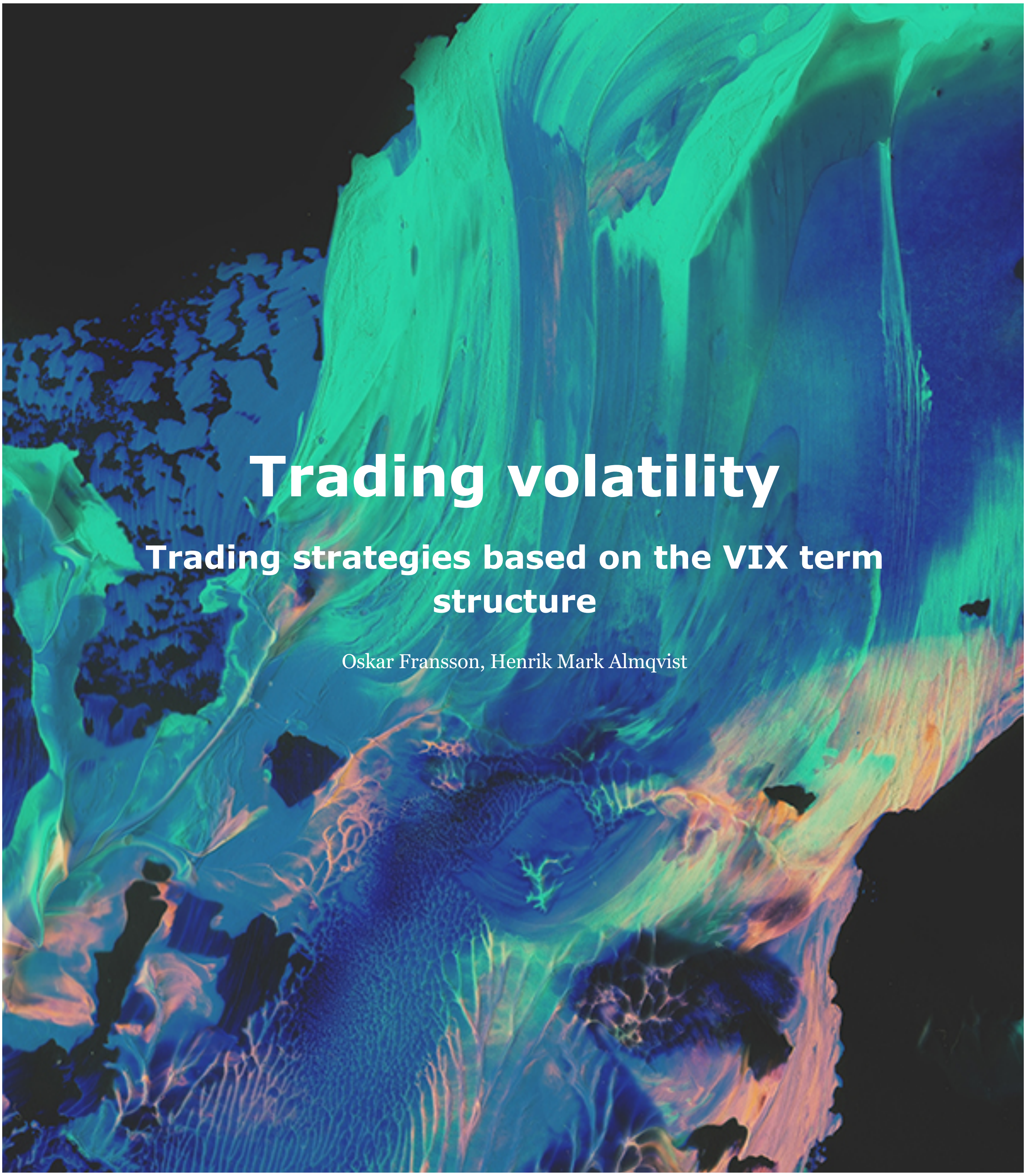
UMEÅ SCHOOL OF BUSINESS, ECONOMICS AND STATISTICS
UMEÅ UNIVERSITY



Trading volatility

Trading strategies based on the VIX term structure

Oskar Fransson, Henrik Mark Almqvist

Department of Business Administration
International Business Program
Bachelor Thesis, 15 Credits, Spring 2020
Supervisor: Irina Alexeyeva

Page intentionally left blank

Acknowledgement

We would like to thank our supervisor Irina Alexeyeva for her support and feedback throughout the process of writing this thesis.

Umeå University, May 2020

Henrik Mark-Almqvist
Oskar Fransson

Page intentionally left blank

Abstract

This study investigates how term structure dynamics of VIX futures can be exploited for abnormal returns. To be able to access volatility as a tradeable asset, the trading strategies only trades ETFs which are designed to replicate the movements of VIX futures index. It is established that such ETFs are unsuitable for buy-and-hold investments because of the negative roll yield it usually suffers, caused by the slope of the VIX term structure. Consequently, these conditions create opportunities for strategies that use direct and inverse VIX ETFs to be profitable. The study is a quantitative study that uses historical price data to back test three different trading strategies. The strategies are tested over the period 11-oct-2011 to 31-mar-2020. The authors have deliberately chosen to delimit the study by not testing the performance of the ETFs, not statistically test the risk-adjusted returns and not perform a regression to calculate optimal hedge ratios for the strategies. The results from this study shows that its possible for strategies that exploit the term structure dynamics of VIX futures to generate abnormal returns.

Page intentionally left blank

Table of content

1. Introduction

In the introduction the authors present the background behind the idea of the research, previous relevant studies, following with a problematization leading to the research purpose. Finally, the contribution of the research and some delimitations are disclosed.

1.1 Background

In the field of finance and in particular portfolio management, the balance between risk and return aims to be optimized. An assets return is the percentage change between two periods prices and the assets risk is traditionally defined as the standard deviation (or volatility) over the periods return, which explains the extent of fluctuations for an asset's historical prices (Berk & DeMarzo, 2014, p. 323). This research investigates how volatility can be traded as an asset, the unique features of volatility instruments and how it can be used for profitable strategies.

In 1993, Professor Robert Whaley created the Cboe VIX-index, which prices are designed to represent the S&P 500 30 days expected future volatility (Chicago Board Options Exchange [CBOE], 2019). The reason for why the VIX index will be emphasized repeatedly in the essay is because it is important to understand how it is derived, how it relates to the stock market and how investors uses it in their forecasts and predictions. The VIX index and its spot prices itself is not a tradeable asset because the prices are only derived from a basket of S&P 500 underlying index options. However, since 2004 the Chicago board of option exchange (Cboe) launched VIX futures contracts of the VIX spot prices. Since VIX futures inception, volatility as an asset have gotten more attention among traders and scholars, and there's been a large increase in tradable products for VIX as an underlying instrument. The VIX index has been proven to generate returns with a negative correlation to the stock market, which has led to an alternative way for investors to hedge their equity portfolio if one does not want to use derivatives linked directly to the stock market (Cboe, 2019).

Several existing literatures that analyzes the pricing of VIX derivatives have investigated the behavior of the VIX term structure and to what extent established economic theories can explain the dynamics of it. Most of the research conclude that the economic theory of rational expectation fails to explain the dynamics of VIX futures and the VIX index price (Nossman & Wilhelmsson, 2009; Simon & Campassano, 2012). The argument behind this is based on the fact that investors are willing to pay considerable amounts to hedge their equity portfolios. In the pricing of VIX derivatives this cost is referred to as VIX risk premium. From an economic point of view this premium could be interpreted as the expected return of selling a VIX future contract. Since there is a high demand on this kind of insurance among investors, the premiums may differ substantially between the VIX futures and the VIX index spot level (Alkelin & Bergkvist, 2019, p. 2). The outcome of this fact is that the VIX term structure often is upward sloping (Alexander, Kapraun & Korovilas, 2015, p.315). Thereupon, this dynamic has given rise to several trading strategies using the term structure of the VIX futures for capitalization.

1.2 Problematization

Because of the inverse relationship between volatility and equity prices and the mean reverting dynamics of VIX (figure 1), VIX futures can be expected to give a potential interesting hedging opportunity for an equity portfolio (Jung, 2016, p.190).

Figure 1.

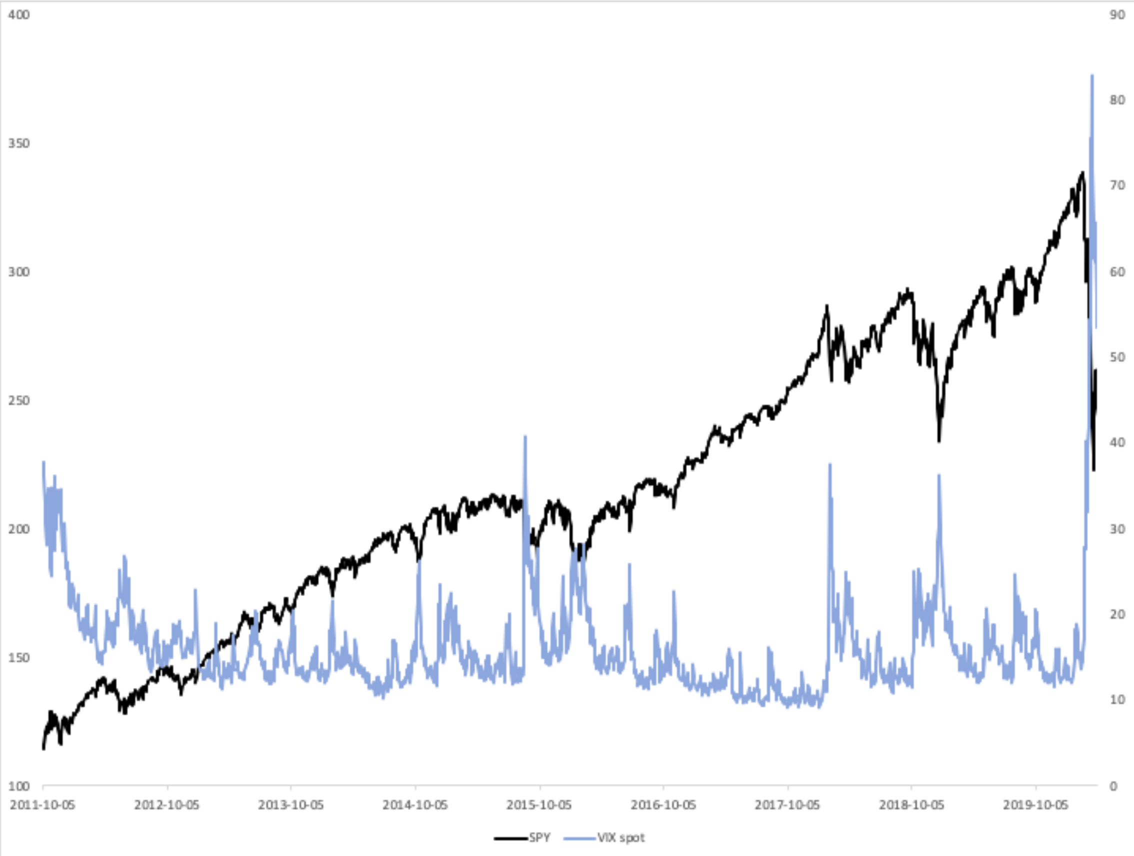


Figure 1. VIX index and S&P 500: Black - SPY, Blue - VIX index.
Source: Reuters Eikon (2020).

However, professor Whaley (2013) shows that a long-term holding position of VIX futures is a poor buy-and-hold strategy and generates negative return over time because the futures normally trades with negative carry and roll yield. The long VIX future position suffers from negative roll yield of the degree to which VIX spot prices and VIX futures prices relate to each other (Whaley, 2013, p.12-13). Previous literature by Asensio (2013) describes how there is an imbalance between the VIX index and prices of VIX futures, creating a slope of the VIX term structure (contango and backwardation). This could be explained with the market consistently expecting higher (contango) or lower (backwardation) prices of the future VIX spot prices (Asensio, 2013, p.2). Furthermore, Simon and Campassano (2012) describes how these imbalances on the term structure have an insignificant forecast power for the VIX index prices, implying there's is a time-varying risk premium (Simon & Campassano, 2012, p.2). Additional studies by Simon and Campassano (2012) and Bordonado and Samdal (2016) shows that trading strategies based on the slope of the VIX term structure can be profitable by taking position capitalizing on the roll yield.

During the last decade, there has been a significant increase of traded volume in VIX exchange traded funds (ETFs). An ETF is a variation of an exchange traded product (ETP) that can expand the opportunities to trade volatility without having to directly use financial derivatives as options or futures. An ETF is best explained as a collection of various financial instruments that are bundled together for the purpose of following a specific underlying asset, such as the VIX- index. This thesis will be focusing on various ETFs with VIX futures as underlying. Products such as ETFs, which are designed to follow the volatility futures movement, are therefore also affected by similar term structure characteristics (Bordonado & Samdal, 2016, p.35). Since a term structure in contango suffers from negative roll yield and carry, it causes a passive buy-and-hold investment in VIX ETFs to be less suitable if one wants to maximize profit over time (Whaley, 2013, p19). Further research by Bordonado and Samdal (2016) show how similar trading strategies as presented by Simon and Campassano (2012) can be applied for trading VIX ETPs/ETFs.

Trading strategies shorting equity volatility are exposed to the risk of volatility spikes. This means that an investor must not only avoid losing due to the slope of the term structure, but also for more unexpected tail events that can greatly increase volatility. For instance, February 5th, 2018 was the day when the VIX index experienced its largest daily increase since the index inception, an event also referred to as "Volmageddon". Volmageddon had a catastrophic impact especially on short VIX short term ETFs, which for example forced the "VelocityShares daily inverse VIX short term note ETF" to be liquidated (Kawa, 2019). This day has since its occurrence symbolized the cannibalized returns and tail-events associated with these kinds of trading strategies. The question that arises is how portfolios can be managed to avoid the negative effects of this kind of events.

1.3 Research Question

The thesis aims to answer the following research question:

> *"How can the term structure dynamics of VIX futures be exploited for abnormal returns?"*

1.4 Purpose

The purpose with this paper is to investigate if trading strategies that exploits VIX term structure behavior (similar to strategies done by Simon and Campassano (2012)) have generated a significant abnormal return during the latest 7 years. The time period used in this study exceeds the periods tested in previous literature, which include significant volatile events that could have an effect on short volatility strategies. This makes it is interesting to investigate the question regarding the robustness of the strategies.

Furthermore, the thesis will investigate whether different modifications of the strategies have generated significant abnormal returns and how similar trading inputs can be useful to protect equity portfolios.

The intention with this research is to provide more insight into how a discrepancy in the markets can be used to profit from by exploiting the dynamics of VIX derivatives. Further, this thesis is expected to increase the understanding of how trading strategies can be applied and highlight the involved financial risks.

1.5 Contribution

This thesis aims to investigate if trading strategies that exploit VIX term structure behavior has generated abnormal returns during the latest 7 years. By improving the knowledge about this topic of research the authors hope to provide empirical foundation and new perspectives to previous research as this study examines a time period not yet investigated. The time period that this study covers contains interesting events that could have a remarkable effect on the performance on trading strategies trying to profit by utilizing the term structure of VIX futures.

