VIX Index Strategies
Shorting volatility as a portfolio enhancing strategy

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Abstract

In this paper we perform an empirical analysis on the VIX Index and we develop a series of portfolio strategies on implied volatility by using VIX Futures. First, we give a brief introduction to the VIX Index and what it represents. Then we focus on the VIX Futures, with an analysis of the VIX Futures curve and its relationship with the VIX Index. The last part will be dedicated to the presentation of the results of different portfolio strategies, extending a long /short position on VIX Futures.

Keywords: VIX Index; equity volatility; trading ; asset allocation ; cross-correlation ; portfolio enhancement.

1. Introduction

The idea of creating a set of financial instruments that represent the volatility, i.e. an index and its related derivatives, was first developed by Prof. M. Brenner and Prof. Dan Galai in 1986 in their academic article "New Financial Instruments for Hedging Changes in Volatility" and their subsequent article " Hedging Volatility in Foreing Currencies". The idea of a volatility index rose from the necessity of having an efficient tools for hedging against changes in volatility; Brenne and Galai proposed the creation of three volatility indexes, for the three asset classes of equity, bond and currency market. Following their ideas, in 1993 the Chicago Board Options Exchange launched the CBOE Market Volatility Index or VIX, which represented the volatility of the S&P100 equity market. In 2003, the VIX calculation methodology was revised and the underlying index was changed to the S&P500 Index. On march 2004, the VIX future began trading on the CBOE futures exchange. VIX options were launched in 2006.

The VIX index is calculated real-time by the CBOE. It represents a weighted blend of prices for a range of option on the S&P500 index over a forward period of 30-days. It is derived from a basket of both put and calls options. The VIX Index is also known as the "investors fear gauge", given that it represents the equity market expectations on volatility over 1 month. When the VIX is high, the market is in distress, while for low levels of the VIX the market behaves the opposite. Accordingly, the VIX futures represent the expected volatility over the following months.

Although its original purpose was to hedge against changes in volatility, the VIX Index has also been considered as a portfolio enhancing instrument. In the last years, investors have been focusing more and more their attention on the opportunities offered by the volatility of the financial markets, up to the point that volatility itself has started to be considered as an asset class on its own. The VIX index can be invested in by using its derivatives, both options and futures.

In this paper, we explore some strategies to enhance portfolio returns by systematically using VIX futures. Most of the academic research and practical examples of volatility selling strategy focused on exploiting a particular structure of the VIX term structure - i.e. the curve of the VIX futures with a progressive time to expiration - or by maintaining their position on the VIX for a brief period of time. On the contrary, we decided to focus our analysis on a series of strategies which are implemented systematically and use a long time investment horizon.
Given this context, we will consider different investing strategies with the VIX Index futures, considering the 1-month (UX1) and the 3-month (UX3) to expiration instruments . First we will analyze a simple strategy involving only a short position on a future, to hedge or enhance the portfolio performance. After that, we will use the difference between the volatility premiums to construct a strategy with reduced volatility.

In the first paragraph we will describe the VIX Index and its main properties in relation to the S&P500. The second paragraph focuses on the VIX futures, i.e. the analysis of the VIX term structure and its characteristics, with a particular attention to the slope of the curve. In the third paragraph we will develop and backtest our strategies of short positioning on the VIX futures: first, a vanilla approach with a short position on a VIX future which is rolled after one month; second, a more complex approach consisting on a long and a short position on VIX future, in order to reduce the volatility of the first strategy. Then, we will use our results to develop a simple indicator to increase the profitability of the VIX index strategies that we considered. In the fourth paragraph, we will test our VIX strategies from a perspective of portfolio enhancement, by implementing them on top of a long position on the SPY ETF, an ETF which tracks the performance of the S&P500.

2. The VIX Index

The CBOE Volatility Index, known as the VIX Index, represent the 30-day implied volatility of the S&P500 Index. It is derived from a basket of both put and calls options. Its calculation formula was introduced in 1990 and updated in 2003. The VIX Index is also known as the "investors fear gauge", given that it represents the market expectations on volatility over 1 month. When the VIX is high the market is in distress, while a calm market means low VIX levels. In 2003, the CBOE together with Goldman Sachs updated the VIX by introducing a new method to measure the expected volatility. The procedure became more accurate by considering a larger base of market participants. The new VIX is broadly used by investors, risk managers and volatility traders. It is based on the index S&P500, the fundamental index of the US stock market, and it estimates the implied volatility by considering the weighted average of the prices of puts and calls on S&P500 in an range of strike prices. The availability of a dataset to replicate the exposition on the volatility with a portfolio of S&P500 options has transformed the VIX from an abstract concept to the practical standard to invest and hedge stock market volatility. The VIX is an useful indicator of either the change of the risk demand associated with a long position on the S&P500 call options or the demand of hedging on a long stock portfolio with S&P500 put options. In relation to the S&P500 behavior, the VIX index has four main properties.

2.1. Negative correlation with stock returns

The characteristic that makes the VIX attractive for investors is its historical negative correlation with stock returns. When the stock market declines, stocks tend to be more volatile. Consequently, the VIX tends to increase. Throughout its history, the VIX changes exhibited a strong and persistent negative correlation with the S&P500 variations. The average 1-year rolling correlation between the S&P500 returns and the VIX Index daily variations

has been -0.84 (-0.83 for both the 3 and 1 months rolling correlations), with a minimum value of -0.90 (-0.93 and -0.97); the maximum correlation reached was -0.75 (1 year rolling).
Although throughout the 2005-2015 period the correlation between the VIX-S&P500 daily variations had not been stable over time, as it fluctuated between -0.70 and -0.90 for the 1-year, -0.93 and -0.61 for the 3-months, -0.97 and -0.19 for the 1-month rolling correlations , it had always regressed toward the mean in a short time.
Generally, the correlation of the VIX and the S&P500 changes is closer to -1 during periods of higher VIX values. However, this is not true for every year. For example, we observed a low average VIX value and highly negative correlation in the first part of 2013, as well as a high average VIX value and relatively smaller (further from -1) correlation in 2009.

[Table 1 about here.]

[Fig. 1 about here.]

2.2. Volatility spikes during stock market falls

The VIX changes asymmetrically with respect to the S&P500 movements. Volatility expectations tend to explode after a large stock market sell-off, but they decrease gradually during a stock rally. This is consistent with investors behavior: they are more anxious to buy protection when stocks are falling than to sell volatility in a period of stock market growth.
This property make the VIX a candidate for protection against tail risks, thanks to its negative correlation and its convexity to large negative stock returns. For instance, after September 2008 the VIX more than triplicated from 25 to a peak of 80, while the S&P500 future fell of only 40% during the same period.
From a statistical point of view, the VIX percent changes present a positive

skew. Skew, or skewness, can be mathematically defined as the averaged cubed deviation from the mean divided by the cube of the standard deviation. If the result of the computation is greater than zero, the distribution is positively skewed. If it is less than zero, it is negatively skewed and equal to zero means it is symmetric. Its financial interpretation focus on downside risk. Statistically speaking, negatively skewed distributions have a long left tail, which for investors can mean a greater chance of extremely negative outcomes.

The changes in VIX shows convexity to large negative equity returns. The convex pattern is common to negative skewed assets. In other words, positive movements of the equity market are followed by little or average negative changes in the VIX Index, while negative movements cause large spikes in the volatility index. The investors react more to negative changes, i.e. when the implied volatility increases, their reaction is much more intensively than when these changes are positive. The convexity to large equity returns makes the VIX potentially attractive as a tail risk hedge.

2.3. VIX is mean-reverting

Stock volatility, and thus the VIX, has a mean-reversion property. Although the VIX is relatively high or low in a certain period, it will eventually abandon these extremes to return to the medium-term average. The speed of reversion depends on different factors, such as the intensity of the VIX movement or the speed with which the volatility has reached that level. As we can see from the graphical plot of the VIX index in figure 2, this level of stability can be inferred with ease.
Although the VIX Index is mean reverting, the medium term average to which the index tended to return was not constant through time. For example, from its inception in 2004 until May 2007, the VIX index average was about 11 with small absolute movements of the index, while from June 2007

to January 2012 the average increase to 20 with a very volatile VIX; then, the VIX return to a lower average of 15 - but still higher than the period 2004-2007.
Therefore, the VIX index present a property of mean reversion, but the mean varied through different periods and the speed of the movement of reversion had not been stable. Both of these points can be explained by its fourth property: the VIX has different regimes.

[Fig. 2 about here.]

2.4. VIX has different regimes

Since stock volatility is a risk measure, it has zero as inferior limit, which would indicate an absence of changes in the market. Although in theory no superior limit exists, in practice volatility is similar to interest rates, which tend to fluctuate between zero and a certain high number. Typically, we can observe volatility shifts between "high" and "low" regimes, with the market that remains for a long period of time in each regime before shifting to the other.
The speed of the mean reversion of the VIX Index is closely related to economic cycles. For instance, during the periods of economic stability (1991-1997 and 2003-2007) the VIX stayed at very low levels, under its long-term average of 19.97. When the stock market started to become turbulent, such as in the periods 1999-2000 and 2007-2008 and especially during periods of high stress in the financial market (2001-2002 and 2008-2012), the mean reversion became more accentuated with frequent zero-crossing, i.e. crossings of the long-term average. Generally, in times of low and high volatility the VIX presents mean-reversion properties that changes only in the frequency of the corrections (lower when the volatility is low and higher when it is high). Moreover, the economic cycles are strictly related with this property, having an effect on the speed, the frequency and the trigger for the VIX mean-

reversion. While the economy is stable and growing, the mean-reversion is not frequent. When the economic cycle is starting to invert, a zero-crossing of the VIX is triggered, followed by frequent mean-reversion when the cycle has reverted. Finally, when the situation returns calm, the VIX starts a new period of low value where the long-term average is not touched for a prolonged period of time.

