the prices decline for a long time the interest of the majority of investors wanes. The markets which have been informationally efficient can subsequently become inefficient (Majumber 2012, 89).

Commodity markets may also generally have somewhat less activity than markets related to the shares of companies. The results indicating possibilities for excess returns with short-term trading strategies are consistent with a recent study which found out that commodity markets tend to be informationally inefficient in the short-term (Jawadi et al. 2017, 582).

The final potential reason for the excess returns is that the utilization of the closing price of the trading day for options has led to unrealistically high trading prices. It may be that the majority of traders try to time their trading as close to the end of the trading day as possible and therefore price rises take place at the very last moments of the day. Therefore an investor isn't able to gain excess returns if he or she isn't able to time the trading to take place during these critical very last moments. This timing may require the utilization of very fast computers and cable connections, for instance.

Several suggestions for further study can be proposed. One should empirically try to identify justified reasons for the bad performance of CVR strategies with the call options of the commodity ETFs. Based on the found underlying reasons trading strategies for the call options could be developed. The capability of CVR strategies to create significant excess returns should possibly be evaluated with more advanced statistical tests. Also the application of the rest of the ten CVR strategies to the CBOE's commodity volatility indices could be studied. The utilization of the CBOE's commodity volatility indices to market timing in other futures and options markets could also be studied as it was stated in the chapter 2 that the CBOE's Silver ETF Volatility Index has been able to predict the volatility changes in the Shanghai silver futures market.

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NOTE ON THE APPENDICES

In this thesis the effect of transaction costs has been examined in the situation where the order has come from a regular customer. However, to enable a reader, who is considering to use these CVR strategies, to evaluate whether the strategies can generate excess return if the order has been placed by some other party than a regular customer, three appendices have been created to present the largest possible transaction costs. These appendices can be also utilized to re-evaluate the applicability of the three CVR strategies, if in the future the CBOE changes their transaction costs for ETF options.

The appendices 1-3 show the transaction costs per option which are maximal for the generation of minimum excess return in those scenarios in which the CVR 1, 3 and 9 strategies led to excess returns (without transaction costs) during most of the studied period and to positive Sharpe ratios (as was stated in the subchapters 5.1-5.3). If the transaction costs are any more than these amounts, the excess return is not created. The unit of these maximum costs is US dollars. From the CBOE's fee schedule one can reason that currently the smallest possible non-zero transaction cost is U$ 0.03 per contract (when the order comes from the CBOE Options Market-Maker) (CBOE 2017c, 1, 3). Therefore the maximum transaction costs which are at least U$ 0.03 are bolded in the tables as in these cases the options currently have real potential to generate excess returns with CVR strategies. In the remaining cases excess return is not currently generated, if the order isn't placed by a regular customer.

Statistically, the criterion for the highest possible transaction cost is that it will lead to the smallest positive (i. e. above 0) lower bound for the confidence region of a Sharpe ratio difference when the significance level is 0.05. The confidence region was explained in the subchapter 4.2. All the p-values in the appendices are below the significance level 0.05, and therefore all the minimum excess returns from the CVR 1, 3 and 9 strategies differ statistically significantly from the returns of the corresponding buy-and-hold strategy. In the appendices it is supposed that all the options have a position limit of 250,000 contracts on the same side of the market (as was mentioned at the beginning of the chapter 5), but no other limitations are posed. This means that the transaction cost per option is same for every option regardless of the amount of bought options. However, because the position limit can affect the rates of return if the investment is big enough, it is assumed in the appendices that the amount of invested money is U$ 10,000.

APPENDIX 1. Maximum transaction costs (U$) when the period of the CVR 1 strategy's 1. rule has varied lengths

Period (days)	**Oil call**	**Oil put**	**Gold call**	**Gold put**	**Silver call**	**Silver put**
1 (1. rule ignored)		0.0026 [>0.0001]		0.0121 [>0.0001]	0.0012 [>0.0001]	
2				0.0093 [>0.0001]		0.0067 [>0.0001]
3				0.0109 [>0.0001]		0.0053 [>0.0001]
4						0.0029 [>0.0001]

APPENDIX 2. Maximum transaction costs (U$) when the period of the CVR 3 strategy's 1., 2. and 4. rules has varied lengths

Period (days)	**Oil call**	**Oil put**	**Gold call**	**Gold put**	**Silver call**	**Silver put**
2	**0.1752** [>0.0001]	**0.6338** [>0.0001]		0.0114 [0.0455]	**0.1346** [0.0012]	
3					**0.0331** [>0.0001]	
4		**0.1055** [>0.0001]			0.0118 [>0.0001]	0.0266 [>0.0001]
5		**0.0501** [>0.0001]			0.0018 [>0.0001]	0.0044 [0.0301]
6		0.0096 [>0.0001]				
7		0.0189 [>0.0001]		0.0235 [0.0448]		
8	0.0019 [>0.0001]	0.0126 [>0.0001]				0.0154 [>0.0001]
9		0.0256 [>0.0001]				0.0264 [>0.0001]
10		0.0218 [>0.0001]			0.0012 [>0.0001]	0.0160 [>0.0001]

APPENDIX 3. Maximum transaction costs (U$) when the period of the CVR 9 strategy's 1. rule has varied lengths

Period (days)	Oil call	Oil put	Gold call	Gold put	Silver call	Silver put
1 (1. rule ignored)				**0.0404** [>0.0001]		0.0054 [>0.0001]
2		0.0147 [>0.0001]		0.0227 [>0.0001]		0.0012 [0.0442]
3		0.0143 [>0.0001]		0.0130 [>0.0001]		0.0037 [>0.0001]
4		0.0210 [>0.0001]		0.0185 [>0.0001]		0.0075 [>0.0001]
5				0.0158 [>0.0001]		0.0089 [>0.0001]
6		0.0045 [>0.0001]				0.0139 [>0.0001]
7		0.0045 [>0.0001]				0.0147 [>0.0001]
8		0.0045 [>0.0001]				0.0116 [>0.0001]
9		0.0017 [>0.0001]				0.0092 [0.0452]
10		0.0050 [0.0414]				0.0092 [0.0452]