The results from the study could also contribute to further theoretical implications. The rational expectation theory is criticized in this study as the authors see that it fails to explain the price development of VIX index. If the trading strategies tested in this study should generate abnormal returns compared to the benchmark it would mean that the term structure can be exploited as predictor for VIX futures return. If this is the case the study aligns with the results of similar research and contribute with further evidence that the rational expectation theory cannot explain this phenomenon.

Furthermore, theories regarding efficient markets will as well be applied as theoretical implication. The efficient market hypothesis is a debatable subject in the field of finance and is closely related to the theories of rational expectation, stating that market returns is not predictable. Hence the performed hypothesis testing in this research could further contribute in the debate of efficient markets.

The contribution of this study can be relevant for traders and investors that seek to get more knowledge about the dynamics of the VIX index and exchange traded products related to it. Based on the results, the strategies themselves could be an attractive way for people to manage their savings. But most important that the results of the trading strategies could create a clearer picture why and how actively a portfolio dealing with these products must be managed. The practical contribution of the study will therefore be connected to the decision-making progress made by traders and investors that are interested to use these kinds of products.

1.6 Delimitations

To be able to conduct a viable thesis some delimitation will be presented. First off, the strategies presented is solely back tested using products categorized as exchange traded funds. The question of the thesis may seem a bit broad to be answered as one could go deeper into how other products could open up alternative opportunities to generate abnormal returns. Since the purpose of the study is to test strategies similar to other studies but during a different time period, tests of the ETFs abilities on tracking their underlying asset might be taken into consideration. This type of statistical testing is performed in previous studies but given that the purpose of the study is not to measure the performance of the products but rather how it can be used to generate abnormal returns, this will not be investigated. Another delimitation is that no empirical tests will be done on the risk adjusted returns which can affect the credibility of the results. In previous research from Simon and Campassano (2012), they documented how regression test could be performed with the purpose to determine the best hedge ratio for strategies trading VIX futures. The authors in this paper will not perform statistical testing to determine a hedge ratio, but only assume a 0,5-hedge ratio for the back-testing period.

1.7 Disposition

Introduction
In the introduction the authors present the background behind the idea of the research, previous relevant studies, following with a problematization leading to the research purpose. Finally, the contribution of the research and some delimitations are disclosed.

Theoretical Background
In the theoretical background, essential theories and facts of the thesis are presented. In the latter part, a couple of established financial theories is lifted with the purpose to discuss how the practical implications of those can be connected with the final results.

Methodology
The methodology explains the philosophical and theoretical approaches applied in the research and its overall design. Further, approaches regarding the process of literature search can be read. In the final part of the chapter the considerations on ethics and societal aspects are stated.

Research methods
This chapter presents how the process of the quantitative study is performed, how the data is collected and how the strategy is created. Further, the authors present the related hypothesis as well as measurements tools, statistics and empirical tests applied in this study.

Results
This chapter includes the presentation and explanation of statistics and performance measurement. In the following part, the empirical tests of the hypothesis and a disclosure of quality criteria is presented.

Analysis and discussion
This chapter includes interpretation, discussion and analysis of the results presented in the previous chapter. It aims to connect theories and arguments with the empirical findings to answer the study research question.

Conclusion
The last chapter will include a summary of the study where the authors reflect upon the findings, the limitations and suggestions for future studies.

2. Theoretical Background

In the theoretical background, essential theories and facts of the thesis are presented. In the latter part, a couple of established financial theories is lifted with the purpose to discuss how the practical implications of those can be connected with the final results.

2.1 The Dynamics of Volatility in Equity Markets

As mentioned earlier, the historical volatility is calculated as the standard deviation (square root of variance σ^2) on a set of historical prices.

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

Where n is the sample size, x_i is the i^{th} return and $\bar{x}$ is the mean return (Sinclair, 2013 p. 14). Since Black, Scholes and Merton introduced their option-pricing formula, its fundamentals have been essential for modelling options. The formula is calculated based on 7 parameters: current time t, current stock price S, option exercise T, strike K, interest rate r, dividend rate γ, and volatility θ. Since all parameters but volatility θ is directly observable in the financial markets, the volatility can be estimated by backing the Black-Scholes formula (also referred as implied volatility), which can be explained as the market expectations of future volatility at a given strike (Andersen & Brotherton-Ratcliffe, 1997, p.5).

The difference of implied volatility between at-the-money (ATM) options and out/in-the-money (O/ITM) options is traditionally referred to as the volatility-skew. Since the Black-Scholes formula is based on the assumption that stock prices follow a normal distribution of returns (Macroption, 2020), the Black-Scholes model also assume that the implied volatility should be the same across the strike dimension (Ann, 2019). However, studies by Foresi and Wu (2005) proves how OTM call and put options on equity indices, on average exhibits implied volatilities with heavily skewed pattern. A structure where OTM put options tend to be priced with higher implied volatility than OTM call options, a pattern referred as volatility "smirk" (figure 2). Thus, causing OTM put options more expensive than the corresponding OTM call option, implying that the risk-neutral distribution for equity indexes are heavily skewed to the downside (Wu & Foresi, 2005, p.9). Hence, this pricing nature of volatility in equity options corresponds with the inverse relationship between S&P 500 and the VIX index.

Figure 2.

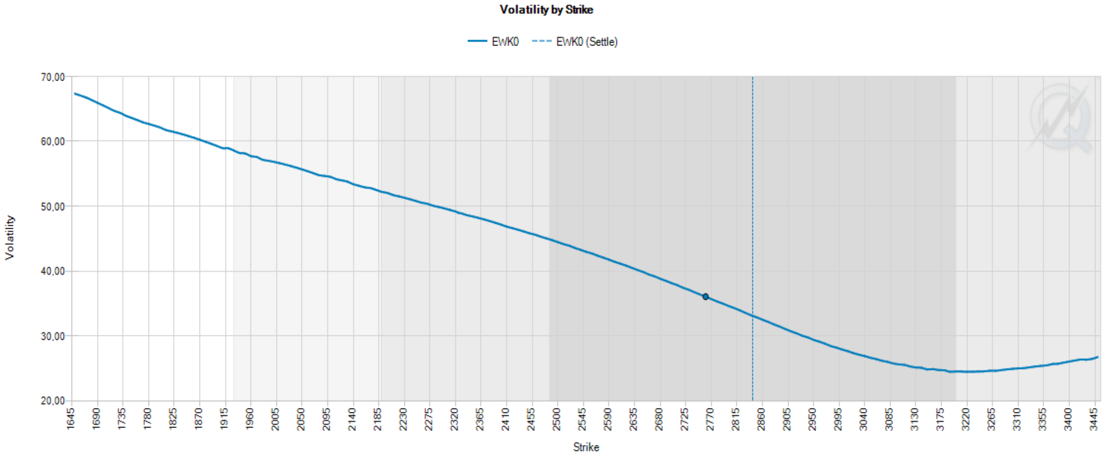


Figure 2. The volatility Skew, "Smirk": Blue line - implied volatility on OTM strikes of S&P 500 options.
Source: CME QuikStrike (2020)

Foresi and Wu (2005) prove that the negative skew on implied volatility over the strike dimension is a natural state for global equity index options. There are however many possible explanations why this asymmetry exists. One explanation is that big jumps in spot prices tend to be down, rather than up. An unexpected significant change in share prices usually occur to the downside since the bad event is usually more unexpected, compared with when good events occur, which usually is less unexpected (Bennett, 2014, p. 187-188). Another explanation is that volatility is a measure of risk and leverage, and leverage increases as equities declines. In a scenario where a company's share price declines (assuming no additional issue in shares or amount of debt) the company's debt/equity ratio increases, hence the company's leverage increase. Therefore, as volatility and leverage are measures of risk, there is a correlation between leverage and volatility as equities decreases (Bennett, 2014, p.187-188).

2.2 The VIX-index

The Cboe VIX-index was first introduced in 1993 with the intentions to measure the market's expectation of 30-day volatility, implied by at-the-money S&P 100 index option prices. Even though the VIX-index has evolved through time, the index became an accepted benchmark for the stock market in United States soon after introduction. The index is often mentioned in financial publications where it usually is more dramatically referred to as the fear gauge (Cboe, 2019).

As mentioned, the Cboe VIX -index has developed during its lifetime. Ten year after Cboe first introduced the index, it was updated with a new way to measure expected volatility which is still actively used in the financial sector. The updated version of the VIX index is based on the S&P 500 Index (SPX), a body for U.S. Equities. The new mechanics of the index became to estimate the expected volatility by aggregating the weighted prices of S&P 500 put and call options for a broad range of exercise prices. In 2014, VIX was upgraded again by including series of S&P 500 options with weekly expiration periods (SPX Weeklies). The SPX weeklies are useful to provide an index that more precisely follow the 30-day target timeframe that the VIX intends to represent (Cboe, 2019).

As the volatility has a strong negative correlation to stock market returns, an opportunity arises to include volatility in an investment portfolio for its diversification properties. In March 2004 Cboe launched the first exchange traded product, the VIX future contract, with the reason of making it more accessible to trade volatility as an asset. Two years later, in 2006, Cboe took it one step further and introduced VIX -options which immediately grew to the most popular new product in Cboe's history. Today, there are several different exchange traded products to use in addition to derivatives as futures and options, such as exchange traded notes and exchange traded fund (Cboe, 2019).

2.3 VIX Term Structure

Just like government bond yields or commodities futures usually is compared over different maturities as a term structure (or yield curve), same can be done with different maturities of VIX futures prices, creating a term structure on all futures maturities (and the spot price). There are two key dynamics of the term structure: contango and backwardation. In contango the longer dated maturities of VIX futures are more expensive than the shorter-term futures and the spot price, illustrating upward sloping curve in figure 3. Most of the time the VIX futures are in contango, but in times of increased risk and volatility in the equity markets VIX futures are usually in backwardation, structured with lower priced long term VIX future price compared to spot price and shorter-term maturities (Bennett, 2014, p.185).

Figure 3.

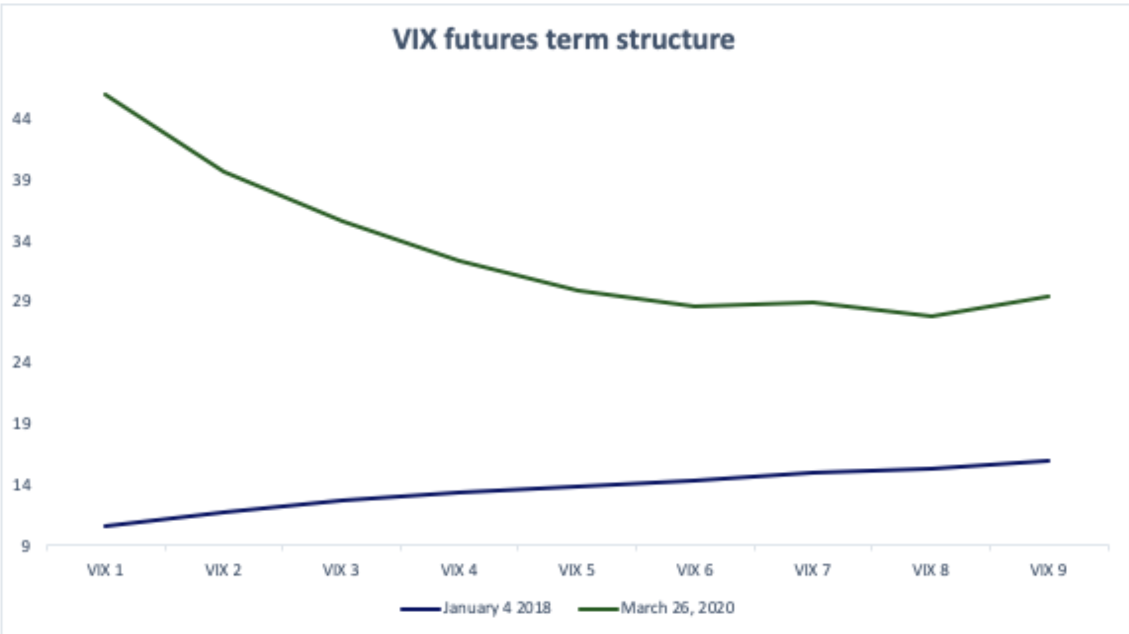


Figure 3. VIX term structure: Blue line - contango, Green line - backwardation. Source: VIX central (2020).

2.4 Long VIX Futures, a Poor Trade

The different dynamics of the VIX term structure problematize a long term buy and hold position in VIX futures, since a VIX future term structure in contango is characterized with a negative carry and roll yield which causes the position to generate negative return over time (Whaley, 2013, p.12-13).

Previous literature where buy-and-hold strategies for VIX ETPs have been evaluated, most have documented that the ETPs is also not a sustainable strategy for investing (illustrated in figure 4). The conclusion drawn is that the investors who lose by taking passive positions on these products have too little knowledge of the product's structure and nature, or act irrationally on the given information (Whaley, 2013, p.18). Various studies have also shown that the buy-and-hold strategy performs worst if one uses ETPs with benchmark to follow VIX short-term future indexes (Whaley, 2013, p.19). The ETPs show particularly poor returns when the term structure is in contango but better returns when the market is in backwardation. It therefore becomes clearer that the return is negatively affected by taking a long position as the market is more often in contango and backwardation happens more seldom (Bennett, 2014, p.184). This creates a demand for more sophisticated trading strategies that can reduce the negative effects of the contango trap. To lead the discussion back to the question of this paper, how the VIX term structure could be utilized to generate abnormal returns, interesting questions arises regarding how the roll yield can be captured in a trading strategy.

Figure 4

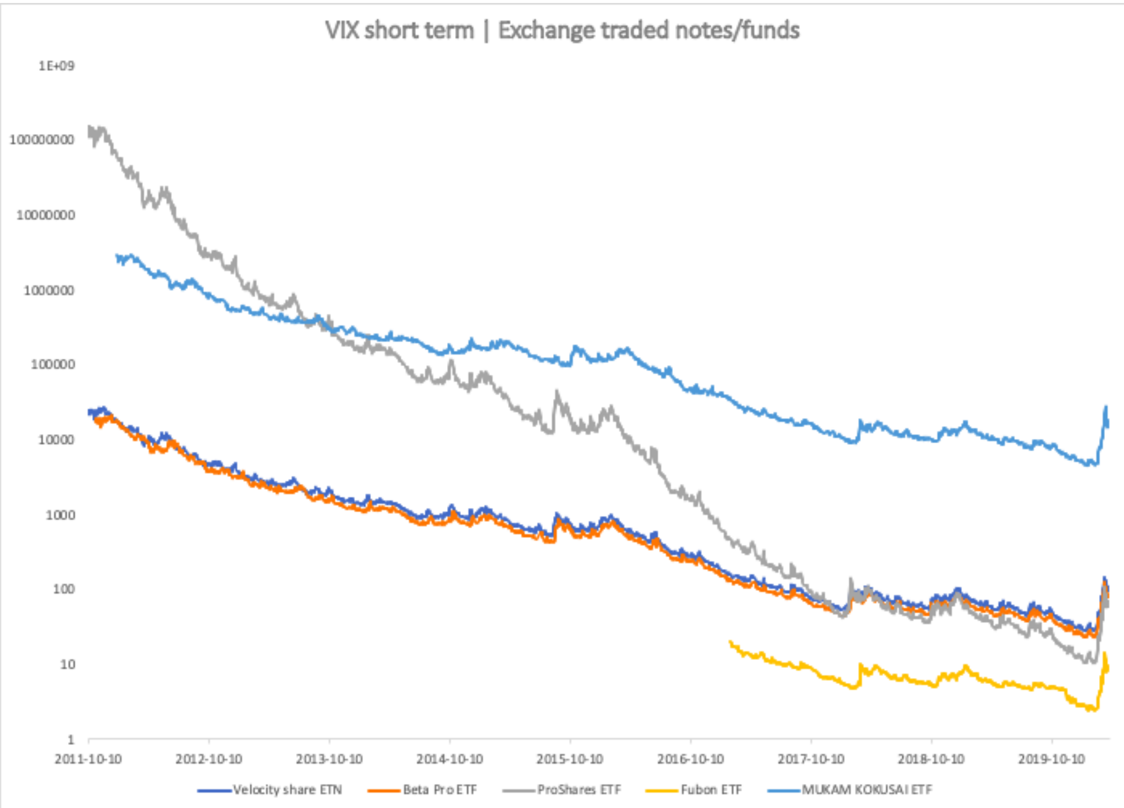


Figure 4. VIX short term ETFs and ETNs
Source: Reuters Eikon (2020)

2.5 Rational Expectation Theory

The rational expectation theory is an economic theory developed by John Muth in 1961, often applied on research analyzing the term structure of interest rates (Deley & Sergi, 2019, p.5). The theory states that expectations will be identical to the optimal forecast using all available information. An important fact to point out with rational expectations is that even though the optimal forecast is based on all available information, a prediction constructed from the forecast does not necessarily need to be perfectly accurate. This theory was developed as a reaction to the objections of previous theories that tried to explain the formation of expectation based from past experience only (Madura, 2014, p.135).