3. VIX and its futures

Given the impossibility to invest directly in the VIX Index, the VIX Future represents the fundamental instrument to invest in the stock market implied volatility. The development of the VIX future has created a "family" of futures, i.e. a series of VIX futures with different months to expiration. In the financial market, there can be found VIX futures with expiration dates that range from 1 to 9 months.

For practicality, in our analysis we considered the "generic" nth VIX future, "UX". The generic nth future is defined as the VIX future which will mature in the next n month. For example, the first UX future, UX1, represents the VIX future with 1 month to maturity; on the opposite, UX3 is the VIX future which will expire in 3 months. Each of the generic UX futures is linked to a specific VIX month for one month. Every third Friday of the month the VIX futures roll, i.e. they will reduce their maturity by 1 month. Hence, the future with 3 months to maturity will then be considered as the future with 2 months to expiration, the 2 to 1, and so on; the future with 1 month to maturity will expire and ceases to exist. Thus, the generic UX3 will roll and become the new generic UX2, while the generic UX2 will be the new UX1; the old UX1 will mature and ceases to exist.

Generally, the most liquid VIX future is the one closer to expiration, that is the 1 month to expiration (UX1). If we are interested in replicating the VIX Index, the natural choice will be UX1. In fact, the correlation between UX1

and the VIX index in the 2004-2014 period was 0.98 (weekly data) or 0.99 (monthly data): UX1 replicated in a close way the underlying index.

3.1. VIX Term Structure analysis

The VIX futures with different maturities create a curve, defined as the VIX Index term structure. The VIX term structure represents the equity implied volatility in the next months, where each pillar - i.e.each of the months of the curve - is the value of the VIX future as the considered month to maturity. During a situation of normality, the VIX future term structure curve is in *contango*, i.e. the slope is positive: the market implied volatility is increasing with maturity. During a situation of stress in the equity market, when the VIX is particularly high, the VIX term structure can be in *backwardation*, that is the implied volatility is inversely decreasing with maturity; In this situation, the market expects the short term volatility to be higher than the future volatility. The backwardation may regard the entire curve, i.e. the curve is down-sloping, if for each month the expected implied volatility is lower than the one expected the month before. In some occasion, it may be that some of pillar-month of the VIX term structure curve are higher than the next pillar. A curve in backwardation is not sustainable, and the term structure will return in contango in a matter of weeks, or even days. This is due to the fact that the greater uncertainty over a longer term has to be reflected in a demand of a higher premium over a longer term than the demand over a shorter term. Although during a situation of stress in the financial market the premium for the shorter term volatility can be higher, when the market calms down the implied risk premium will return to a normal condition in order to reflect the higher uncertainty of time.
In table 2 we compute the statistics of the contango of the VIX term structure. We consider two buckets: the UX1-UX3 and the UX4-UX7 slopes, i.e. the difference between the VIX futures 1 month and 3 months to expiration for the firts bucket, and the difference between the VIX futures 4 months and

7 months to expiration for the second bucket. The values are considered in percentages, as they represent how higher is the second future in terms of the first. The UX3-UX1 was on average on a higher contango thant the UX4-UX3 slopes, 9% vs 4% , but was also more volatile, with a standard deviation of 10% vs 5%. The minimum values represent a situation of backwardation for the VIX term structure: for the 1-3 months, we had a maximum value of 47% , that is the UX3 was 47% lower than UX1; for the 4-7 months, the maximum backwardation was at a value of 16%, much lower than the first case.

[Table 2 about here.]

Another point of interest is the rate of return of the VIX term structure from an atypical situation of backwardation to a normal contango. Table 3 shows the frequency in days of the rate of return. For the 1-3 months VIX term structure, 74% of the cases show the rate of return is lower than 5 days, and 88% of the time lower than 10%; for the 4-7 months slopes, in 80% of the cases the curve returned in contango in less than 5 days, 72% in less than 3 days.

The rate of return to contango diminished consistently during the two most volatile periods of the life of the VIX index. In the middle of the 2007 financial crisis, the UX1-UX3 VIX slope remained in backwardation for 147 days, from September 2008 to April 2009, while the 4-7 months term structure was inverted for 240 days, from September 2009 to August 2008; in 2011, the European debt crisis kept the 1-3 months VIX slope in backwardation for 57 days, from August to October, and 16 days for the UX4-UX3 slope. Those periods were by far the longest in backwardation, but they were also very rare.

[Table 3 about here.]

[Fig. 3 about here.]

The VIX index is strongly correlated with its term structure. As we can see from table 3, we found that the correlation between the VIX Index and its futures is decreasing with the time to maturity. For instance, the correlation UX1 vs VIX is 0.98 (the maximum), while for UX3 vs VIX is 0.87.

[Table 4 about here.]

The same behavior can be observed in the correlation between the changes of the VIX Index and its futures. In this case the maximum and minimum values are lower than before: the correlation ΔUX1 vs ΔVIX is 0.82, while ΔUX3 vs ΔVIX is 0.74. The correlation values decays faster than the previous case.

[Table 5 about here.]

In table 6 we compute the statistics of the VIX term structure up to the 3rd month to maturity. As expected, the average slope is positive, given that the VIX future curve is usually in contango. Furthermore, all the slopes have a negative skew, i.e. they have a greater chance to assume extremely negative outcomes. This characteristic is not surprising, as the VIX term structure will abruptly reverse to backwardation during a stress on the equity market. We give particular attention to the slope of the VIX futures 1-3 months. It is viewed by the market participants as the benchmark of the relationship between short term (UX1), and medium term equity volatility (UX3). Further maturities are less common, due to the fact that they are are less liquid and more volatile. The 2005-2015 average for UX3-UX1 was 1.23, with a standard deviation of 2.77. Normally, the 1-3 slope oscillated around its mean.

However, during the periods of high stress in the financial markets, 2008 and 2011 in particular, it became very negative reaching its absolute minimum of -28 in October 2008 (UX1 higher than UX3 futures, backwardation). On the contrary, in the time frame 2008-2010, the slope has been very positive and stable. The maximum of the UX3-UX1 slopes of 7.65 was reached in March 2012.

[Table 6 about here.]

Every month, at a specific date, the VIX futures are rolled . A future roll consists of a switch from the front month contract that is close to expiration to another contract in a further-out month. At the roll date, the VIX future of the t month to maturity becomes the future of the *t-1* month to maturity. The roll date may represent a day of heightened volatility in the futures market.

At the the roll day the VIX futures with 3 months to expiration, for example, become the VIX futures with 2 months to expiration. Obviously, this will be reflected in a change of the price of tsuch future; in a normal condition, i.e. when the VIX term structure is in contango, the new price will be lower as the rolled future is closer to expiration. Furthermore, the t future will near the value of the *t-1* future over time as it approaches the roll date.

In table 7 we computed the statistics of the rolls of the VIX futures at 3,2 and 1 month to expiration; the future at 1 month to expiration (UX1) is considered to be rolled into the VIX Index itself: this will not happen as the future will cease to exist, but it is useful for our analysis as it represent a way to capture its value at expiration.The roll value is the difference between the past value of the future of maturity t and the new value of the same futures rolled and considered as the future of maturity *t-1*.

As described in the table, the highest average roll is the UX1/VIX Index roll, i.e. the representation of the difference between the value of the VIX future 1 month to expiration and the same future at the maturity date. In other

words, the UX1 future is the VIX future that loses the biggest value of all the futures of the VIX term structure curve. Furthermore, the same UX1/VIX roll has the highest standard deviation. Lastly, all the roll values present a negative skew, i.e. a higher probability of extremely negative outcomes. Negative outcomes happen when the the future rolls at a higher value as its maturity lowers.
The positive rolling effect is a periodical effect in normal market condition. A future with higher maturity should have a higher price than one closer to expiration. This characteristic of the roll would be useful for the development of our VIX strategies.

[Table 7 about here.]

4. VIX Futures Investment Strategies

From the analyisis of the VIX term structure and its roll statistics, we noted the presence of an average positive slope and, most importantly, a consistently positive roll of the curve, especially in the shorter part. Given these observations, we want to explore the following strategies: shorting the implied volatility of the equity market in order to enhance our income. Most of the time, the implied volatility captured by the VIX Index includes a risk premium that tends to disappear at the time of maturity: in other words, the 1-month implied volatility is usually higher than the spot implied volatility. Thereafter, by shorting the VIX index, we want to capture this risk premium.
Obviously, this premium is also present in the VIX index futures, due to their strong correlation with the underlying index; therefore we are focusing our attention on the VIX future 1-month to expiration (UX1), given its liquidity and high correlation with the underlying VIX. The strategy consists of systematically shorting equity volatility in order to capture the risk premia

of implied volatility.
Unfortunately, the VIX futures have been quoted from 2004: therefore, our statistical analysis present a limited time series, which could represent a limitation. In addition, the 2007 financial crisis has had a very interesting "break" effect on the strategy, caused by strong movements of volatility (high volatility of volatility), which have been partially present also the following years.

4.1. The vanilla strategy: shorting the futures

The first strategy consists in a short position on VIX futures rolled at the time of maturity, i.e. we close the position and we open a new one with the same maturity.
The strategy is tested in the 2005-2015 period with the generic VIX Future with settlement after 1 month (UX1), 2 months (UX2) and 3 months (UX3). We assume a total portfolio with a value of 100 thousands dollars per year, with 1 open position on a VIX future contract. The contract size for a VIX futures is 1,000 US dollar per index: thus, if the value of the future is 15, the value of the VIX future contract will be 15,000 USD.
By back-testing the possible roll dates on the most profitable strategy - the short UX1 index - we found that the most efficient time for the roll is to close the position one day before the roll date and to open the new position one day after the roll date, in order to avoid the most of the volatility of the futures roll period and to have enough liquidity, i.,e. decent bid-ask spread. As summarized in table 8, closing the short position at T-1 and reopening the short position at $\mathbf{T}$+1, where T is the roll day, clearly outperforms all the other possible cases up to 5 days before and after the roll date.

[Table 8 about here.]

In table 9 we summarize the results our our VIX shorting strategies. As we can see, in every case the strategies are profitable.In particular, the 1-

month strategy dominates the other two in terms of returns and risk, with a total return of 118%, a monthly total return of 0.6%, an average monthly return of 0.7% and a standard deviation of 3.4%.

[Table 9 about here.]

For the moment, we focus our attention on the short UX1 strategy, given that it is the best both in term of return and risk. As already mentioned, the total return was 118%, i.e. the original portfolio of 100 thousand dollars increased to 218 thousand dollars; the other strategies had a total return of 71% and 34%, respectively for the 2 months and 3 months to maturity.
First, we consider the statistics per month. The average total return for the UX1 strategy was 0.7% with a volatility of 3.4% and a monthly win/loss ratio of 2.2. The average drawdown was -4.6% and the maximum DD was -28%, experienced in 2009 during the financial crisis. The Sharpe Ratio versus the T-Bill was 0.18. By analyzing the statistics per year, the total return per month was 7.4%, the average return was 10.8% with a standard deviation of 14%. The win-loss ratio per year was 2.7, while the Sharpe ratio versus the T-Bill was 0.17. The UX1 short strategy outperformed the UX2 and UX3 strategies in most of the statistics.
Furthermore, the analysis of the strategy breakdown per month in figure 4 leads to various conclusions. Firstly, the average loss is generally higher than the average profit, -3.8% vs -3.0%. Equally, the maximum loss of -23.8% was consistently higher than the highest profit of 13.2%. Those events do not surprise as they are consistent with the VIX positive skew: equity volatility spikes are much higher than the respective downward movements and last a short amount of time; given that the strategy is shorting volatility, we are losing money. Although this characteristic can hurt the strategy performance, the losses did not last long - after a maximum of 4 months the strategy started to generate profit again - and most of the years they were

offset by the lower but stabler profits.
Thus, the strategy experienced positive profits in 8 out of 11 years, except in 2008 - when the equity volatility spiked due to the financial crisis - and 2014-15 - two years of low equity volatility interrupted by brief falls of the financial market. In 2008 the strategy registered a loss of -13%, while in 2014 and 2015 the losses were considerably lower, at -0.4% and -2.5% respectively. The period 2009-2013 were years of particularly good performances, with 31.5%, 30.2%, 10.9%, 31.8% and 8.5% of total yearly return respectively.
It is also present a seasonal effect, as the strategy had an average loss of -1.1% in the months of August and an average loss of -0.9% in the months of October, both well knows as months of financial instability. The most profitable months were April (+2.2%) and December (+1.8%). The average monthly returns ranged from 0.4% to 1.5%.
A last point of remark: in the last two years of our analysis, 2014 and 2015, shorting volatility was not a profitable strategy. The total return for the UX1 strategy was -0.7% in 2014 and -4.1% in 2015. It seems the VIX Index and its term structure have entered in a new regime where simply shorting volatility is no longer profitable. A more complex approach is necessary.

In conclusion, shorting volatility is a sound strategy if you apply it systematically and for a long period of time.

[Fig. 4 about here.]

[Fig. 5 about here.]

4.2. Long and short position on the VIX futures

The weakest point of a VIX shorting strategy, the huge losses during financial stresses, derived from the previously discussed negative skew of both

the VIX term structure curve and its roll characteristic. A negative skew means that there is a higher probability of extremely negative values: in our cases, these negative values were reflected in a consistent loss for the period. By considering the results that we obtained with the vanilla VIX shorting strategy, we tried to improve the strategy in two ways: by reducing the volatility and by lessening the huge losses that were registered during volatility spikes, mainly in 2008 and 2011. In the previous paragraph, we noted that the strategy had its weakness in the period of high financial stress. For this reason , we try to reduce these negative returns.

The first idea is to combine the short position on equity volatility with a long position on the same volatility, but in a different time horizon: in other words, we will open a short position on a VIX Index future and a long position on a VIX futures with a different time to maturity. The idea is developed by looking at the term structure of the VIX futures and how it is possible to generate a positive carry with the passing of time, by exploiting the differential of volatility (spread).

Given the results obtained with the vanilla strategies, we will take the best short strategy in term of returns- the UX1 - as the short leg, and the worst short strategy in term of returns - the UX3 - as the long leg of our long-short strategy. The idea behind this approach is to profit from a short position on equity volatility by taking the most efficient VIX future shorting strategy and at the same time to limit the losses derived from the VIX Index spikes during the periods of heightened financial stress. Obviously, the long position on the 3-month future will reduce the profit obtained during the calm period by shorting volatility. Both futures are rolled each month.

The implementation of the short UX1 - long UX3 futures present the following results. The combined strategy is better than the vanilla UX1 shorting, in terms of risk - monthly volatility is 2.4% vs 3.4%, average drawdown is -4.9% vs -6.4% - and performed worse in term of returns, with a monthly average return of 0.4 vs 0.7% of the UX1. Nonetheless, the combined strategy

is still highly profitable, with a total return of 57% vs a previous of 118%.

[Table 10 about here.]

As we can see from the monthly breakdown of the strategy results, the long-short strategy was able to reduce some of the huge losses registered during the periods of high financial stress. The trade-off was a lessened profitability in normal times, when the long position on equity volatility reduced the profits of the short position on the VIX.
As before, the last two years 2014 and 2015 were still negative, and 2015 saw a bigger loss than the short UX1 strategy. It seems that in the last two years it would have been better to go long UX1 and short UX3, inverting the two position of the combined strategy.

[Fig. 6 about here.]

[Fig. 7 about here.]

4.3. Short position on VIX futures with a contrarian indicator

The combined long-short strategy on VIX futures is useful to reduce the volatility on the VIX shorting strategy. Unfortunately, the trade-off is a reduced profit during the prolonged period of low equity volatility. In order to avoid this issue, we would take a different approach by analyzing the VIX Index trend and taking a trigger signal that would advise us to reverse the strategy of VIX future shorting. The aim is to avoid the losses that may happen during the time of high stress in the financial markets.
We consider three different indicators, based on the shapes of the VIX futures curve and the VIX index level: the difference between the VIX future 1 month

to expiration and the VIX (UX1-VIX), the difference between the VIX future 3 month to expiration and the VIX(UX3 -VIX) and the difference between the VIX futures 3 and 1 months to expiration (UX3-UX1). By studying the shape of the VIX term structure curve and the VIX index, we want to analyze and act on the base of the drift of the aforementioned curve from its average and its normal structure.
The strategy is updated in the following way:

- We derive the values of the indicator for each day of the strategy implementation
- We calculate the rolling 260 average of the indicator for each day
- If the average of a defined number of days of the indicator is outside a defined number of standard deviations from the average, we would invert the strategy for the next month, i.e. we would buy the VIX futures instead of shorting it.

The foundation of the indicator is to identify the situation of abnormality on the VIX term structure. We implement this concept by considering the drift movement of the slope from its average and inverting the shorting strategy at the next roll when the drift is outside a certain threshold: when the VIX future slope is outside a specific amount of standard deviation - we tested with 1, 1.5, 2 and 2.5 - from its 260 days average, we will invert the strategy of shorting volatility, by going long instead.
In figure 11 we tested the strategy with different sets of *a.* number of days of average considered for the value of the indicator and of **b** the standard deviations that represent the limit to trigger the inversion of the strategy.
The worst results are obtained if we choose 1 standard deviation from the average as the trigger point of the indicator. The strategy is still profitable, with a maximum total return of +167% if the indicator is built on a 15 days average of the difference between the VIX future 1 month and the VIX index. The results are better when the limit is set at 1.5 standard deviation from the average: in this case, the most profitable strategy is built when the

indicator is set on a 4-day average of the UX1-VIX spread. Finally, the best results are obtained when the trigger is positioned at 2 standard deviations from the average, with the indicator built again on a 4-day average of the UX1-VIX spread.

To summarize, the spread between the VIX future 1 month to expiration (UX1) and the VIX index is the most efficient variable for the construction of the indicator, while the limit to trigger the inversion of the strategy is best set at 2 standard deviations from the average, i.e. the UX1-VIX spread 4-day average has to move far away from the 260 rolling average of the said indicator. The threshold at 2.5 standard deviations is slightly worse than the best case at 2, thus confirming that our choice of 2 standard deviations as a limit to trigger a contrarian strategy is on the efficient frontier and represent the best implementation.