Two reasons why an expectation fail to be rational would be that people might be unaware of information that would have an effect on the future outcome and/or that people are aware of all information but do not want to make the effort to make their expectation the best guess of the future. To avoid confusion, it is also worth mentioning that if important information that could have an effect on the outcome is unavailable the prediction may fail to be accurate but the expectation would still be considered rational as it takes account to all information available (Madura, 2014, p.136).

Applying this theory to the prices of VIX futures it suggests that the prices of the VIX futures are unbiased predictors of the future VIX index spot prices. The slope of the VIX term structure should therefore forecast the progress of the VIX spot index itself (Bordonado & Samdal, 2016, p.21). However, research by Nossman and Wilhelmsson (2009) proves how the expectation hypothesis on VIX futures can strongly be rejected and that VIX futures prices constantly overestimates realized volatility (VIX spot) (Nossman and Wilhelmsson, 2009, p.65). The research by Campassano and Simon (2012) further confirms this rejection of the rational expectation hypothesis. They present evidence that the term structure can be used as a predictor for the VIX futures. That is, if the VIX futures trades above the VIX spot, the futures tend to fall, and if the futures trades below the spot, the futures tend to raise. The rational expectation hypothesis should contradict this evidence. Stating that future prices is an unbiased predictor of the future value of spot (VIX spot should progress according to the slope of the term structure), and if this was true the basis would not have predictive power (Sinclair, 2013, p.225). Furthermore, according to Simon and Campassano (2012), the characteristics of the term structure suggests that longer dated expiration of VIX futures discounts for a risk premia, and that VIX futures prices tend to roll down during contango and roll up during backwardation, causing a negative (positive) carry of term premia in contango (backwardation). The evidence can explain the historically poor performance of long VIX futures positions (Campassano & Simon, 2012, p.21)

The term structure itself could be explained by the fact that investors are risk averse and that they are likely to pay a premium for VIX exposure. This premium could represent an insurance against losses in the equity market. Additionally, Nossman and Wilhelmsson (2009) presents evidence that the hypothesis cannot longer be rejected if the VIX futures prices is adjusted for a risk premium. In fact, Nossman and Wilhelmsson presents evidence indicating that VIX futures prices, when adjusted for risk premium to be a good predictor of the VIX index spot prices (Nossman and Wilhelmsson, 2009, p.65).

2.6 Efficient Market Hypothesis

In 1970, Eugene Fama introduced the hypothesis of efficient market which states that prices of financial assets, at some point, fully reflect all available information. This hypothesis points out that prices trades at an equilibrium which is an effect of every market participant having the same available information. The price equilibrium only moves on new available information which per definition is an unpredicted event. Therefore, prices in capital markets is unpredictable and abnormal return shouldn't be possible. This leads to the essential argument of the efficient market hypothesis, that prices in financial markets follows a random walk (Bodie, Kane & Marcus, 2014, p.351-352).

In Famas work on efficient markets in 1970, he further introduces three versions of the hypothesis, which represents versions of the theory in context with what type of information is considered: weak-form, semi strong-form and strong-form. The weak form suggests that all historic information that can be derived from market data (such as historical prices and trading volume) is reflected in the market price. Hence, strategies based on historical market data that is reliable for predicting prices should already be known and exploited between all market participants. Consequently, the strategy loses its predictive value since prices trades immediately at its fair value and the strategy will no longer be able to predict future price changes. The semi strong-form states that all information available in the market is reflected in prices. That is, in addition to historic market data, all fundamental information as well, such as balance sheet, patents held, earning forecasts and management. The strong form of efficient market hypothesis states that all form of information is reflected in prices, including information not available to the public, this version of the hypothesis suggests that insider trading is a reflection of price equilibrium. (Bodie, Kane & Marcus, 2014, p.353-354)

According to Bodie, Kane and Marcus (2014), the efficient market hypothesis is a highly debatable subject in the academic and industry of finance. Even though the efficient market hypothesis is a widely accepted subject among scholars, there is still several studies rejecting it. Examples of such studies that provide proofs of variables being able to predict market returns have been documented by Fama and French in 1988, concluding that higher dividend yield ratio can predict higher market return. Furthermore, a study by Campbell and Shiller shows how earning yields as well can predict market returns. A study done by Keim and Stambaugh proved that yield spreads between high- and low grades corporate bonds could predict stock market returns (Bodie, Kane & Marcus, 2014, p.365-366). Yet, the contradictory argument is that the interpretation of these results is difficult, and the results is not an indication of a capturing of abnormal risk-adjusted return, but rather an prediction of risk premium, hence the hypothesis of efficient markets cannot be rejected (Bodie, Kane & Marcus, 2014, p.362-366).

2.7 Trading based on the VIX term structure

Campassano and Simon (2012) introduced a trading strategy with the purpose to capitalize based on the fact that the rational expectation hypothesis can be strongly rejected on VIX futures. This was done by trading VIX futures, aiming to capitalize on the up and down roll of VIX futures positions. The trading strategy involves shorting the front month future contract when the VIX term structure is in contango and buying the future contract when the term structure is in backwardation. Both of these positions are exposed for unfavorable movements of the VIX futures prices; thus, this risk is hedged by taking position of S&P futures. A short position in VIX futures are matched with shorting S&P futures and long VIX futures are matched with long S&P futures. This hedging technique is based on the tendency that VIX future prices and S&P futures returns move inversely and thereupon the capitalization is essentially a collection of roll yield. Additionally, Bordonado and Samdal (2016) presents evidence that VIX ETP follow VIX future indices quite well and proved that approaches of adopting similar strategies as Campassano and Simon (2012) could be done for trading VIX ETFs.

3. Methodology

The methodology explains the philosophical and theoretical approaches applied in the research and its overall design. Further, approaches regarding the process of literature search can be read. In the final part of the chapter the considerations on ethics and societal aspects are stated.

3.1 Research philosophy

When defining the term research philosophy, it refers to different beliefs and assumptions regarding the development of knowledge. Throughout a study the author will make different types of assumptions, consciously or not. These assumptions include how the authors perceive human knowledge (epistemology), and reality (ontology). These assumptions will have an impact on how the authors shape the research, thus create a deeper understanding of how to approach the research question, what method to use and how to interpret the results (Saunders, 2009, p.124).

3.2 Ontology

Ontology is the knowledge regarding existence and relates to the nature of reality, thus what exists and how one perceives it (Burrell and Morgan, 1979, cited in Holden & Lynch, 2004, p.5). The concept can be divided into two different configurations, constructivism and objectivism. The two configurations have opposite views on how social entities should be perceived. Objectivism is the ontological position that describes that the existence of social phenomenon is independent of social actors, while constructivism describes social phenomenon as something being created by the influence of social actors (Saunders, 2009, p.596) (Saunders, 2009, p.111)

As the purpose of this study is to find out whether the dynamics of the term structure of VIX futures can be exploited for an abnormal return the authors have chosen to adopt an objective perspective. The argument for this is that a constructionist perspective would emphasize more on the behavior of the individuals that the market consists of to answer the research question. An objectivistic approach focuses more on the solid objects that are measurable which the authors believe is more suitable for the purpose of this study.

3.3 Epistemology

Epistemology involves the assumptions about knowledge that covers how to establish acceptable and valid knowledge and how to communicate it to others (Saunders, 2009, p.112). Positivism and interpretivism are the two branches mostly used in the context of social science. There are considerable differences between these philosophies. Interpretivism highlights a reality that is socially constructed and focuses on social phenomenon and subjective meanings to conform human interest into the study (Collis & Hussey, 2014, p.44). Positivism, on the other hand, states that only objective observations can be the basis for credible data, which makes causality and law like generalizations a central part of the philosophy. This is achieved by accessing quantitatively measurable observations that can be statistically tested (Saunders, 2009, p.113).

The epistemological matters are often associated with the ontological approach and therefore the authors believe that a positivistic research should be adopted to answer the research question of the study. With the knowledge that secondary data in the form of historical prices can be used to back test different strategies matches with the philosophical assumptions of the authors that the research question should be answered through quantifiable observation that leads to statistical tests.

3.4 Research strategy and methodological choice

A research strategy can be explained as a step-by-step plan that tries to explain the systematic way of conducting a research, often connected to the methodological choice of the researcher. The theory that tries to explain how research should be conducted is called methodology (Saunders, 2009, p.3). The research strategy is often dependent on the choice of methodology, which itself often is connected to the ontological and epistemological assumptions made by the researcher (Holden & Lynch, 2015, p.3).

The research strategy can be divided into two different branches, qualitative and quantitative research (Bryman & Bell, 2017, p.58). Qualitative research is based on non-numeric data where the data may be produced by the researcher in the form of fieldnotes, while quantitative research is based on data that can be gathered through a quantifiable measurement process (Neuman, 2014, p.17). The qualitative methodology strives to construct a social reality by emphasizing on themes and patterns of the data collected (Collis & Hussey, 2014, p.10). In contrast, the quantitative approach uses quantitative data to do statistical tests to be able to analyze it (Collis & Hussey, 2014, p.6). As this study depends on the back testing of trading strategies, using price history of different financial products, the authors believe that a quantitative methodology is best suited for the study.

3.5 Research Approach

The research approach can be divided into two different categories, inductive and deductive (Bryman & Bell, 2017, p.23). The inductive approach aims to create new theories by exploring data, generalizing from the specific to the general and generate untested conclusions. The deductive approach focuses on constructing theoretical or conceptual frameworks to test data, generalizing from the general to the specific (Saunders, 2009, p.145). This study is created as a response to previous similar studies that have conducted their research with a deductive approach. Because the authors have chosen to statistically test their results with hypotheses based on pre-existing theories, a deductive approach will be applied to this research. A deduction process is presented by Bryman (2012) and will be used as guidance for this study. The process starts with presenting theories to be able to create different hypothesis that later will be statistically tested. To be able to perform the tests, data will be collected. The findings will be tested and presented to get empirical evidence to confirm or reject the hypotheses. Lastly there will be a revision of the theories.

3.6 Research Design

When discussing research design in sense of data collection time dimension needs to be taken into account. There are two ways to incorporate time, cross-sectionally and longitudinally. What differs these main types of data collection is that cross sectional research gathers data in one time point with attempt to show what a social context looks like, while longitudinal research collects data for more than one time point when trying to explain a social context. Time-series data is a type of longitudinal study that enables the researchers to observe the movements of the features of a unit over time, by collecting data across multiple time points (Neuman, 2014, p.44). As this study aims to gather price history for different financial products to investigate the profitability of trading strategies based on price movements from one time period to another, the study is based on time-series data.

This subchapter will also specify how this research is classified regarding research purpose. There are three types of research purpose classifications: exploratory, explanatory and descriptive. The purpose of exploratory research is to investigate a new issue to find new perspectives and ways to assess a specific phenomenon. The primary purpose of explanatory research is to ask the question why different social phenomenon occur and to investigate theories to strengthen the assumption (Neuman, 2014, p.40). Descriptive research aims to create a more clearly defined picture of an issue or problem by describing various aspects of the phenomenon. Descriptive research focuses to answer "how" and "who" questions. In a descriptive research the researcher only observes and measures variables instead of controlling and manipulating them (Neuman, 2014, p.38-39).

In this study the purpose is to answer the research question: *"How can the term structure dynamics of VIX futures be exploited for abnormal returns".* As this study poses a "how" question and the authors tries to answer it by observing and measuring historical phenomenon the study is classified as a descriptive research. In order to answer this question, there is also an ongoing discussion of what causes the conditions that are necessary for the trading strategies to be profitable. This "what" question will be investigated by analyzing theories and also discussing the theoretical implications of the study results.

3.7 Literature search and source criticism

The literature search process should be performed thoroughly and therefore it should rely on careful reading of journals, books and reports (Bryman, 2012, p. 113). According to Bryman (2012, p. 115) it is important that the search for literature should be conducted by using trustworthy sources and databases. Bryman also includes a figure (figure 5) in the book that will be used as a guideline for the literature search in this study (Bryman, 2012, p. 119).

Figure 5.

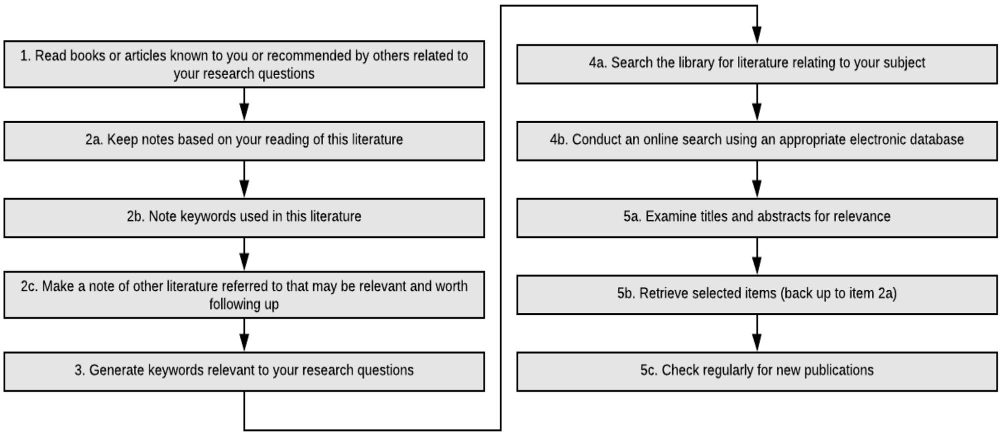


Figure 5. The literature search process
Source: Bryman, 2012, p. 119

By using this process map as a guideline, the authors have aimed to use trustworthy databases and sources. The authors have had access to the database platform of UB through Umeå University where most of the literature search for literature has been made. Given full access to the UB database platform includes the possibility to browse different databases which gives the authors good conditions to find useful material. The information found in library databases is either originally created or comes from different, reliable sources. The study is based on academic articles that have undergone a peer review process. In addition, databases provide all the information that makes it possible to evaluate a source for credibility. The authors have tried to retrieve information from its primary source and refer to it accordingly.