By applying this approach on our sample period, we would have inverted the strategy on October and November 2008, thus obtaining a 2-month profit of 45%, instead of a loss of the same amount. Unfortunately, we would have also stopped the strategy on November 2014, registering a loss of 14% instead of a profit.

[Table 11 about here.]

4.4. VIX INDEX strategies as portfolio enhancement strategies

The short VIX Index strategies that we introduced represent a series of portfolio enhancement strategies, i.e. they are implemented in order to increase the performance of a portfolio. In contrast with the majority of the portfolio managers, we will not use a long position on the VIX Index in order to hedge the portfolio, instead we want to increase the portfolio returns by shorting equity volatility. This approach may increase the losses during the

periods of high financial stress, when the equity market falls and the VIX index rises abruptly. Thereafter, the volatility of the enhanced portfolio may be higher than the respective one of the base portfolio.

We consider a 1 million dollar long position on the SPDR S&P 500 ETF Trust (SPY), an exchange-trade fund incorporated in the USA which tracks the S&P500 Index, as the base portfolio . On top of this portfolio, we will implement our VIX strategy for a notional amount of 10, 20 and 30% of the notional amount of the base portfolio. The aim is to enhance the return of the strategy.

We analyzed the 3 VIX index strategies that we considered in the previous paragraph: a short position in UX1, a long position in UX3 with a short position on UX1, and the short UX1 with the contrarian indicator strategy. Each of the strategy is implemented with a notional as a percentage of the long position in the SPY ETF. For example, the first strategy we tested was a long position of 1 million US dollars in the SPY and a 10% short position on UX1 (i.e. 100,000 US dollars): the total portfolio would be 1,100,000 US dollars.

The results are presented in the following tables. As expected, the implementation of the VIX strategy enhances the portfolio returns. However, there is a second effect: the overall volatility of the portfolio is reduced. By increasing the amount of the VIX Index strategies, expressed as a percentage of the notional amount of the long position on the SPY, the standard deviation of the composite portfolio is increasingly reduced and the average returns increased.

The first strategy we tested was the base VIX strategy of a short position on the VIX future 1 month to expiration.The short UX1 strategy increases the average return of the base SPY strategy from 5.5% to 6.5% and the volatility from 15.1% to 14.3%, when the notional of the VIX strategy is 30% of the SPY notional (i.e. the composite portfolio is composed of 1 million US dollars and 300,000 US dollars of short UX1 futures. If the notional of the

strategy is increased to 50% of the SPY notional, the average return improves to 6.6% and the standard deviation to 13.4%; at 100% of the SPY notional, the average return reached 6.9% with a volatility of 12%.

The second strategy, the long position on UX3 coupled with a short position on UX1, presented an opposite behavior than the previous strategy. In this case, the implementation of the enhancing VIX strategy reduced the average return of the overall portfolio, but also lowered consistently its volatility. The average return is less (from 5.5% to 5.7% at 30% of the SPY notional, to 5.5% at 50%, to 5.2% at 100% of the notional), by reducing importantly the volatility (from 15.1% to 12.8% at 30% of SPY notional, to 11.2% at 50%, to 8.6% at 100% of the notional). If we compared the two strategies at an implementation rate of 100% of SPY notional, we find that the UX1 strategy increased the average return of 1.4% and the total return of 9.9% by reducing the volatility for 3.1%. On the contrary, the UX3-UX1 strategy reduced the average return of 0.3%, the total return of 8.8% and the volatility of 6.5%. In summary, by introducing a long position on the VIX futures 3 months to expiration we lost 1.7% of average return, 18.8% of total return and gained 3.4% of less volatility.

The last strategy that we introduced, the short position on UX1 supported by the contrarian indicator, which was the best in term of profitability and volatility, performed as the best one also as a portfolio enhancement strategy. At 30% of the long SPY portfolio, the average return increased from 5.5% to 7.6% with a volatility decreasing from 15.1% to 11.1%. When the enhanced portfolio is at 50% of the notional, the average return is at 8.2% and the standard deviation is at 9.0%. When the SPY portfolio is enhanced at 100% of notional with the VIX strategy, the average return increases to 9.4% and the volatility decreases to 6.8%.

The 3 VIX strategies retained their characteristics when implemented in a portfolio enhancing view: the short UX1 had high returns coupled with high volatility, while the long UX3-short UX1 sacrificed a portion of the return in

order to be less volatile. The third strategy, the short UX1 with the contrarian indicator, was the best in terms of both return and volatility.
The results of the enhancing strategy are somewhat curious, considering that the bulk of the VIX strategies is based on selling equity volatility. As described in the paragraph on the VIX Index properties, the VIX Index and its futures greatly increased during a fall of the stock market. Given that the composite portfolio is composed by a long position on the S&P500 ETF and a short position on VIX futures, we would have expected to register an increased loss than we would have registered in a simple long position on the SPY, without the enhancing strategy. These additional losses indeed happened in the implementation of the strategy, but they are mitigated by two factors: first of all, the VIX index spikes usually did not last for a long time while the equity market did not recuperate its losses in the short time, thus reducing the percentage loss of the overall portfolio if compared to the loss of the single position of the SPY. Second of all, it is most common in the financial markets to experience a negative trend with low volatility than the opposite situation of a positive trend with high volatility; thanks to that, the combined portfolio would outperform the simple long position in the S&P500.

[Table 12 about here.]

[Table 13 about here.]

[Table 14 about here.]

[Table 15 about here.]

[Fig. 8 about here.]

[Fig. 9 about here.]

[Fig. 10 about here.]

5. Conclusion

In this paper we presented the results of shorting implied equity volatility, represented by the VIX index, by investing in a short position on VIX futures. The results are straightforward: a short position on the VIX index generated profit throughout the life of the instrument, with the exception of 2008 and 2014-2015. Shorting implied equity volatility is a profitable strategy due to the fact that most of the time the implied volatility, thus the VIX index and its futures, are higher than realized volatility; consequently, by selling the VIX futures at the roll date and closing the position at the time of maturity - and reopening a similar position - we were able to catch the risk premium of the implied volatility.

A strategy built on a short position on the most liquid of the VIX futures, the 1-month to expiration (UX1), generated the best profit in the 2004-2015 period: a 198% total return, 1% average monthly return and 5.1% monthly standard deviation; as expected, the strategy was highly negative in 2008 due to the spike on equity volatility during the financial crisis. Unfortunately, the strategy did not performed well in the last two years 2014 and 2015.

In order to reduce the volatility of the strategy, which suffers from some huge losses caused by the sudden spike of equity volatility, we introduced a calendar spread on the most profitable VIX shorting strategy. The strategy built with a short position on the VIX future 1 month to expiration and a long position on the VIX future 3 months to expiration did indeed reduced the volatility of the volatility shorting strategy, while remaining highly profitable.

Finally, we tried a different approach by analyzing the VIX term structure, in order to invert the short volatility strategy in case of stress on the implied volatility curve. Therefore, we compared the spread between different points of the VIX term structured in terms of average and standard deviations, inverting the strategy when the average of the spread was outside a certain number of standard deviations from the average. The results are promising: it is indeed possible to reduce some of the huge losses that could happen

during equity volatility spikes.
Two points of a short volatility strategy has to be further developed, in order to build a strategy efficient during all financial conditions. Firstly, it is necessary to adopt an indicator or a rule that could predict a probable situation of stress on the volatility market, such as our analysis on the VIX term structure curve. Secondly, the negative performance of the last two years 2014 and 2015 has to be analyzed, in order to understand if it represents a new paradigm for volatility investing, or just a short or medium-term drift from the normal behaviour of the VIX index.

Appendix

VIX Index calculation

The general formula used for VIX calculation is :

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2 \tag{1}$$

where

σ is $\frac{VIX}{100} \Rightarrow VIX = \sigma \times 100$

T is time to expiration

F Forward index level derived from index option prices

K_0 First strike below the forward index level, F

K_i Strike price of i^{th} out-of-the-money option; a call if $K_i > K_0$ and a put if $K_i < K_0$; both put and call if $K_i = K_0$

ΔK_i Interval between strike prices, half the difference between the strike on either side of K_i:

$$\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2}$$

(note: ΔK for the lowest strike is simply the difference between the lowest strike and the next higher strike. Likewise,ΔK for the highest

strike is the difference between the highest strike and the next lower strike)

R Risk-free interest rate to expiration

$Q(K_i)$ The midpoint of the bid-ask spread for each option with strike K_i.

The VIX measures 30-days expected volatility of the S&P500 index (SPX). The VIX components are put and call options "near term" and "next term", usually of the first and second SPX contract months. "Near-term" options must have at least a week to expiration: the condition is requested to minimize price anomalies that can happen close to the expiration date. When the "near-term" options have less than a week to expiration, the VIX rolls to the second and third SPX contract months. For example, on the second Friday of April, the VIX will be calculated using SPX options that expire in June and July. Next Monday, July will replace June as "near-term" and August will replace July as "next-term".