3.8 Ethical and societal considerations

When conducting a research and presenting results it may be relevant to consider what moral values and principles that the study should follow. These principles create a base for a code of conduct that dictates how a study should be conducted (Collis & Hussey, 2014, p.30). This study is a quantitative study that uses data collected from the database platform Eikon by Refinitiv. This method of collecting data excludes this study from important ethical aspects such as anonymity, confidentiality, personal information and other data protection acts that could have been affected if data would have been collected through other methods. The literature that has been collected for the purpose of the study such as books, journals and research articles have been referenced by using the Harvard referencing system, following the guidelines provided by Umeå School of Business and Economics.

As this study aims to test different test of different trading strategies, the authors also want to clarify that the results of the study should not be viewed as financial advice for future investments, only as research based on historical data that will help to increase knowledge in the subject of finance. In addition, the authors strive as far as possible to conduct honest and transparent research by presenting a complete research process to prevent deliberate and unintentional misrepresentation.

4. Research Methods

This chapter presents how the process of the quantitative study is performed, how the data is collected and how the strategy is created. Further, the authors present the related hypothesis as well as measurements tools, statistics and empirical tests applied in this study.

4.1 Data

The data used for each strategy is collected from the database platform Eikon by Refinitiv, formerly Thomas Reuters Financial & Risk. The sample includes daily opening prices of the VIX index and the daily opening prices of the VIX futures with one month to maturity. The VIX futures are issued by the Chicago Board of Exchange (CBOE). The price history of the index and future prices will primarily be used to be able to interpret the historical term structure of the products. The sample includes the price history of the period, October 11th, 2011 to March 31th, 2020. The datasets for the derivatives consist of 2134 data points each, a number representing the number of days included.

The sample also includes price history of closing and opening prices of three different exchange traded funds, Proshares VIX Short-Term Futures ETF (VIXY), Proshares Short VIX Short-Term Futures ETF (SVXY) and SPDR S&P 500 ETF Trust (SPY). Proshares VIX Short-Term Futures ETF (VIXY) is an ETF that provide long position on the S&P 500 VIX Short-Term Futures Index which suits investors trying to gain profit from an increase of the expected volatility of the S&P 500, calculated from the prices of VIX futures contracts. The S&P 500 VIX Short-Term Futures Index measures the returns of a portfolio that consists of monthly VIX futures contracts that on a daily basis rolls positions from first-month future contracts to second-month contracts (Proshares.com, 2020a). In contrast to VIXY, Proshares Short VIX Short-Term Futures ETF (SVXY) is an ETF that provides inverse exposure to the S&P 500 VIX Short-Term Futures Index. This product is designed for investors trying to gain profit from a decrease of the expected volatility of the S&P 500 (Proshares.com, 2020b). SPDR S&P 500 ETF Trust (SPY) is an index fund that tries to correlate with the prices and return performance of S&P 500 (Ssga.com, 2020). The data gathered of these products also covers the period October 11th, 2011 to March 31th, 2020.

Figure 6 show the price history of the different products during the period October 11th, 2011 to March 31th, 2020. A noticeable observation is the Short VIX Short-Term Futures ETF prices that dropped significantly in the beginning of 2018. This event is previously mentioned and referred to as the Volmageddon.

Figure 6.

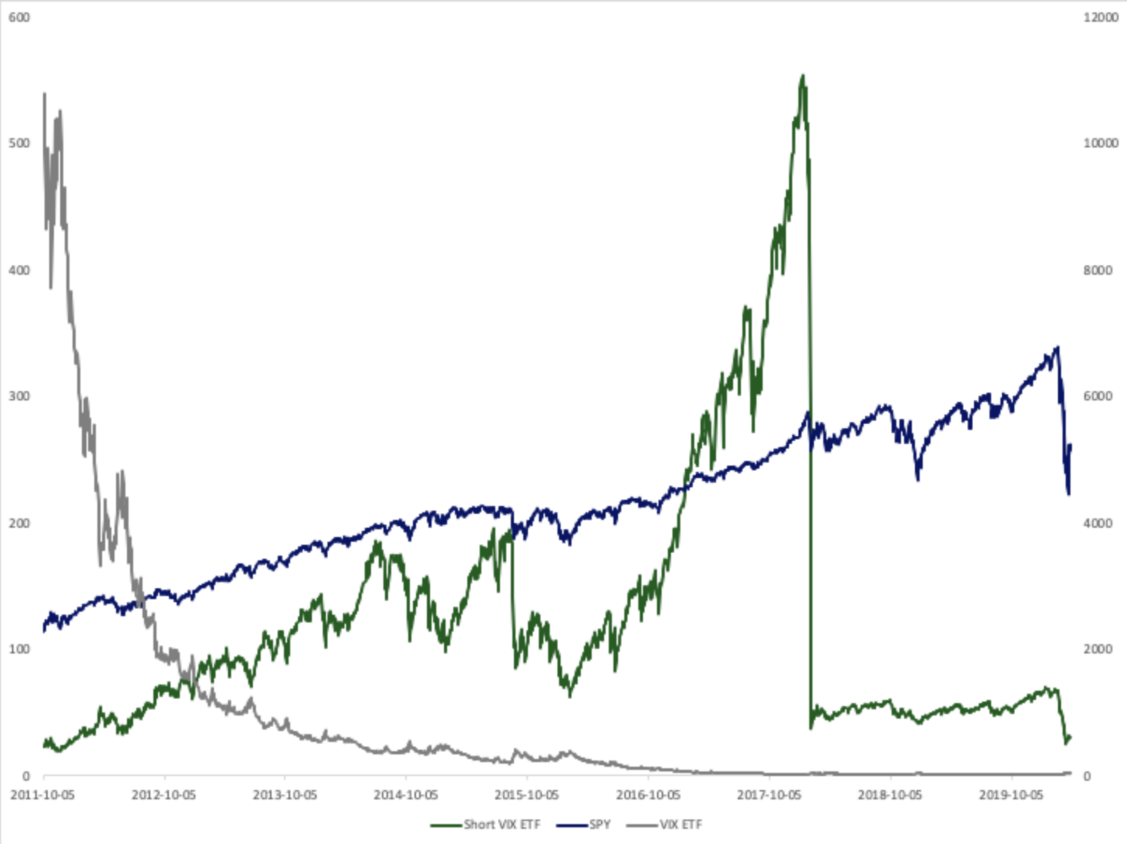


Figure 6. Sample data ETFs: Green line - SVXY, Grey line - VIXY, Blue line - SPY. Source: Reuters Eikon (2020).

4.2 The Trading Strategies

As mentioned previously, the trading strategies that are being tested in this study are based on a similar strategy performed by Simon and Campassano (2012) but differentiate in a few inputs and data points. The authors will introduce three different trading strategies. The first strategy consists purely of long and short VIX positions, which will be called "Long Short VIX" (LSV). In order to only collect the roll yield and hedge the long-short VIX strategy, a second strategy is created consisting of long and short VIX positions, but additionally adds a hedge of long or short exposure to the S&P 500. This strategy will be called "Hedged Long Short VIX" (HLSV). The last strategy to be introduced will be called "Long SPY Long VIX" (LSLV). LSLV is created with the purpose to investigate how the VIX term structure can be used as protection for an equity portfolio. This strategy consists of a buy and hold portfolio of long S&P 500 exposure but will be switching towards long VIX exposure during times of backwardation. The reason to allocate VIX exposure as protection during backwardation is that backwardation in the VIX term structure corresponds with high VIX prices and falling equity prices (Sinclair, 2013, p. 185).

As mentioned in previous sections, the back tested trading strategies will solely assume to trade various ETFs with the consideration of Bordonado and Samdal (2016) proof of using ETFs as a complement instead of directly trading VIX futures. Hence, for exposure to long VIX positions the VIXY ETF is used, and for short VIX positions, the SVXY

ETF is used. For exposure towards the S&P 500 long and short positions, the SPY ETF will be used.

The first step of the strategy is to create an indicator for buy and sell signals when the VIX term structure is either in contango or backwardation for period t. Going forward, this indicator will be called “the basis” (B_t), and is calculated:

$$B_t = \frac{VIX_1}{VIX_{Spot}} - 1$$

Where, VIX_{Spot}= Spot VIX opening price and VIX_1= front VIX futures opening price. If B_t < 0 there's an indication the VIX term structure is in backwardation, and B_t> 0 the VIX term structure is in contango.

All strategies are created using Microsoft Excel and each of the three trading systems is illustrated as a separate flow chart in Figure 7, 8 and 9. The strategies is created by using time series of historical opening prices. Since a new position is assumed taken during the market opening, the return for day t (R_t) is calculated between the opening price of asset x at $t-1$ (P_{t-1}^{open}) and the opening price of asset x at t (P_t^{open}).

$$R_t = \frac{P_t^{open}}{P_{t-1}^{open}} - 1$$

Every trade is also adjusted for brokerage fee and slippage and the position is continuously assumed paying for management fees.

$$R_t - brokerage\ fee\ -\ slippage\ -\ management\ fee$$

All fees for ETFs are usually low but should still be accounted for since transaction costs can have significant effect on the return. The brokerage fee is assumed at 0,15% which is a common commission for ETFs (Nordnet, 2020). The cost of slippage is assumed at 0,04% which is based on the historical average spread between bid and ask prices (ETF.com, 2020). The management fee is at 0,85% annually (ETF.com, 2020).

At the beginning of each trading day, the trader calculates the basis. If the basis signals backwardation, LSV strategy enters a long position in VIXY at the market open, if a long VIXY position already is open, the trader proceeds to the next day without any execution. If the basis is in contango at the beginning of the trading day, a long SVXY position is entered at the market open, unless a long SVXY position is already open. The HLSV strategy follows the same system but allocates a 50% long SPY position if the basis signals backwardation and a 50% short SPY position if the basis signals contango. The SPY positions are used as hedges for VIXY/SVXY exposure. The LSLV strategy follows the same approach except it continuously holds a 100% long SPY position if the basis signals contango and a 25% long VIXY plus 75% long SPY position if the basis is signaling backwardation.

Figure 7.

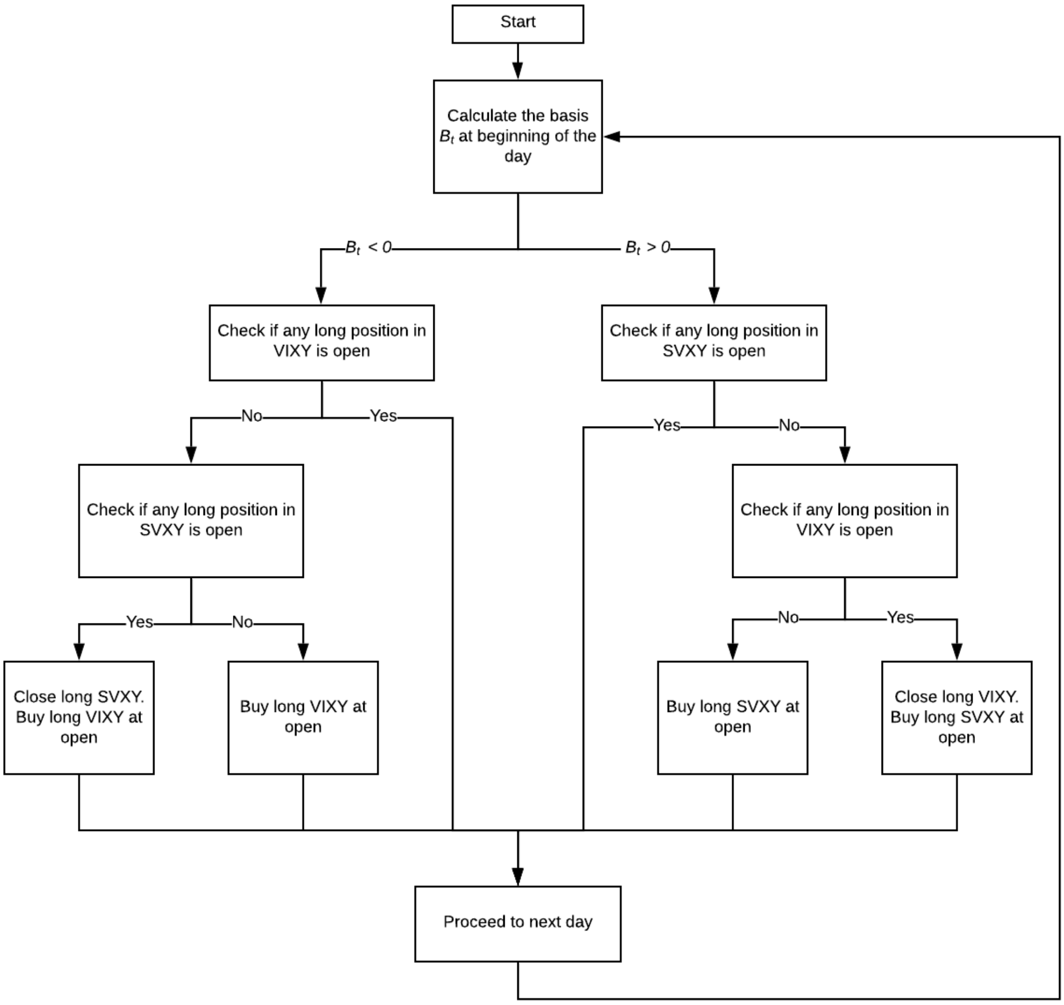


Figure 7. LSV trading strategy.

Figure 8.