The method for VIX calculation measures the time to expiration, T, in calendar days and divides each day in minutes with the aim to replicate the precision usually employed by professional investors of options and volatility. The time to expiration is given by the expression:

$$T = M_{current\ day} + M_{settlement\ day} + M_{other\ days}/minutes\ in\ a\ year$$

where

$M_{current\ day}$ = minutes remaining until midnight of the current day

$M_{settlement\ day}$ = minutes from midnight until 8:30 a.m. on SPX settlement day

$M_{other\ days}$ = total minutes in the days between current day and settlement day.

VIX is obtained as the square root of the price of variance, and this price is derived as the forward price of a particular strip of SPX options. The justification for this derivation is that variance is replicated by delta-hedging the options in the strip. An intuitive explanation of the mechanics of this replication is based on the work of Demeterfi, Derman, Kamal and Zou (1999).

The fundamental idea is that the price of a stock index option varies with the index level and with its total variance to expiration. This suggests using S&P500 options to design a portfolio that isolates the variance. The portfolio which does that is centered around two strips of out-of the money S&P 500 calls and puts. Its exposure to the risk of stock index variations is eliminated by delta hedging with a forward position in the S&P500. A clean exposure to volatility risk independent of the value of the stock index is obtained by calibrating the options to yield a constant sensitivity to variance. If each option is weighed by the inverse of the square of its strike price times a small strike interval centered around its strike price, the sensitivity of the portfolio to total variance is equal to one. Holding the portfolio to expiration therefore replicates the total variance. Arbitrage implies that the forward price of variance must be equal to the forward price of the portfolio which replicates it. Observing that the S&P500 forward positions in the portfolio contribute nothing to its value, the forward price of variance is reduced to the forward price of the strips of options.

VIX Index futures

[Fig. 11 about here.]

[Fig. 12 about here.]

VIX futures strategies statistics

[Table 16 about here.]

[Table 17 about here.]

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Useful Links

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List of Figures

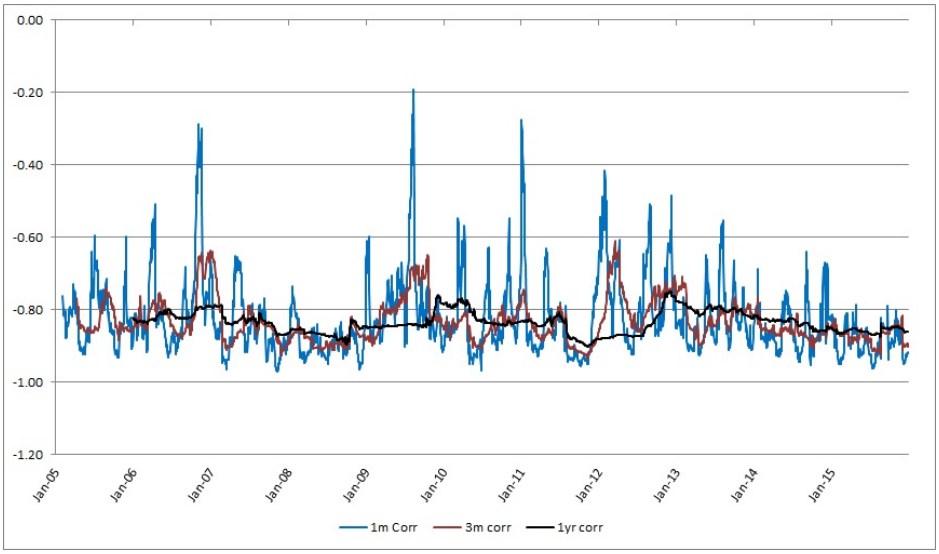

Fig. 1. VIX Index -S&P500 1 year correlation, 2006-2015

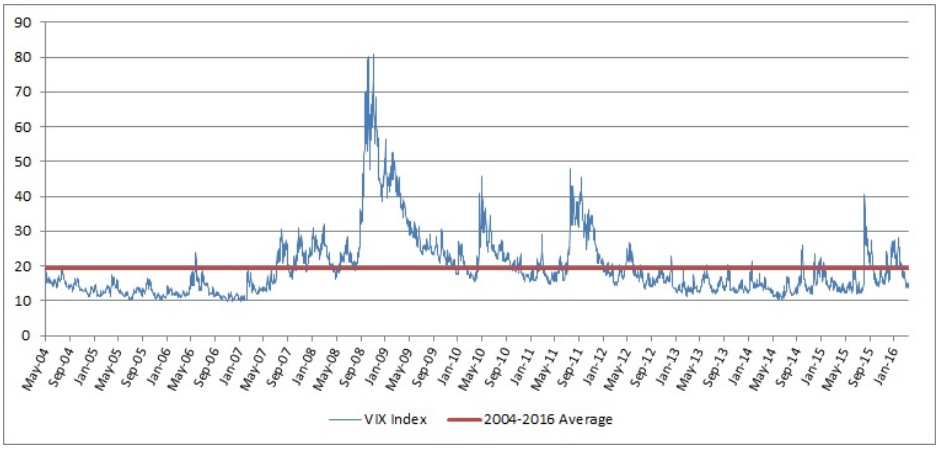

Fig. 2. VIX Index and average 2004-march 2016

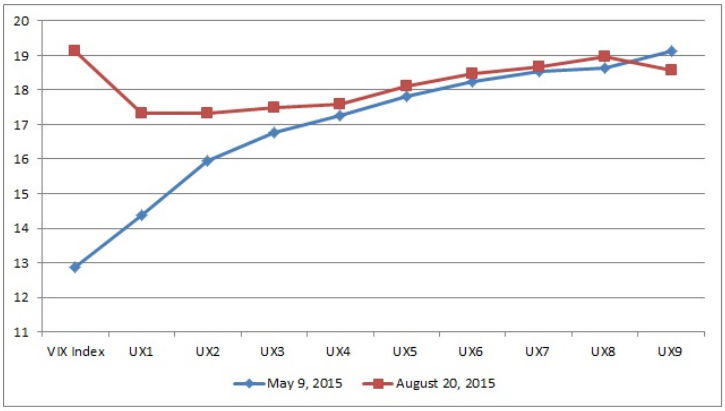

Fig. 3. VIX Term structure on 9 May 2015 and 20 August 2015

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average	Seasonality
January	2.3%	1.1%	3.0%	0.0%	-12.9%	10.8%	4.1%	4.3%	5.4%	2.2%	-5.1%	1.3%	93.4%
February	4.3%	1.8%	1.0%	2.1%	3.4%	0.0%	3.2%	4.5%	2.9%	-1.4%	2.7%	2.0%	148.3%
March	-2.0%	1.9%	-3.4%	-1.1%	7.3%	7.2%	-10.3%	11.8%	1.1%	-1.2%	3.3%	1.2%	88.5%
April	-1.6%	-0.2%	2.4%	6.8%	9.4%	6.3%	13.4%	0.2%	1.6%	0.1%	4.8%	3.6%	262.5%
May	-0.4%	-1.1%	-1.7%	9.2%	14.4%	-23.5%	0.2%	-2.6%	6.0%	4.2%	3.3%	0.7%	48.7%
June	4.7%	-4.0%	2.0%	1.0%	0.3%	16.8%	-1.1%	12.8%	-4.8%	2.8%	-1.1%	2.4%	178.5%
July	1.9%	-3.7%	-0.9%	-9.6%	8.9%	4.8%	4.4%	11.1%	8.8%	0.9%	1.4%	2.3%	170.8%
August	-0.5%	5.0%	-14.9%	5.4%	-0.8%	4.8%	-25.6%	2.8%	0.7%	2.4%	-2.3%	-1.9%	-140.2%
September	1.1%	3.5%	17.1%	-12.7%	7.1%	13.6%	-0.3%	2.6%	1.3%	0.5%	-9.0%	2.1%	149.8%
October	-0.9%	4.4%	1.3%	-39.7%	8.3%	6.8%	10.6%	1.4%	-5.8%	-11.5%	7.2%	-1.5%	-110.3%
November	5.3%	3.7%	-6.8%	-5.5%	1.8%	-0.5%	3.3%	2.5%	1.4%	13.8%	-5.0%	1.2%	85.1%
December	2.0%	1.6%	6.9%	22.0%	5.4%	3.3%	16.3%	1.4%	-4.3%	-13.3%	-4.2%	3.1%	225.0%
Total Ret	16.2%	13.9%	6.0%	-22.0%	52.5%	50.3%	18.2%	52.9%	14.2%	-0.7%	-4.1%	197.2%	
Avg	*1.3%*	*1.2%*	*0.5%*	*-1.8%*	*4.4%*	*4.2%*	*1.5%*	*4.4%*	*1.2%*	*-0.1%*	*-0.3%*	*1.5%*	
STDEV	*2.4%*	*2.8%*	*7.3%*	*14.4%*	*6.6%*	*9.7%*	*10.6%*	*4.7%*	*4.3%*	*6.7%*	*4.6%*	*7.7%*	

Fig. 4. VIX futures 1 month (UX1) short strategy, per month breakdown returns, 2005-2015