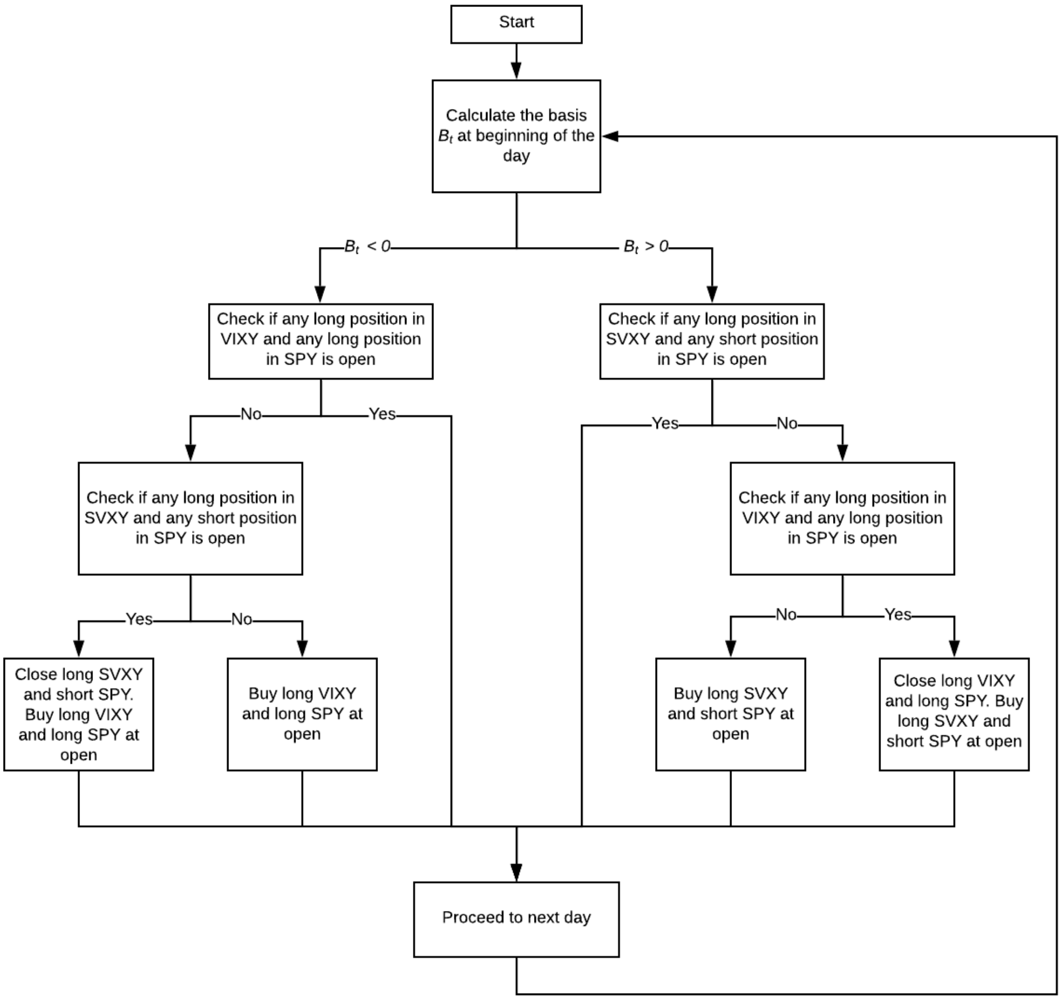


Figure 8. HLSV trading strategy

Figure 9.

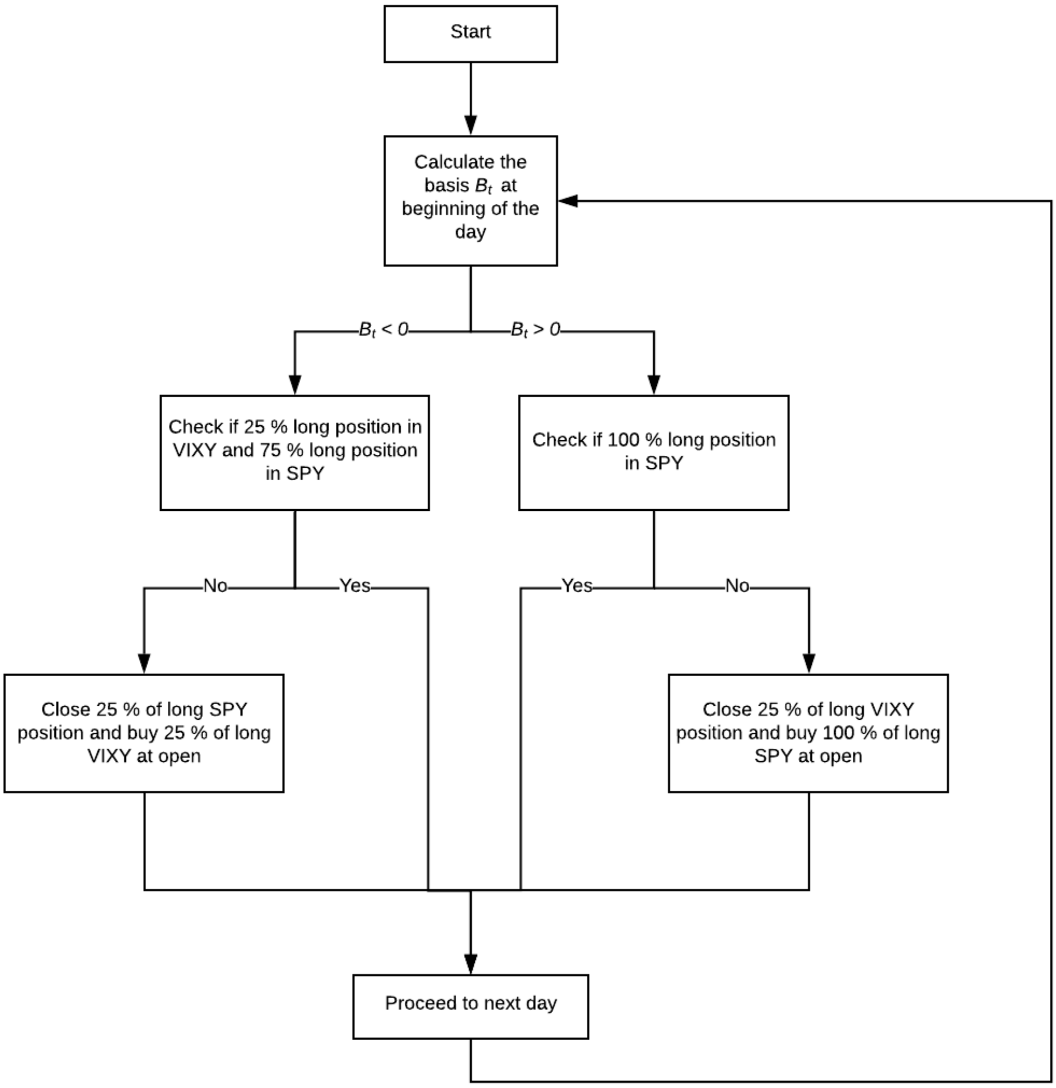


Figure 9. The LSLV strategy.

4.3 Performance Measurements

In order to accurately measure each strategy performance, several different approaches can be used. With the reason to only measure total returns without adjusting for the risk of strategy s, the average annualized geometric return (GeR_s) will be considered between beginning of each year portfolio value ($PV_{t,beginning}$) and each year ending portfolio value ($PV_{t,ending}$).

$$GeR_s = \frac{1}{T}\sum_{t=1}^{T} log(\frac{PV_{t,ending}}{PV_{t,beginning}})$$

To measure a strategy performance with adjusting returns on risk, the Sharpe ratios is a widely used measurement for this purpose. To calculate the Sharpe ratio the average excess return for strategy s, $\overline{ER}_s$ is divided by the risk (or volatility), where the volatility is defined as the strategy's σ_s.

$$Sharpe_s = \frac{\overline{ER}_s}{\sigma_s}$$

$\overline{ER}_s$ is calculated by the following formula:

$$\overline{ER}_s = \frac{1}{T}\sum_{t=1}^{T} R_{t,s} - R_f$$

$R_{t,s}$= strategy s return at t, R_f= risk free rate and T= number of returns. σ_s is calculated:

$$\sigma_s = \sqrt{\frac{\sum_{t=1}^{T}(R_{t,s} - \bar{R}_s)^2}{T-1}}$$

$\bar{R}_s$= strategy s average return. A Sharpe ratio that is calculated using daily data should be annualized in order to accurately be comparable with other assets Sharpe ratios, this is because the Sharpe ratio is not independent over the time period it is measured (Sharpe, 1994). However, regarding the assumption that return follows a normal distribution, volatility theoretically scales with the square root of time. Hence, the annualized Sharpe ratio is calculated by multiplying the ratio with the square root of trading days in a year (usually 252) (Harwood, 2019).

$$Annualized\ Sharpe_s = \frac{\overline{ER}_s}{\sigma_s}\sqrt{252}$$

According to Bennett (2014), the standard deviation is a good measurement of risk only if the return is normally distributed. Since return seldom is normally distributed the Sharpe ratio is a tool with some limitations (Bennett, 2014, p 269). If a strategy yields returns that is skewed to the upside, which usually is preferred by the trader, the standard deviation as a denominator increases from the outliers of positive returns, which results in a declining Sharpe ratio (Rollinger & Hoffman, 2020, p.3). Hence, it is intuitively for a trader to also consider the downside volatility. Regarding the issue that returns has a skewed distribution there is no perfect measure of risk. This is further emphasized by Bennett (2014) as he highlights this problem and the importance of using several measures of risk.

Another commonly used risk-adjusted ratio was introduced in 1980 by Dr. Frank Sortino. This ratio is a modified version of the Sharpe ratio but only accounts for the downside risk and is calculated by following the formula:

$$Sortino_s = \frac{\bar{R}_s - TR}{TDD_s}$$

Where TR is the targeted return. The targeted return is traditionally set as zero or as the risk-free rate (Bennett, 2014, p.269). TDD is the targeted downside deviation, calculated as (Rollinger & Hoffman, 2020, p.3):

$$TDD_s = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(min(0, R_{t,s} - TR))^2}$$

Another ratio to measure risk-adjusted return is the Calmar ratio. This is defined as the average return divided by the historically maximum drawdown. According to Sinclair (20214) a Calmar ratio of 1 is considered to be a good benchmark and can be a useful rule of thumb, that is, if the trader expects x percent return the trader should expect x percent amount of drawdown (Sinclair, 2014, p. 174). This investigation will consider a Calmar ratio calculated as:

$$Calmar_s = \frac{GeR_s}{Drawdown_s} \times -1$$

Where $Drawdown_s$ is the historical maximum daily drawdown for strategy s.

4.4 Abnormal Returns

Abnormal returns are traditionally defined as the difference between the expected return and the actual returns. In order to test whether a strategy generates abnormal returns, expected returns must first be defined. In stock market trading or investing, the expected return is often referred to as the return of a broad stock market index such as the Dow-Jones Industrial or S&P 500. If a strategy has a positive difference between the benchmark index return, the strategy outperforms the index and is considered to be generating abnormal returns (Bodie, Kane, & Marcus, 2014, p 359).

With the purpose to compare each strategy performance with a benchmark and investigate if the strategies have generated abnormal returns, the return of the S&P 500 ETF (SPY) will be considered. Although the strategies created in this research is not directly trading stocks, the SPY can still be seen as a suitable comparison since the strategies is indirectly trading the volatility of stock prices. Thus, the results of the tests aim to reflect the profitability of trading volatility compared to a buy-and-hold investment of stocks.

4.5 Empirical Tests

The purpose with this thesis is to investigate whether trading strategies exploiting the VIX term structure have generated abnormal returns. In order to answer this, three different two-sample t-tests will be performed on the back tested return, retrieved from the defined strategies in section 3.2. T-tests is commonly used in statistics and econometrics with the purpose to test if there is a significant difference between two means based on a null and an alternative hypothesis (The Minitab Blog, 2016). The tested hypothesis is defined as:

$$H_o: \textit{Difference in means is not greater than zero}$$
$$H_1: \textit{Difference in means is greater than zero}$$

The two-sample t-test will be performed assuming unequal variances and the t-test is calculated:

$$t = \frac{\bar{R}_1 - \bar{R}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where n_1 and n_2 is the sample sizes and s_1^2 and s_2^2 is the estimated variances and calculated as:

$$s_1^2 = \frac{\sum_{t=1}^{n_1}(R_{t,1} - \bar{R}_1)^2}{n_1 - 1}$$

$$s_2^2 = \frac{\sum_{t=1}^{n_2}(R_{t,2} - \bar{R}_2)^2}{n_2 - 1}$$

One of the underlying assumptions when performing a two-sample t-test is that the sampled data follows a normal distribution. Before performing the t-test, the sample should therefore be tested for normality (Moore, McCabe, Alwan, Craig & Duckworth, 2011, p.419-420). In this research a Shapiro-Francia test for normality will be performed with the defined hypothesis as:

$$H_o: \textit{The sample is normally distributed}$$
$$H_1: \textit{The sample is not normally distributed}$$

To further investigate the normality of the sampled data under the same hypothesis, test will be performed on skewness and kurtosis. Skewness is measurement on the amount of asymmetry a distribution consists with. A normal distribution is characterized with a mean equal to the mode and the median so that both sides of the distributions have the same lengths and thickness (Jain, 2018). The skewness calculation is:

$$Skew = average\left[\frac{(R_{t,s} - \bar{R}_s)^3}{s_s^3}\right]$$

A result close to zero indicates a normal distribution with no skew and an increasing result indicates skewness of the data (Bodie, Kane, & Marcus, 2014, p.138). In addition, the kurtosis is a measure of the degree of fat tails that exists under the distribution. A normal distributed data is characterized with light tails and few outliers. The kurtosis test is performed under the same hypothesis as the skewness test and the Shapiro-Francia test. The kurtosis is calculated as:

$$Kurtosis = average\left[\frac{(R_{t,s} - \bar{R}_s)^4}{s_s^4}\right] - 3$$

A kurtosis results close to zero indicates a normal distribution and an increasing kurtosis is an indication of fat tails and rejects the null hypothesis of normally distributed data (Bodie, Kane, & Marcus, 2014, p.139).

4.6 Bootstrapping

According to Malkiel and Saha (2005) financial data do not follow a normal distribution. In order to statistically test the average value of the return, the data collected for the research needs to be adjusted if it is not normally distributed. To solve this problem, the authors adjust the data using the statistical method called bootstrapping. Bootstrapping is a resampling method that means that you generate new data points using the ones that already exist. Each resample that is made on the original sample with replacement is called a bootstrap sample. The bootstrap samples can be evaluated statistically and from this evaluation you can create a sampling distribution to make further statistical inference.

The resampling is done by taking a sample from a population with sample size n. Make a new random re-sample of the original sample data and calculate a statistic (such as the sample mean $\hat{X}$) of each re-sample. This is replicated B number of times, creating a sampling distribution of the B number of resamples. Based on the theorem of the law of large numbers, when $B \to \infty$, the sample mean $\hat{X}$gets closer to the true mean of the population μ. Thus, these bootstrap statistics can be used as statistical inference for a population parameter θ (Yen, 2019).

5. Results

This chapter includes the presentation and explanation of statistics and performance measurement. In the following part the empirical tests of the hypothesis and a disclosure of quality criteria is presented.

5.1 Strategy Performance

From the results of the conducted back tests of each trading strategy, an overview of the historic performance can be summarized in table 1. The first row shows the average annual geometric return GeR_s. During the period 11-oct-2011 to 31-mar-2020 the LSV strategy have performed best with an average annual GeR_s of 71%, second best is the HLSV strategy with 59% average annual GeR_s, and the third best performing strategy measured in absolute return is LSLV, printing a 20% average annual GeR_s. The benchmark portfolio of buy and hold SPY ETF has had an average annual GeR_s of 10%, leaving the results of all three created strategies outperforming the benchmark portfolio, measured in average annual GeR_s. This conclusion can be visualized in figure 10 which represents the logarithmic portfolio value for each strategy during the back tested period.

Table 1.

	LSV	*HLSV*	*LSLV*	*SPY*
Average Annual Geometric Return	71%	59%	20%	10%
Annualized Downside Vol	69%	36%	14%	18%
Annualized Vol	68%	37%	15%	16%
Max draw down	-27%	-14%	-9%	-11%
Annualized Sharpe Ratio	1,44	1,11	1,49	0,66
Annualized Sortino Ratio	1,42	1,13	1,57	0,59
Calmar ratio	2,63	4,34	2,32	0,88

Table 1. Performance statistics.

Figure 10.