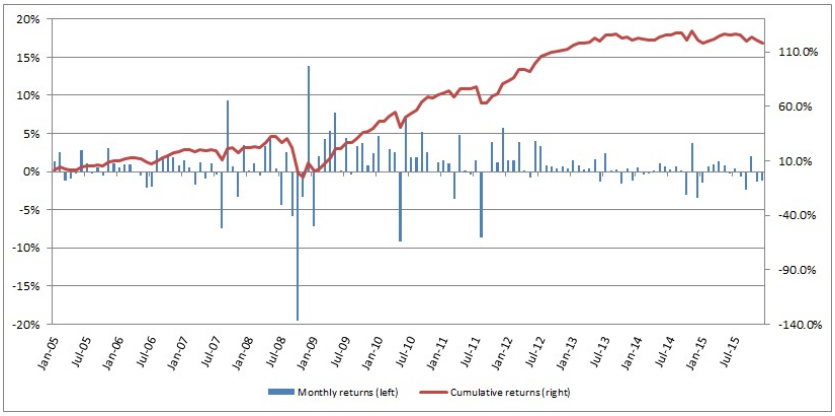

Fig. 5. VIX futures 1 month (UX1) short strategy, monthly and cumulative returns, 2005-2015

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average	Seasonality
January	2.1%	0.9%	0.9%	1.6%	-4.8%	3.0%	0.6%	1.5%	2.3%	-0.2%	-1.5%	6.3%	79.9%
February	0.0%	1.5%	0.4%	-0.8%	-2.0%	0.1%	-2.2%	1.3%	-0.8%	-1.8%	2.8%	-1.2%	-15.4%
March	-2.2%	0.0%	-1.1%	-0.8%	3.5%	3.3%	-5.0%	5.8%	0.2%	-0.1%	1.5%	5.2%	66.1%
April	0.0%	-0.3%	1.2%	4.1%	8.3%	2.6%	7.2%	-2.3%	-0.6%	-0.1%	2.7%	22.7%	287.8%
May	-0.5%	-1.2%	-0.4%	7.0%	2.9%	-9.3%	-2.0%	-1.2%	2.9%	1.5%	0.8%	0.6%	7.6%
June	4.6%	-0.5%	1.2%	-0.6%	-0.5%	8.7%	-2.3%	7.2%	-1.6%	0.3%	-0.9%	15.7%	198.6%
July	1.0%	-3.8%	1.4%	-5.7%	7.6%	7.2%	0.8%	1.8%	4.4%	-1.0%	0.8%	14.4%	182.8%
August	0.3%	4.9%	-6.3%	5.0%	-0.3%	3.8%	-17.3%	0.8%	-1.3%	1.2%	-1.4%	-10.7%	-135.9%
September	1.0%	2.0%	12.6%	-10.0%	3.8%	5.8%	3.8%	-2.5%	-0.2%	0.7%	-3.8%	13.2%	167.8%
October	-1.1%	1.3%	2.2%	-27.3%	4.9%	2.4%	5.2%	-1.3%	-4.1%	-5.2%	3.2%	-19.7%	-250.2%
November	5.2%	1.5%	1.9%	22.4%	3.4%	-2.6%	2.5%	0.5%	0.5%	6.8%	-3.3%	38.8%	491.3%
December	2.1%	2.3%	3.3%	14.0%	3.7%	-2.4%	6.0%	-2.5%	-4.9%	-7.8%	-4.3%	9.4%	119.6%
Total Ret	12.7%	8.8%	17.2%	8.9%	30.6%	22.6%	-2.8%	9.2%	-3.2%	-5.8%	-3.6%	94.7%	
Avg	*1.1%*	*0.7%*	*1.4%*	*0.7%*	*2.5%*	*1.9%*	*-0.2%*	*0.8%*	*-0.3%*	*-0.5%*	*-0.3%*	*0.7%*	
STDEV	*2.1%*	*2.0%*	*4.1%*	*11.8%*	*3.6%*	*4.7%*	*6.3%*	*3.0%*	*2.6%*	*3.4%*	*2.5%*	*5.0%*	

Fig. 6. Combined short UX1 - long UX3 strategy, per month breakdown returns, 2005-2015

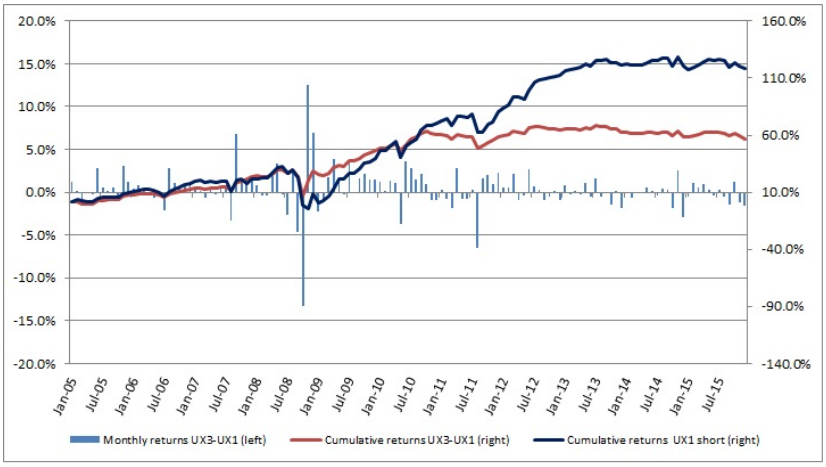

Fig. 7. Combined short UX1 - long UX3 strategy, monthly and cumulative returns, 2005-2015

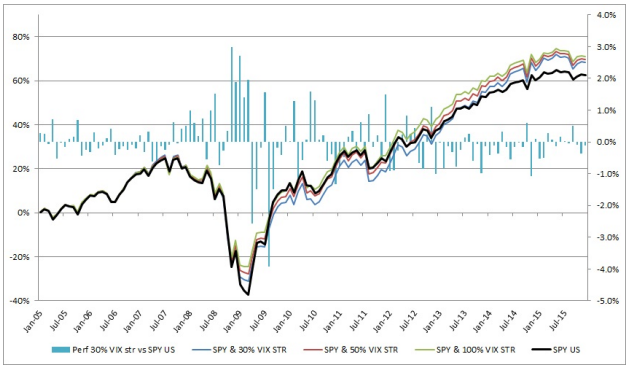

Fig. 8. Long SPY US portfolio base VS enhanced by short UX1 strategy, expressed as a percentage of the notional amount, total return, 2005-2015

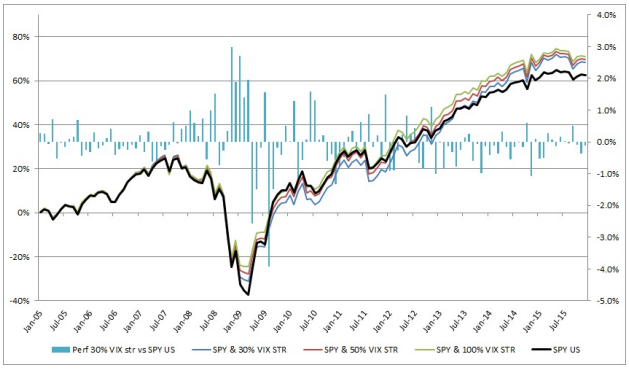

Fig. 9. Long SPY US portfolio base VS enhanced by short UX1-long UX3 with indicator strategy, expressed as a percentage of the notional amount, total return, 2005-2015

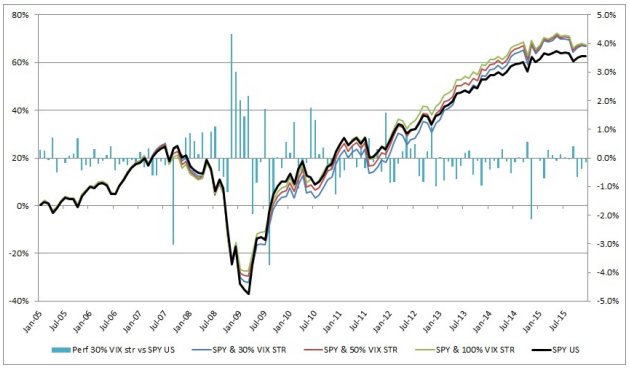

Fig. 10. Long SPY US portfolio base VS enhanced by short UX1 with indicator strategy, expressed as a percentage of the notional amount, total return, 2005-2015

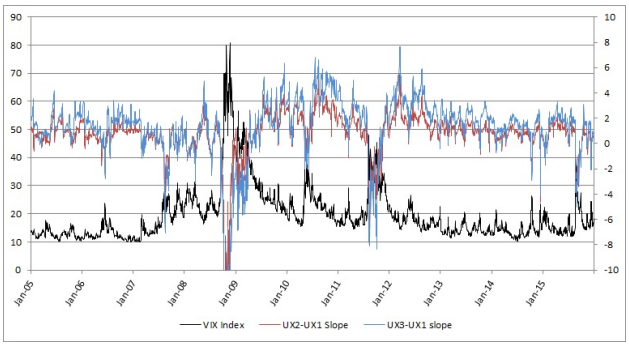

Fig. 11. VIX Index and VIX futures slopes, 2005-2015

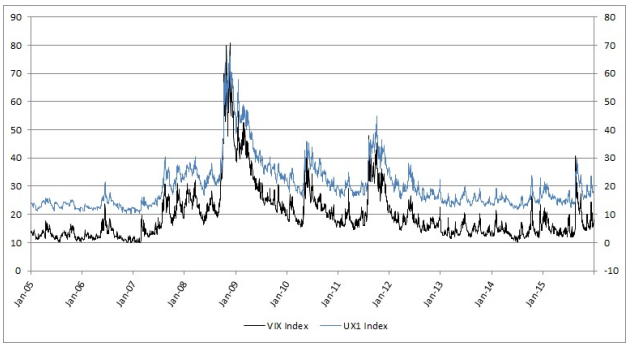

Fig. 12. VIX future 1 month to expiration (UX1) and VIX Index, 2005-2015

List of Tables

$\Delta VIX/\Delta S\&P$ *Correlation*	Average	Median	Min	Max	St Dev	Skew
1 month	-0.83	-0.85	-0.97	-0.19	0.1	1.92
3 months	-0.83	-0.85	-0.93	-0.61	0.06	1.15
1 year	-0.84	-0.84	-0.90	-0.75	0.03	0.36