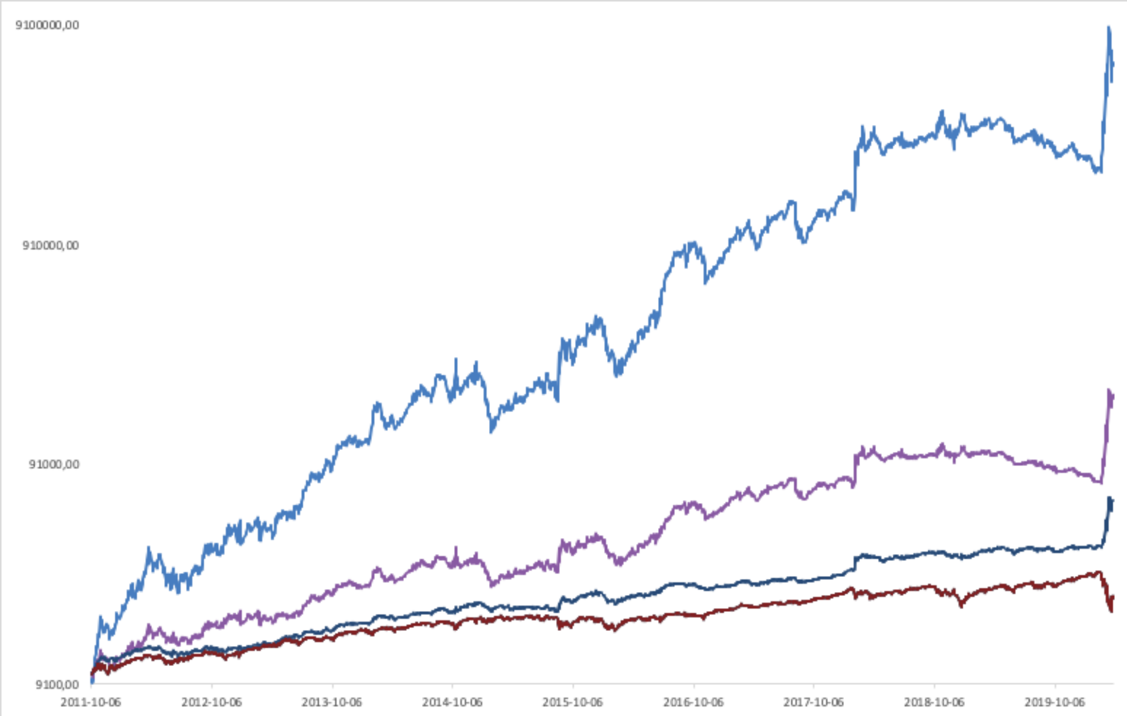


Figure 10. Portfolio value: Light blue line - log LSV, Purple - log HLSV, Dark blue - log LSLV, Red - log SPY.

In order to further examine each strategy's past performance, the annualized volatility, annualized downside volatility and maximum drawdown was calculated in row two, three and four which is a representation of the realized risk. As the LSV strategy have generated highest realized return, it consequently has traded with the highest amount of risk at a 68% annualized volatility, 69% annualized downside volatility and a maximum drawdown of -27%. The HLSV strategy have traded with approximately half the risk with annualized volatility at 37% and annualized downside volatility at 36% and a maximum drawdown at -14%. During the back tested period the LSLV strategy have had an annualized volatility at 15% and an annualized downside volatility at 14% plus a max drawdown of -9%, meanwhile the SPY portfolio has had slightly higher annualized downside volatility of 18% and a total annualized volatility of 24% and a maximum drawdown of -11%. Notable to point out is that the LSLV strategy traded with the lowest downside volatility, total volatility and maximum drawdown.

With the purpose to compare each strategy return adjusted for the risk, the annualized Sortino, Calmar and Sharpe ratios was calculated. Looking at the Sharpe ratio, the LSLV strategy is historically the best performing strategy with a ratio printing 1,49, second best is the LSV strategy at 1,44 and third best is the HLSV strategy at 1,11. Comparing all strategy with the benchmark portfolio SPY, all trading strategies have had definite higher risk-adjusted returns measured with Sharpe ratio.

However, with the reason to adjust return to the downside risk, the Sortino ratio was calculated. The results differentiated to some extent compared with Sharpe ratios, where the LSLV strategy and the HLSV strategy had higher Sortino ratio at 1,57 and 1,13. The LSV strategy printed a lower Sortino ratio than the Sharpe ratio at 1,42 and the SPY benchmark portfolio printed a lower Sortino ratio at 0,59.

The Calmar ratio which is a measurement of the average geometric return over the maximum drawdown, documents the HLSV strategy as the best performing strategy during the back tested period, with a ratio at 4,34. The second best is the LSV strategy with a Calmar ratio at 2,63, third best is the LSLV strategy with a Calmar ratio at 2,32. The strategy with the poorest performed risk-adjusted return measured with a Calmar ratio is the benchmark portfolio SPY, printing below 1 at 0,88.

In figure 11, 12 and 13 each trading year logarithmic portfolio performance is illustrated in the colored lines and the average logarithmic portfolio performance for every year is illustrated in black. Each year represents the portfolio value from the first trading day of the year to the last. This illustration can be helpful in analyzing whether the strategy performance comes from any yearly outliers that deviates from the average.

Figure 11.

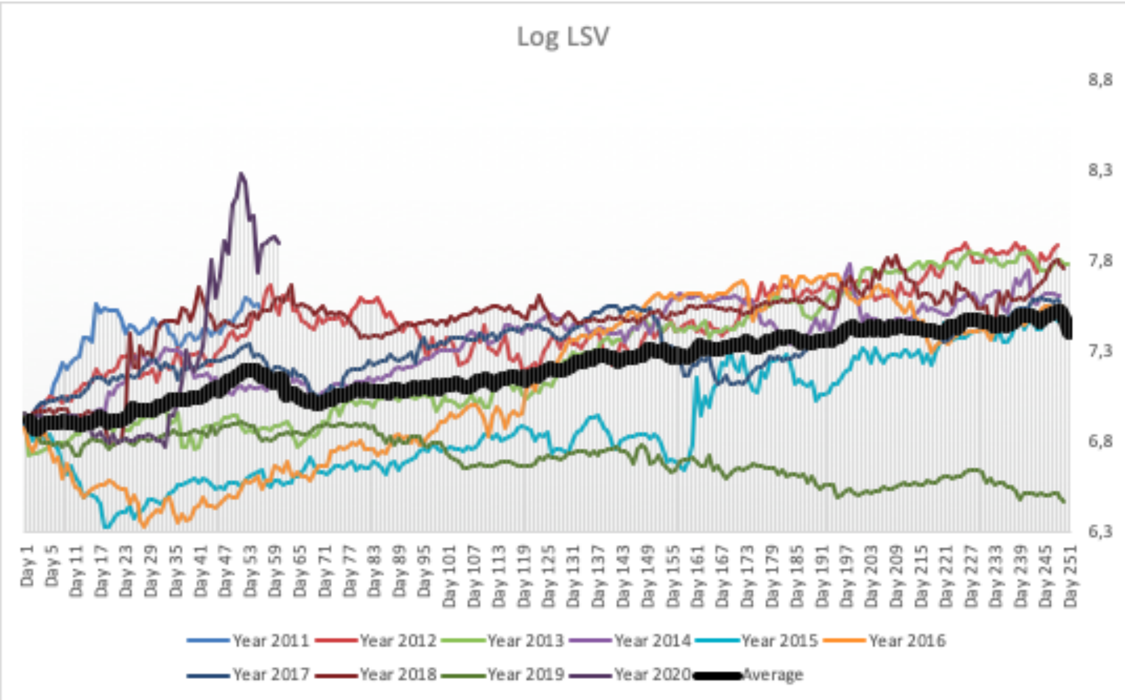


Figure 11. Yearly LSV portfolio value.

Figure 12.

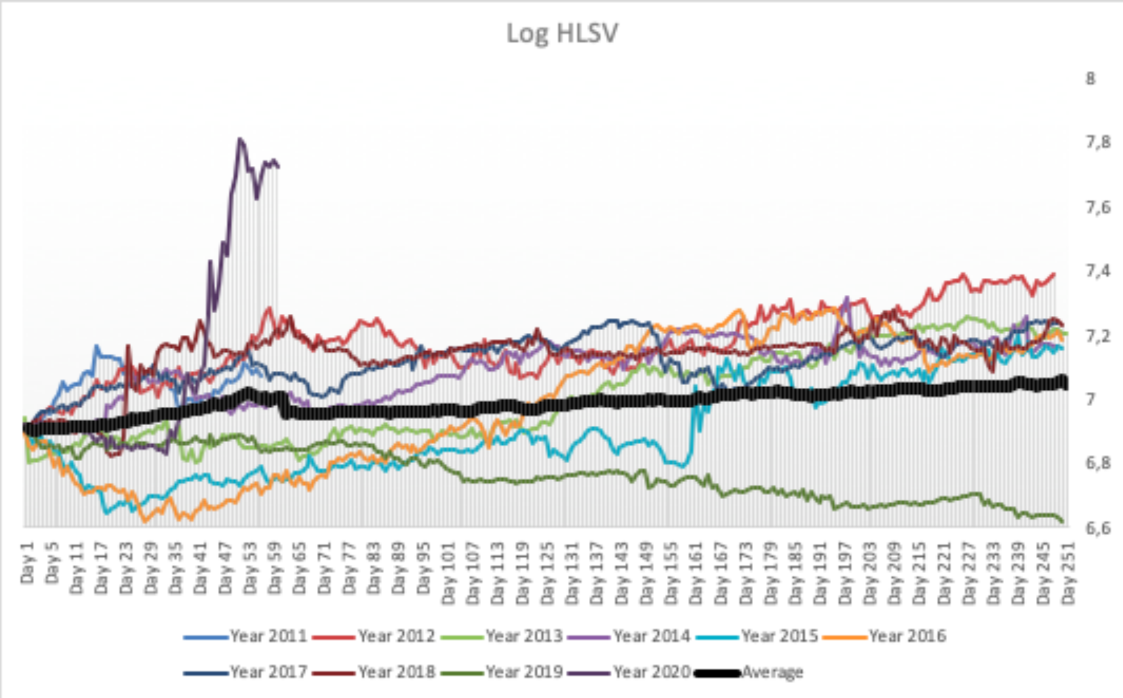


Figure 12. Yearly HLSV portfolio value.

Figure 13.

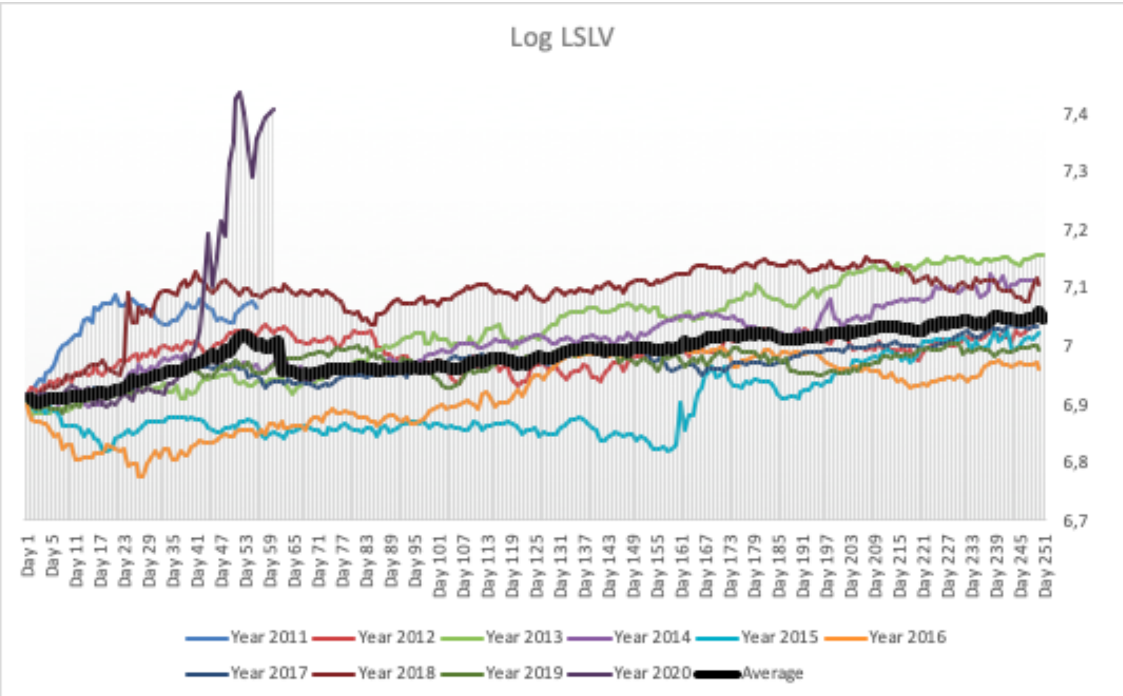


Figure 13. Yearly LSLV portfolio value.

5.2 Descriptive Statistics

Table 2 is illustrating a Pearson correlation matrix for each single portfolio return, and its r-values with a 95% confidence interval. Notable to point out, is that all three trading strategies have had low and negative correlation with the compared benchmark portfolio SPY.

Table 2.

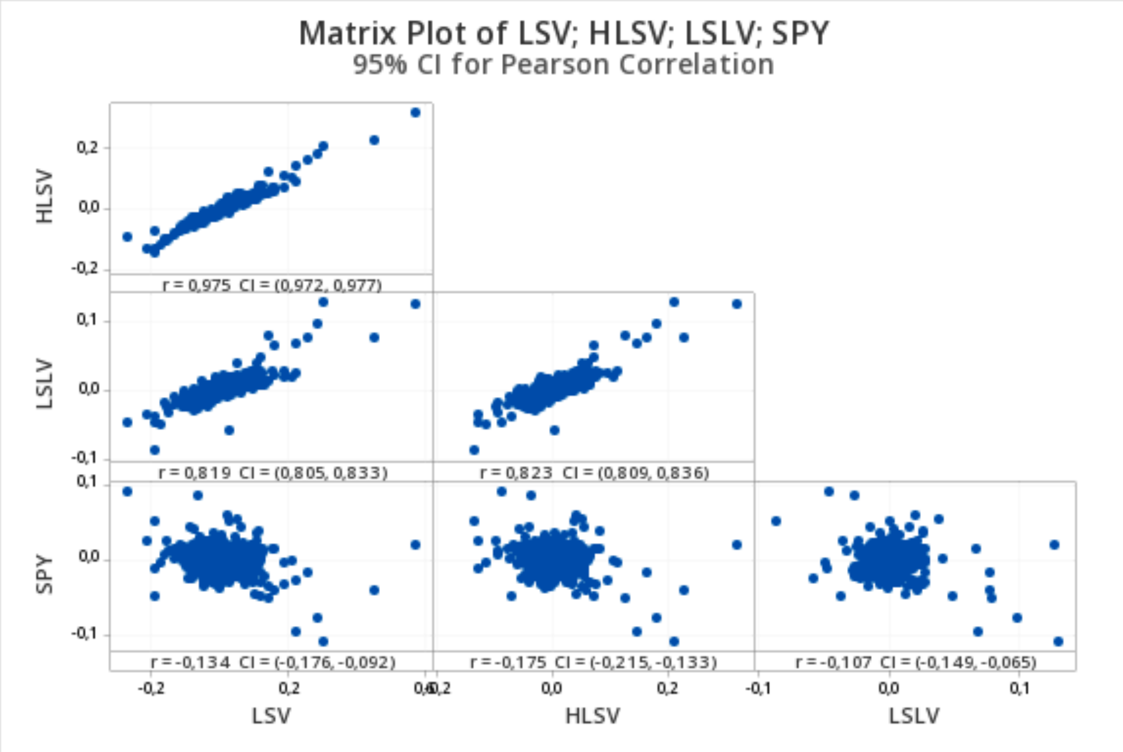


Table 2. Pearson Correlation matrix.