Table 1: Correlation of VIX-S&P500 daily variations 1,2 months 1 year, 2005-2015

VIX contango	Average	Median	Min	Max	St Dev	Skew	Kurtosis
UX1-UX3	9%	10%	-44%	47%	10%	-0.7	1.5
UX4-UX7	4%	5%	-16%	28%	5%	-0.3	0.8

Table 2: VIX term structure contango statistics, 2005-2015

Contango RR (days)	UX1-UX3	UX4-UX7
1	38%	42%
3	28%	30%
5	9%	8%
10	14%	2%
15	1%	5%
30	6%	7%
60	3%	5%
90	0%	0%
180	1%	0%
260	0%	2%

Table 3: Rate of return in days from backwardation to contango for the VIX term structure, 2005-2015

VIX Future	UX1	UX2	UX3	UX4	UX5	UX6	UX7	UX8	UX9
Correlation	0.98	0.94	0.87	0.88	0.79	0.78	0.81	0.63	0.58

Table 4: Correlation between the values of VIX Futures and VIX Index, 2004-2015

ΔVIX Future	UX1	UX2	UX3	UX4	UX5	UX6	UX7	UX8	UX9
Correlation	0.82	0.76	0.74	0.69	0.68	0.64	0.58	0.48	0.33

Table 5: Correlation between the changes of VIX Futures and VIX Index, 2004-2015

	Average	Median	Max	Min	St Dev	Skew	Kurtosis
UX3-UX2	0.49	0.65	3.25	-10.25	1.08	-2.50	13.56
UX3-UX1	1.23	1.65	7.65	-28.41	2.77	-3.53	23.32
UX2-UX1	0.73	0.95	5.45	-21.10	1.87	-3.97	29.19
UX1-VIX	0.50	0.66	4.97	-23.31	1.92	-4.69	39.82

Table 6: VIX futures slopes statistics, 2005-2015

	Average	St Dev	Skew	Kurtosis
Roll UX3/UX2	0.39	1.17	-3.26	15.48
Roll UX2/UX1	0.48	2.04	-4.17	28.18
Roll UX1/VIX	0.85	2.33	-2.95	12.28

Table 7: VIX futures roll statistics, 2005-2015

Open/close the position at	T+5	T+4	T+3	T+2	T+1
T-5	1.5%	14.4%	13.8%	52.3%	65.8%
T-4	32.6%	45.5%	45.0%	83.5%	96.9%
T-3	28.7%	22.5%	22.0%	60.5%	73.9%
T-2	23.9%	36.8%	36.3%	74.8%	88.3%
T-1	54.0%	66.9%	66.4%	104.9%	**118.3%**

Table 8: Backtest of short UX strategy with different days for opening and closing the positions, 2005-2015

Per Month Statistics	1 Month	2 Months	3 Months
Initial Value	100,000	100,000	100,000
Final Value	218,330	171,320	134,310
Total Return	118.3%	71.3%	34.3%
Total Return - month	0.6%	0.4%	0.2%
Average Return	0.7%	0.5%	0.3%
Standard Deviation	3.4%	3.4%	3.3%
Skewness	-1.4	-1.7	-2.5
Kurtosis	10.1	8.8	15.6
Win/loss Ratio	2.2	1.8	1.4
Avg Drawdown - value	-6,957	-6,925	-8,690
Avg Drawdown - %	-4.6%	-5.8%	-8.1%
Max Drawdown - value	-37,290	-37,520	-40,740
Max Drawdown - %	-28.1%	-35.7%	-39.9%
Sharpe Ratio	0.18	0.13	0.08
CVaR 5%	-10.0%	-9.0%	-8.5%
Amount	-9,984	-9,044	-8,513

Per Year Statistics	1 Month	2 Months	3 Months
Total Return - month	7.4%	5.0%	2.7%
Average Return	10.8%	10.8%	5.2%
Standard Deviation	14.1%	23.2%	20.2%
Win/loss Ratio	2.7	2.7	1.8
Sharpe Ratio	0.17	0.13	0.08

Table 9: VIX shorting vanilla strategy, 1-2-3 months to expiration, 2004-2015, per month per year statistics $1000 for point of volatility

Per Month Statistics	Short UX1	Short UX1 - Long UX3
Initial Value	100,000	100,000
Final Value	218,330	156,790
Total return	118.3%	56.8%
Total Return - month	0.6%	0.3%
Average Return	0.7%	0.4%
Standard Deviation	3.4%	2.4%
Skewness	-1.4	-0.4
Kurtosis	10.1	13.2
	0.0	
Win/loss Ratio	2.2	1.5
Avg Drawdown - value	-6,957	-4,848
Avg Drawdown - %	-4.6%	-3.4%
Max Drawdown - value	-37,290	-23,170
Max Drawdown - %	-28.1%	-17.8%
Sharpe Ratio	0.18	0.14
CVaR 5%	-10.0%	-7.8%
Amount	-9,984	-7,805

Per Year Statistics	Short UX1	Short UX1 - Long UX3
Total Return - month	7.4%	4.2%
Average Return	10.8%	8.6%
Standard Deviation	14.1%	11.2%
Win/loss Ratio	2.7	1.8
Sharpe Ratio	0.17	0.14

Table 10: Short UX1, long UX3 strategy,2004-2015, per month per year statistics $1000for point of volatility

	1 std dev.			1.5 std dev.			2 std dev.			2.5 std dev.		
# days of avg	UX3-UX1	UX3-VIX	UX1-VIX	UX3-UX1	UX3-VIX	UX1-VIX	UX3-UX1	UX3-VIX	UX1-VIX	UX3-UX1	UX3-VIX	UX1-VIX
20	27.6%	-5.3%	38.8%	37.1%	71.8%	90.3%	**116.7%**	116.7%	125.3%	118.3%	124.9%	124.9%
19	30.3%	-5.0%	38.8%	37.1%	32.4%	76.1%	116.7%	96.2%	125.3%	124.9%	125.3%	124.9%
18	30.3%	-15.6%	28.0%	42.8%	38.1%	73.3%	96.2%	96.2%	125.3%	125.3%	125.3%	124.9%
17	10.2%	-15.6%	52.7%	40.0%	31.6%	81.9%	96.2%	104.8%	125.3%	125.3%	125.3%	124.9%
16	10.2%	-15.6%	61.3%	38.3%	29.9%	81.9%	96.2%	104.8%	125.3%	125.3%	125.3%	125.3%
15	-24.8%	-21.9%	**100.0%**	38.3%	56.3%	81.9%	96.2%	104.8%	125.3%	125.3%	125.3%	125.3%
14	-30.1%	-21.9%	98.6%	38.3%	54.9%	84.7%	79.7%	84.7%	125.3%	125.3%	125.3%	125.3%
13	-30.1%	**60.4%**	93.3%	39.1%	63.5%	68.2%	79.7%	68.2%	105.2%	**125.3%**	125.3%	125.3%
12	0.6%	57.8%	93.3%	17.6%	60.0%	68.2%	84.1%	72.6%	105.2%	104.8%	125.3%	125.3%
11	0.6%	57.8%	93.3%	20.4%	54.7%	115.9%	84.1%	72.6%	105.2%	104.8%	84.7%	125.3%
10	0.4%	48.2%	85.1%	20.4%	75.9%	115.9%	84.1%	70.9%	105.2%	104.8%	84.7%	125.3%
9	-4.6%	42.3%	89.9%	20.4%	**107.2%**	115.9%	64.0%	66.5%	105.2%	88.3%	68.2%	125.3%
8	43.0%	48.0%	94.8%	26.5%	83.7%	115.9%	66.3%	66.5%	156.5%	88.3%	88.3%	125.3%
7	**44.7%**	41.3%	88.1%	25.2%	83.7%	115.9%	72.4%	115.9%	156.5%	88.3%	88.3%	124.9%
6	23.8%	48.0%	92.1%	**80.5%**	79.7%	115.9%	47.9%	126.8%	156.1%	94.4%	88.3%	108.4%
5	15.6%	49.9%	94.2%	77.9%	78.6%	120.7%	47.9%	126.8%	156.1%	94.4%	115.9%	156.1%
4	15.6%	43.8%	92.7%	56.5%	69.5%	**141.3%**	95.6%	**127.2%**	**156.5%**	74.3%	120.7%	156.1%
3	38.3%	43.8%	77.8%	35.0%	59.4%	141.3%	95.6%	119.6%	156.1%	122.0%	120.7%	149.5%
2	22.4%	54.5%	62.2%	48.7%	65.9%	104.6%	110.2%	110.7%	136.0%	122.0%	**126.8%**	**156.1%**
1	42.1%	36.7%	50.9%	18.6%	44.8%	81.2%	54.6%	72.2%	70.4%	82.2%	104.6%	125.6%