Table 3 is a representation of further descriptive statistics of the daily data. During the back tested period the LSV strategy have, on average, yielded a daily return of 0,39%, the HLSV strategy have had an average at 0,16%, the LSLV strategy 0,09% and the SPY 0,04%. Noteworthy to point is that the LSV and the HLSV strategy have a big range between minimum and maximum daily return, hence, printing relatively high standard deviation. For example, the LSV strategy, which have had a minimum daily return of negative 27% and a maximum daily return of 57,1%. Furthermore, the skewness and kurtosis were calculated for each strategy. The LSLV strategy have had the most skewed distribution and also the thickest tails. Nonetheless, the SPY portfolio is the only portfolio with a negative skew.

Table 3.

Statistics

Variable	Mean	StDev	Minimum	Median	Maximum	Range	Skewness	Kurtosis
LSV	0,003906	0,043021	-0,269709	0,004181	0,571279	0,840988	1,86	24,71
HLSV	0,00162	0,023184	-0,137117	0,001943	0,321563	0,458679	2,21	30,4
LSLV	0,000901	0,009634	-0,086772	0,000759	0,129334	0,216106	2,99	45,05
SPY	0,000425	0,0102	-0,109424	0,000534	0,090603	0,200027	-0,73	19,43

Table 3. Descriptive statistics

5.3 Normality Tests

Table 4 shows the results of the Shapiro-Francia test that test if the original sample follows a normal distribution. The hypothesis is stated in the following way:

H_o: *The sample is normally distributed*
H_1: *The sample is not normally distributed*

The p-value from the test shows low scores of 0,00001 for all variables which is significantly lower than the chosen significance level of 1%. This observation gives empirical evidence to reject the null hypothesis that the sample is normally distributed, leaving with the alternative hypothesis that the sample is not normally distributed. Table 5 shows the results of the skewness/kurtosis tests of the original sample. In this test emphasis is put on the quantity of prob>chi2 that takes both skewness and kurtosis into account. Once again p-values lower than the significance level of 1% is observed, which gives empirical evidence to reject the null hypothesis that the sample is normally distributed.

Table 4

Shapiro-Francia W' test for normal data

Variable	Obs	W'	V'	z	Prob>z
LSV	2.133	0.84583	205.332	12.799	0.00001
HLSV	2.133	0.81232	249.966	13.272	0.00001
LSLV	2.133	0.73701	350.271	14.083	0.00001
SPY	2.133	0.84086	211.959	12.876	0.00001

Table.4 Shapiro-Francia test for normal distribution: original data

Table 5

Skewness/Kurtosis tests for normality

Variable	Obs	Pr(Skewness)	Pr(Kurtosis) adj	chi2(2)	Prob>chi2
LSV	2.133	0.0000	0.0000	.	0.0000
HLSV	2.133	0.0000	0.0000	.	0.0000
LSLV	2.133	0.0000	0.0000	.	.
SPY	2.133	0.0000	0.0000	.	0.0000

Table 5. Skewness/Kurtosis tests for normality: original data

As the results of the tests indicated that the data was not normally distributed and suffered from skewness and fat tails, adjustments of the data had to be made to advance to future statistical t-tests. To solve the normality problem the bootstrapping technique was performed by resampling the original dataset 2000 times to create a new population parameter. After adjusting the data, the same test was conducted once more to test if the problem of normality was solved for the resampled version of the dataset. Looking at table 6 the p-value quantities of the Shapiro-Francia test for the resampled data shows scores that exceed the significance level of 1%. This gives evidence to accept the null hypothesis that the resampled version is normally distributed. Same goes for the results that is observable in table 7, the Prob>chi2 values are greater than the significance level of 1% and therefore the null hypothesis is accepted.

Table 6

Shapiro-Francia W' test for normal data					
Variable	Obs	W'	V'	z	Prob>z
ResLSV	2.000	0.99848	1.905	1.543	0.06142
ResHLSV	2.000	0.99900	1.255	0.543	0.29341
ResLSLV	2.000	0.99924	0.952	-0.119	0.54723
ResSPY	2.000	0.99932	0.859	-0.365	0.64242

Table 6. Shapiro-Francia test for normal distribution: resampled data

Table 7

Skewness/Kurtosis tests for normality						
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj	chi2(2)	Prob>chi2
ResLSV	2.000	0.9621	0.0588		3.56	0.1684
ResLSV	2.000	0.6006	0.7397		0.39	0.8239
ResLSLV	2.000	0.5946	0.9705		0.28	0.8674
ResSPY	2.000	0.5175	0.8282		0.47	0.7910

Table 7. Skewness/Kurtosis tests for normality: resampled data

5.4 Two sample T-test

Following procedure is made to statistically test if the average return of the strategies is greater than the average return of the benchmark during the period. The hypothesis that will be tested is defined as:

Hypothesis 1:

$$H_o: \bar{R}_{LSV} - \bar{R}_{SPY} = 0$$
$$H_1: \bar{R}_{LSV} - \bar{R}_{SPY} > 0$$

Hypothesis 2:

$$H_o: \bar{R}_{HLSV} - \bar{R}_{SPY} = 0$$
$$H_1: \bar{R}_{HLSV} - \bar{R}_{SPY} > 0$$

Hypothesis 3:

$$H_o: \bar{R}_{LSLV} - \bar{R}_{SPY} = 0$$
$$H_1: \bar{R}_{LSLV} - \bar{R}_{SPY} > 0$$

The test statistics in table 8 and 9 shows the results from the hypothesis testing. In table 9, each tests P-value have quantities of zero, that is below the significance level of 1%, which gives us empirical evidence to reject the null hypothesis. Rejecting the null hypothesis leaves us with the alternative hypothesis that the average return of all the tested strategies is higher than the benchmark average return.

Table 8

Descriptive Statistics				
Sample	N	Mean	StDev	SE Mean
ResLSV	2000	0,00389	0,00095	0,00002
ResHLSV	2000	0,00163	0,00050	0,00001
ResLSLV	2000	0,00090	0,00021	0,00000
ResSPY	2000	0,00042	0,00022	0,00000

Table 8. Descriptive statistics: Two Sample T-Test

Table 9

Two sample t-test

H_0: $\mu_1 - \mu_2 = 0$
H_1: $\mu_1 - \mu_2 > 0$

Variable	T-Value	DF	P-Value
ResLSV	160,15	2214	0,000
ResHLSV	99,95	2753	0,000
ResLSLV	69,97	3989	0,000

Table 9. Two Sample T-Test: T-Value & P-Value

5.5 Quality Criteria

A valid quantitative research is categorized with trustworthy and unbiased results. In order to evaluate for this, quality criterions of reliability, validity, generalizability and replicability is traditionally examined (Bryman & Bell, 2017, p.157).

5.5.1 Reliability

In the process of conducting a quantitative research, reliability refers to issues on how consistent a measure is. This is traditionally categorized in to three aspects: stability, internal reliability and inter-observer consistency. Stability is a consideration on how stable the measure is over time. If the results in a study fluctuates over different time periods it is an indication of low stability. Internal reliability aims to explain the consistency of an indicator that make up a scale or index. The inter-observer consistency refers to issues when there's a subjective judgement involved in the data collection or research. The consideration of inter-observer consistency and internal reliability is of most relevance when a research is conducted on primary data. Since the research conducted in this thesis only covers secondary data, a reliability assessment in the aspects of stability is only considered (Bryman & Bell, 2017, p.157-158).

It is common to experience problems of reliability and stability when a trading strategy is back tested. That is, when the trading strategy is tested on historic data it shows promising results, but when the strategy is performed in real-time trading, the performance start to deviate from the tested results. Folger (2012) describe this error as an effect of curve-fitting. Curve-fitting (or over-fitting) is the process of creating a strategy that matches the historical data to closely. There are a few approaches that can be considered in order to avoid curve-fitting, such as, creating a strategy that from an economic point of view exploits a fundamental inefficiency in the market (Liew, n.d.). This approach can be assumed in the research since earlier empirical studies proves there is a discrepancy in the market to capitalize on. Another approach of avoiding curve-fitting is to use both in-and out-of-sample data in the back test. This is done as, in addition to only test on the original sampled data (in-sample), add a second unused data set (out-of-sample) which the strategy is tested on once more. If the results from the out-of-sampled data correspond with the in-sampled data the results can be considered as having high stability (Folger, 2012, p.1-2). In this research there is no back test performed on out-of-sampled data. However, if similar strategies from previous studies corresponds with the results conducted in this research, it can be assumed to indicate high stability of this research.

5.5.2 Validity

In a conducted research where a concept is aimed be measured, validity tries to explain the extent of accuracy a measurement can represent the concept. Bryman and Bell (2017) presents different types of validity that is typically distinguished in scientific research. Measurement validity is of most relevance for the research of this study. Measurement validity concerns questions of how well a measure actually reflect the concept it is supposed to explain. In the context of this research, measurement validity would argue for how well the constructed variables can explain the nature of what the variables is intended to.

Since the research aims to investigate how the term structure can be exploited to trade volatility as an asset, two variables are essential to investigate concerning their level of validity. The variable constructed to explain the term structure (B_t) and the instrument assumed to represent volatility as a tradable asset (VIX ETFs). The level of validity for variable B_t can be assumed to be high since the behavior and the gathered data of the variable represents the actual definition of what the term structure is. Regarding the VIX ETFs capability of representing volatility as a traded asset, the authors assume the validity to be high. Because, as stated in earlier sections, it is proven that VIX ETFs performs according to the underlying derivative well.

5.5.3 Generalizability and replicability

According to Bryman and Bell (2017) an essential aspect of the research is that the results can be generalized in a broader context, beyond the actual research. Replicability explains the extent to which a research can be replicated. Replicability is an important aspect since it is essential for future researcher to examine potential errors in the conducted results (Bryman & Bell, 2017, p.164-165). Since the research in this study consists of large sample sizes, the probability of precise results increases. Therefore, the results can be validly generalized (Olsson & Sörensen, 2011, p.201). Additionally, the fact that VIX ETFs trades with high precision to the underlying derivative, the results can be further generalized to a broad range of VIX underlying products (Bordonado & Samdal, 2016, p.35). The data used for the research are secondary samples of financial instruments that is accessible from many different sources. And each flow chart illustrated in figure 7, 8 and 9 makes the trading strategies easy to replicate. Hence, the authors assume the research to have high level of replicability.

6. Analysis and Discussion

This chapter includes interpretation, discussion and analysis of the results presented in the previous chapter. It aims to connect theories and arguments with the empirical findings to answer the study research question.

As mentioned in previous sections, the purpose with this research was to investigate if trading strategies that exploits the VIX term structure can generate abnormal returns. Thus, with inspiration from strategies introduced in previous literature, the authors created three different strategies to perform back test on. In order to answer the research question with empirical support, three different hypothesis tests were performed in two-sample t-tests. Additionally, the empirical and the statistical results aims to be further explained in the context of established theories that describes the efficiency of capital markets.

In previous sections the authors have presented additional literature that intend to explore the dynamics of the VIX term structure (Nossman & Wilhelmsson, 2009; Simon & Campassano, 2012) and strategies that aims exploit it (Bordonado & Samdal, 2016; Simon & Campassano, 2012). The research in this thesis investigates a time period exceeding previous literature and presents new inputs for new trading strategies. The results correspond with previous literature which further adds to an interesting discussion regarding the relevance of theories that argues over efficiency and predictability of capital markets.

6.1 The LSV Strategy

The LSV strategy, is the unhedged strategy which short VIX exposure during contango and goes long VIX exposure during backwardation. This was the best performing strategy measured in geometrical return and showed clear signs of being highly profitable. However, high return usually corresponds with high risk, and the LSV strategy is no exception in this case. In fact, the annualized volatility was 68% and the biggest drawdown for one single trading day was -27%. Hence, a trader, at some point, could be expected to experience a decrease of at least a third of its portfolio value. There is no surprise that the strategy showed evidence of high risk since it is established that the VIX experience periods of substantial shocks and characterizes as mean reverting. As mentioned in previous sections, an event that exemplifies the risks involved when trading short VIX exposure is the Volmageddon event in 2018, which caused some short VIX ETFs to liquidate (Kawa, 2019). The shocks and the mean reverting nature of VIX can also explain the positive skewness and fat tail of the strategy's distribution. Since the strategy aims to go long volatility during backwardation, the strategy is long volatility when volatility is high, therefore the strategy is positively exposed to these shocks. With the aspect to avoid events that can have an extreme effect on short volatility strategies, the back test shows promising results of being robust during periods of high volatility.

By further investigating the strategies performance for each year, it can be observed that 2019 was a year with poor performance and stands out as an anomaly deviating from the average. A possible explanation for this deviation could be that the basis has started to lose its predictive power for VIX futures or that market environment changed after the

Volmageddon event in 2018. However, there was no such signs during the three-month period of trading in 2020, as the strategy performed historically good with a return deviating on the upside, capitalizing from being long volatility during the covid-19 sell off.

6.2 The HLSV Strategy

Since a long-short strategy of VIX is traded with substantial amount of risk. It is reasonable to hedge the VIX exposure and thereupon creating a strategy that mostly collects the roll yield. The HLSV strategy does this by adding a short S&P 500 exposure during contango and a long S&P 500 exposure during backwardation. The back test resulted with substantially less risk, printing a maximum daily drawdown of -14%, and an annualized volatility at 36%. Consequently, the average annual geometric return was lower at 59%.

Comparing the results in the context of risk-adjusted performance ratios, the Sharpe and the Sortino ratios was lower for the HLSV strategy compared to the LSV strategy. This implies that an unhedged strategy is preferred over the hedged strategy. The Calmar ratio, which uses the maximum drawdown as risk ratio contradicts the Sharpe and the Sortino ratios and measures the hedged strategy as the preferred strategy. A trader should interpret these mixed results as how she defines risk, if the trader wants to avoid large, single day drawdowns rather than a volatile portfolio she should put more emphasis on the Calmar ratio.

6.3 The LSLV Strategy

As mentioned earlier, one purpose with the research was to investigate how different modification of these strategies could be traded. The LSLV strategy was created to investigate how the VIX term structure can be used as protection for an equity portfolio. The strategy does this buy continuously holding a buy and hold exposure of equities but trades 25% long VIX exposure during backwardation.

The back test shows an interesting result of an annual average geometric return at 20% and additionally been trading with relatively low risk. Comparing the results with an 100% equity exposed portfolio (SPY), the LSLV have outperformed SPY with twice as high return and yet traded with lower risk measured as volatility, downside volatility and maximum drawdown. Furthermore, the Sharpe and the Sortino ratio has been the highest for LSLV strategy, implying the LSLV performance has the best risk-adjusted returns. In conclusion, the results indicate that the prediction power of VIX term structure can as well be used as a good compliment for protecting equity portfolios.

6.4 Empirical Tests

Regarding the purpose of answering the research question based on empirical evidence, three different two-sample t-test was performed between the difference of each strategy's average daily return and the average daily return of the benchmark equity portfolio. The original sample size for each strategy consisted of 2133 data points, covering approximately 7 years of trading days. However, the original data could not be accepted as normal distributed. By bootstrapping the data 2000 times the assumption of normal data could be accepted.

All tests resulted with empirical evidence to reject the null hypothesis of not generating abnormal returns. Leaving with the alternative hypothesis, stating that the strategies generated abnormal return during the back tested period. This concludes the research question for this thesis, proving that strategies exploiting the term structure dynamics can generate abnormal returns. Additionally, these findings suggest that earlier literature evidence is still applicable in modern market environment.

6.5 Theoretical Implications

This section will include a discussion regarding how the empirical results will be analyzed in connection to the applied theories that are specified in chapter 2. The theories introduced was the rational expectation theory and the efficient market hypothesis.

The rational expectation theory states that the expectation will be identical to the optimal forecast using all available information (Madura, 2014, p.135). If the theory would be applied to explain the nature of the development of VIX future prices it would suggest that VIX futures are unbiased predictors of the VIX spot price. Previous studies by Nossman and Wilhelmsson (2009) and Simon and Campassano (2012) have provided evidence that this theoretical assumption should be rejected as the VIX futures consistently overestimates realized volatility.

The efficient market hypothesis is closely related to the rational expectation theory and aims to explain that capital markets prices is fully reflected on all available information. Thus, prices should follow a random walk, meaning that return is unpredictable and abnormal returns is not possible in the long term (Bodie, Kane & Marcus, 2014, p. 351-352). The efficient market hypothesis suggests that, based on available market information, it’s impossible to create trading signals predicting the development of prices (such as the basis reflecting the term structure), thus generating strategies with abnormal returns.

As the profitability of the trading strategies rely on the fact that the VIX future prices will decay towards the spot price over time and this price change can be predicted by looking at the term structure of the products, the results of this study align with previous studies to reject these theories. The results show that the trading strategies can outperform the benchmark by generating higher returns and risk-adjusted returns.

7. Conclusion

The last chapter will include a summary of the study where the authors reflect upon the findings, the limitations and suggestions for future studies.

7.1 Summary

The purpose with this paper is to investigate if the dynamics of VIX term structure can be exploited for trading strategies in order to yield abnormal returns. To do this, three different strategies was created based on signals indicating if the VIX spot price and the VIX future front month price is in contango or backwardation. The strategies were assumed to trade VIX and S&P 500 ETFs, a choice based on earlier literature findings that investigates the price discovery of VIX ETPs and documenting that such products performs according to the underlying derivative well. The strategies were thereupon tested on a set of historic data during the sample period of October 2011 to Mars 2020. The results could provide an answer for the research question, and based on empirical evidence, it can be concluded that the strategies generate abnormal returns.

Literature that investigates the VIX futures and the term structure is extensive. Many studies aim to investigate the pricing dynamics of VIX-index and VIX derivatives (Alexander, Kapraun, & Korovilas, 2015; Asensio, 2013; Nossman & Wilhelmsson, 2009; Whaley, 2013). Most of the studies conclude that buy-and-hold strategies of VIX derivatives has poor performance and that there is a time-varying risk premium in VIX derivatives. Most studies also question the rational expectation hypothesis on VIX index/futures. Further literature was introduced by Simon and Campassano (2012) on how the dynamics of the VIX term structure could be exploited for a profitable long-short trading strategy on VIX futures.

The research in this study is an extension of earlier literature and aims to empirically contribute to new perspectives and inputs of previous research and to further examine a time period not yet investigated. The findings correspond to earlier research results, documenting the usefulness of the VIX term structure as a predictor and demonstrates how trading strategies can be developed based on this fact. The results also indicate that similar trading inputs can be useful to protect equity portfolios. Additionally, the strategies have shown promising results of being robust during periods of high volatility, avoiding events that can have an extreme effect on short volatility strategies.

Regarding the purpose of connecting the findings with theories of rational expectations and efficient markets, the results contradicts to what the theories states. Both theories summarize the equilibrium process of prices in capital markets. According to the rational expectation theory, the VIX term structure should not have prediction power on VIX future prices. Since the strategies was created based on earlier evidence suggesting the contrary, the results of generating abnormal returns indicate that the rational expectation hypothesis can be rejected. Additionally, the weak form of efficient market theory states that abnormal returns cannot be generated based on signals created with historical and public available information. Since all strategies in this study resulted in abnormal returns and were created using historic and publicly available information, the findings contradict the theory of efficient markets.

To increase the validity of the study, a summary of the research delimitations will be presented. To test the performance of the strategies, empirical tests was only conducted on the average returns and not the risk-adjusted returns. One could argue that the results of risk-adjusted return ratios should be strengthened by further statistical testing and that risk-adjusted returns is a more accurate measurement when comparing different performances. The calculated risk-adjusted return ratios indicated a substantial difference between the strategies and the benchmark return. Due to the fact that the risk-adjusted returns were not statistically tested, further empirical conclusions could not be made. The authors also want to clarify that there was no regression made when deciding a hedge ratio to the strategies, which means that there are no statistical tests to ensure the optimal ratio. The ETFs used in the strategies have also not been tested on their ability to track their underlying asset, for the time period investigated. This delimitation creates some level of uncertainty in our choice of products.

7.2 Future research

The delimitations of this study may serve as a basis for future research. To provide further knowledge about the strategy's performance, future studies could focus on how to modify the strategies. For example, adding thresholds for a buy and sell signal or exploring how similar strategies performs on longer maturity derivatives.

Another potential future research could be aimed to explore strategies connected with the dynamics of volatility term structure beyond US equity markets. For instance, exploring how similar strategies performs on volatility products of fixed income or commodity derivatives. Additionally, an interesting investigation for future research could be applied in European or Asian derivatives, investigating if the performance deviates compared to the derivative market in US.

7.3 Limitations

The empirical testing in this research was only conducted with in-sampled data, hence there is a lack of evidence that could support the avoidance of curve-fitting. However, since the strategies is created based on one single indicator and a proven economic dynamic in the market, there is a decreasing risk of curve-fitting. The back-testing performed in the research can be contextualized as a test of validity on previous research since all testing is performed on data previously not yet tested. As results corresponds with previous research results, one could argue for increased validity.

A second possible limitation is what expected return should be in the context of defining abnormal return. This research has assumed to use an ETF that corresponds with S&P 500 as a benchmark portfolio of equities. When trading volatility products, one could argue a comparison should be made with a benchmark of volatility. Since a volatility benchmark is not tradeable and the corresponding derivatives is burden by a continuous time decay, it is not a suitable measurement as expected return. As the strategies are indirectly trading the volatility of equity prices, therefore the authors assume an equity buy-and-hold portfolio as the most suitable comparison for expected return.

Reference List

Alexander, C., Kapraun, J. and Korovilas, D., 2015. Trading and Investing in Volatility Products. *Financial Markets, Institutions & Instruments*, 24(4), p.315.

Alkelin, A. and Bergkvist, O., 2019. *Actively Managed Volatility Strategies*. Master. Copenhagen Business School.

Andersen, L. and Brotherton-Ratcliffe, R., 1997. The equity option volatility smile: an implicit finite-difference approach. *The Journal of Computational Finance*, 1(2), p.5.

Ann, K., 2019. *Volatility Skew And Prospect Theory*. [online] Medium. Available at: <https://medium.com/@postbio/volatility-skew-and-prospect-theory-73cf1628a0a> [Accessed 17 April 2020].

Asensio, I.O. (2013). The VIX-VIX Futures Puzzle.

Bennett, C., 2014. *Trading Volatility*. San Bernardino.

Berk, J. and DeMarzo, P., 2014. *Corporate Finance*. 3rd ed. Edinburgh: Pearson Education Limited.

Bodie, Z., Kane, A. and Marcus, A., 2014. *Investments*. 10th ed. New York: McGraw-Hill Education, pp.138-139.

Bordonado, C., and Samdal, S., 2016. VIX Exchange Traded Products: Price Discovery, Hedging, and Trading Strategy. *Journal of Futures Markets*, 37(2), pp.164-183.

Bryman, A., & Bell, E. (2017). *Business Research Methods.* 3rd edition. Malmö: Liber.

Bryman, A. (2012). *Social Research Methods*. 4th edition. New York: Oxford University Press.

Cboe.com. 2019. *Cboe VIX White Paper*. [online] Available at: <http://www.cboe.com/micro/vix/vixwhite.pdf> [Accessed 20 April 2020].

Cheng, I., 2018. The VIX Premium. *The Review of Financial Studies*, 32(1), pp.180-227.

CME QuikStrike. 2020. *Vol Curve & Skew*. [online] Available at: <https://cmegroup.quikstrike.net/> [Accessed 31 March 2020].

Collis, J., & Hussey, R. (2014). *Business Research: A Practical Guide for Undergraduate and Postgraduate Students*. 4th edition. Basingstoke: Palgrave Macmillan

Delcey, T. and Sergi, F., 2019. The Efficient Market Hypothesis and Rational Expectations: How Did They Meet?. [online] p.5. Available at: <https://hal.archives-ouvertes.fr/hal-02187362> [Accessed 18 May 2020].

ETF.com. 2020. *VIXY*. [online] Available at: <https://www.etf.com/VIXY#overview> [Accessed 2 May 2020].

Folger, J., 2012. Back- vs. forward testing: Test twice (or more), trade once. *Futures: News, Analysis & Strategies for Futures, Options & Derivatives Traders*, pp.1-2.

Harwood, V., 2019. *Scaling The Sharpe & Sortino Ratios For Daily Returns | Six Figure Investing*. [online] Sixfigureinvesting.com. Available at: <https://sixfigureinvesting.com/2013/09/daily-scaling-sharpe-sortino-excel/> [Accessed 5 May 2020].

Holden, M.T., & Lynch, P. (2004). Choosing the appropriate methodology: Understanding research philosophy. *The marketing review*, 4 (4), 397-409. doi: 10.1362/1469347042772428

Jain, D., 2018. *Skew And Kurtosis: 2 Important Statistics Terms You Need To Know In Data Science*. [online] Medium. Available at: <https://codeburst.io/2-important-statistics-terms-you-need-to-know-in-data-science-skewness-and-kurtosis-388fef94eeaa> [Accessed 7 May 2020].

Jung, Y., 2016. A portfolio insurance strategy for volatility index (VIX) futures. *The Quarterly Review of Economics and Finance*, 60, pp.189-200.

Kawa, L., 2019. The Day The Vix Doubled: Tales of ‘Volmageddon’. *bloomberg*, [online] Available at: <https://www.bloomberg.com/news/articles/2019-02-06/the-day-the-vix-doubled-tales-of-volmageddon> [Accessed 12 May 2020].

Macroption.com. n.d. *Black-Scholes Model Assumptions - Macroption*. [online] Available at: <https://www.macroption.com/black-scholes-assumptions/> [Accessed 17 April 2020].

Madura, J., 2014. *Financial Markets And Institutions*. 12th ed. CENGAGE Learning Custom Publishing.

Malkiel, B. and Saha, A., 2005. Hedge Funds: Risk and Return. *Financial Analysts Journal*, 61(6), pp.80-88.

Moore, D., McCabe, G., Alwan, L., Craig, B. and Duckworth, W., 2011. *The Practice Of Statistics For Business And Economics*. 3rd ed. New York: W.H. Freeman and Company, pp.433-434.

Neuman, W. (2014) *Social Research Methods: Qualitative and Quantitative Approaches.*7th edition. Harlow: Pearson Education Limited.

Nordnet.se. 2020. *Prislista*. [online] Available at: <https://www.nordnet.se/se/kundservice/prislista> [Accessed 2 May 2020].

Nossman, M. and Wilhelmsson, A., 2009. Is the VIX Futures Market Able to Predict the VIX Index?A Test of the Expectation Hypothesis. *The Journal of Alternative Investments*, 12(2), pp.64-65.

Olsson, H. and Sörensen, S., 2011. *Forskningsprocessen*. Stockholm: Liber, p.201.

Proshares.com. 2020a. *Fact Sheet PROSHARES SHORT VIX SHORT-TERM FUTURES ETF*. [online] Available at: <https://www.proshares.com/media/fact_sheet/ProSharesFactSheetSVXY.pdf?param=1589293421447> [Accessed 22 April 2020].

Proshares.com. 2020b. *Fact Sheet PROSHARES VIX SHORT-TERM FUTURES ETF*. [online] Available at: <https://www.proshares.com/media/fact_sheet/ProSharesFactSheetVIXY.pdf?param=1588172232848> [Accessed 22 April 2020].

Reuters Eikon. 2020. *Reuters Eikon Platform*. [online] Available at: <https://www.refinitiv.com/en/products/eikon-trading-software> [Accessed 31 March 2020].

Rollinger, T. and Hoffman, S., 2020. *Sortino: A 'Sharper' Ratio*. [online] Redrockcapital.homestead.com. Available at: <http://redrockcapital.homestead.com/Sortino__A__Sharper__Ratio_Red_Rock_Capital.pdf> [Accessed 6 May 2020].

Liew, L., n.d. What is Overfitting in Trading?. [Blog] *AlgoTrading101*, Available at: <https://algotrading101.com/learn/what-is-overfitting-in-trading/> [Accessed 22 May 2020].

Saunders. M., Lewis. P., & Thornhill. A. (2009). *Research Methods for Business Students*. 5th edition. Harlow: Pearson Education Limited.

Sharpe, W., 1994. *The Sharpe Ratio*. [online] Web.stanford.edu. Available at: <http://web.stanford.edu/~wfsharpe/art/sr/SR.htm> [Accessed 5 May 2020].

Simon, D. and Campasano, J., 2012. The VIX Futures Basis: Evidence and Trading Strategies. *SSRN Electronic Journal*,.

Sinclair, E., 2013. *Volatility Trading*. Hoboken, N.J.: John Wiley & Sons, Inc., p.14.

Ssga.com. 2020. *SPDR® S&P 500® ETF Trust*. [online] Available at: <https://www.ssga.com/library-content/products/factsheets/etfs/us/factsheet-us-en-spy.pdf> [Accessed 22 April 2020].

The Minitab Blog, 2016. Understanding t-Tests: 1-sample, 2-sample, and Paired t-Tests. Available at: <https://blog.minitab.com/blog/adventures-in-statistics-2/understanding-t-tests-1-sample-2-sample-and-paired-t-tests> [Accessed 7 May 2020].

VIX central. 2020. *CBOE Delayed Quotes*. [online] Available at: <http://vixcentral.com> [Accessed 1 April 2020].

Whaley, R., 2013. Trading Volatility: At What Cost?. *SSRN Electronic Journal*,.

Wu, L. and Foresi, S., 2005. Crash-O-Phobia: A Domestic Fear or A Worldwide Concern?. *SSRN Electronic Journal*,.

Yen, L., 2019. *An Introduction To The Bootstrap Method*. [online] Medium. Available at: <https://towardsdatascience.com/an-introduction-to-the-bootstrap-method-58bcb51b4d60> [Accessed 10 May 2020].

UMEÅ SCHOOL OF BUSINESS,
ECONOMICS AND STATISTICS
UMEÅ UNIVERSITY

Business Administration SE-901 87 Umeå www.usbe.umu.se