Table 11: Calendar Spread strategy, 2005-2014, VIX Futures as 20% of portfolio

		Short UX1 Strategy									
Per Year Statistics	**SPY US**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Total Return - month	4.7%	4.8%	4.9%	5.0%	5.1%	5.1%	5.2%	5.2%	5.2%	5.3%	5.3%
Average Return	5.5%	6.2%	6.3%	6.5%	6.6%	6.6%	6.7%	6.8%	6.8%	6.9%	6.9%
Total Return	66.5%	68.3%	69.8%	71.1%	72.2%	73.1%	73.9%	74.7%	75.3%	75.9%	76.4%
Standard Deviation	15.1%	15.7%	14.9%	14.3%	13.8%	13.4%	13.0%	12.7%	12.4%	12.2%	12.0%
Win/loss Ratio	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Sharpe Ratio	0.11	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.14	0.14	0.14

		Short UX1 - Long UX3									
Per Year Statistics	**SPY US**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Total Return - month	4.7%	4.6%	4.6%	4.5%	4.4%	4.4%	4.4%	4.3%	4.3%	4.3%	4.2%
Average Return	5.5%	5.9%	5.8%	5.7%	5.6%	5.5%	5.4%	5.4%	5.3%	5.3%	5.2%
Total Return	66.5%	64.8%	63.5%	62.4%	61.4%	60.6%	59.8%	59.2%	58.6%	58.1%	57.6%
Standard Deviation	15.1%	15.1%	13.8%	12.8%	11.9%	11.2%	10.5%	9.9%	9.4%	9.0%	8.6%
Win/loss Ratio	10.0	10.0	10.0	10.0	10.0	4.5	4.5	4.5	4.5	4.5	4.5
Sharpe Ratio	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.14

		Short UX1 with indicator									
Per Year Statistics	**SPY US**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Total Return - month	4.7%	4.9%	5.1%	5.2%	5.3%	5.4%	5.4%	5.5%	5.6%	5.6%	5.7%
Average Return	5.5%	6.3%	6.5%	6.7%	6.9%	7.1%	7.2%	7.3%	7.4%	7.5%	7.6%
Total Return	66.5%	69.5%	72.0%	74.2%	76.0%	77.6%	79.0%	80.2%	81.3%	82.3%	83.1%
Standard Deviation	15.1%	14.6%	13.0%	11.7%	10.6%	9.7%	8.9%	8.3%	7.7%	7.3%	6.9%
Win/loss Ratio	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Sharpe Ratio	0.11	0.12	0.13	0.15	0.16	0.17	0.18	0.19	0.19	0.20	0.21

Table 12: Long SPY US portfolio enhanced by VIX strategies, expressed as a percentage of the notional amount, Per year statistics, 2005-2015

		Short UX1 Strategy			
Per Month Statistics	**SPY US**	**10%**	**30%**	**50%**	**100%**
Initial Value	1,000,000	1,100,000	1,300,000	1,500,000	2,000,000
Final Value	1,664,536	1,850,946	2,223,767	2,596,588	3,528,641
Total Return	66.5%	68.3%	71.1%	73.1%	76.4%
Total Return - month	0.4%	0.4%	0.4%	0.4%	0.4%
Average Return	0.5%	0.5%	0.5%	0.5%	0.5%
Standard Deviation	4.1%	3.9%	3.6%	3.4%	3.1%
Skewness	-1.1	-1.2	-1.4	-1.4	-1.4
Kurtosis	5.0	5.4	6.1	6.8	8.3
Win/loss Ratio	1.8	1.9	2.0	2.1	2.1
Avg Drawdown - value	-183,913	-72,826	-71,764	-80,612	-96,956
Avg Drawdown - %	-12.3%	-5.1%	-4.3%	-4.1%	-3.7%
Max Drawdown - value	-744,401	-632,467	-649,765	-675,116	-752,053
Max Drawdown - %	-53.6%	-45.5%	-39.8%	-36.1%	-30.3%
Sharpe Ratio	0.11	0.11	0.12	0.13	0.14
CVaR 5%	-10.6%	-10.4%	-10.0%	-9.2%	-8.3%
Amount	-106,190	-114,007	-129,641	-137,606	-166,525

Table 13: Long SPY US portfolio enhanced by short UX1 strategy, expressed as a percentage of the notional amount, Per month statistics, 2005-2015

		Short UX1 - Long UX3			
Per Month Statistics	**SPY US**	**10%**	**30%**	**50%**	**100%**
Initial Value	1,000,000	1,100,000	1,300,000	1,500,000	2,000,000
Final Value	1,664,536	1,813,326	2,110,906	2,408,486	3,152,436
Total Return	66.5%	64.8%	62.4%	60.6%	57.6%
Total Return - month	0.4%	0.4%	0.4%	0.4%	0.3%
Average Return	0.5%	0.5%	0.4%	0.4%	0.4%
Standard Deviation	4.1%	3.7%	3.2%	2.9%	2.4%
Skewness	-1.1	-1.2	-1.3	-1.4	-1.8
Kurtosis	5.0	5.0	5.7	6.8	9.4
Win/loss Ratio	1.8	1.8	1.9	1.9	2.0
Avg Drawdown - value	-183,913	-71,449	-73,630	-71,972	-79,204
Avg Drawdown - %	-12.3%	-5.1%	-4.4%	-3.7%	-3.1%
Max Drawdown - value	-744,401	-616,294	-601,246	-586,197	-556,890
Max Drawdown - %	-53.6%	-44.4%	-37.0%	-31.5%	-22.6%
Sharpe Ratio	0.11	0.11	0.12	0.13	0.14
CVaR 5%	-10.6%	-9.9%	-8.8%	-8.0%	-7.1%
Amount	-106,190	-108,818	-114,075	-119,331	-142,807

Table 14: Long SPY US portfolio enhanced by long UX3-short UX1 strategy, expressed as a percentage of the notional amount, Per month statistics, 2005-2015

		Short UX1 with indicator			
Per Month Statistics	**SPY US**	**10%**	**30%**	**50%**	**100%**
Initial Value	1,000,000	1,100,000	1,300,000	1,500,000	2,000,000
Final Value	1,664,536	1,864,359	2,264,005	2,663,651	3,662,767
Total Return	66.5%	69.5%	74.2%	77.6%	83.1%
Total Return - month	0.4%	0.4%	0.4%	0.4%	0.5%
Average Return	0.5%	0.5%	0.5%	0.5%	0.5%
Standard Deviation	4.1%	3.6%	3.0%	2.6%	2.2%
Skewness	-1.1	-1.0	-0.8	-0.7	-0.6
Kurtosis	5.0	4.0	2.7	2.3	2.5
Win/loss Ratio	1.8	1.9	1.9	2.1	2.2
Avg Drawdown - value	-183,913	-72,435	-67,214	-69,716	-79,702
Avg Drawdown - %	-12.3%	-5.1%	-3.9%	-3.5%	-2.9%
Max Drawdown - value	-744,401	-592,837	-530,875	-469,607	-337,521
Max Drawdown - %	-53.6%	-42.7%	-32.5%	-25.1%	-13.6%
Sharpe Ratio	0.11	0.12	0.15	0.17	0.21
CVaR 5%	-10.6%	-9.3%	-7.8%	-6.7%	-5.9%
Amount	-106,190	-102,548	-101,191	-101,071	-118,208

Table 15: Long SPY US portfolio enhanced by short UX1 with indicator strategy, expressed as a percentage of the notional amount, Per month statistics, 2005-2015

1 Month	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Initial Value	100,000	109,690	118,010	121,590	108,380	139,880	170,030	180,930	212,680	221,180	220,780
Final Value	109,690	118,010	121,590	108,380	139,880	170,030	180,930	212,680	221,180	220,780	218,330
Total Return	9.7%	7.6%	3.0%	-10.9%	29.1%	21.6%	6.4%	17.5%	4.0%	-0.2%	-1.1%
Total Return - month	0.8%	0.6%	0.2%	-1.0%	2.1%	1.6%	0.5%	1.4%	0.3%	0.0%	-0.1%
Average Return	0.8%	0.6%	0.3%	-0.7%	2.2%	1.7%	0.6%	1.4%	0.3%	0.0%	-0.1%
Standard Deviation	1.4%	1.5%	3.8%	7.5%	3.6%	3.8%	3.7%	1.5%	1.2%	1.8%	1.3%
Skewness	0.3	-0.6	0.4	-0.8	-1.3	-1.8	-1.2	0.8	-0.1	-0.3	-0.2
Kurtosis	-1.3	-0.4	2.6	3.3	3.1	5.0	2.3	-0.5	-0.5	1.6	-0.9
Win/loss Ratio	0.6	0.7	0.6	0.6	0.8	0.8	0.7	0.9	0.8	0.7	0.5
Max Drawdown - value	-2,370	-5,410	-9,880	-630	-37,290	-14,100	-15,550	-1,550	-2,900	-6,900	-11,050
Max Drawdown - %	-2.3%	-4.8%	-8.2%	-0.5%	-28.1%	-9.1%	-8.7%	-0.8%	-1.3%	-3.0%	-4.8%
Sharpe Ratio	0.54	0.39	0.08	-0.09	0.61	0.44	0.15	0.90	0.26	-0.02	-0.09
VaR 5%	1.5%	1.9%	5.9%	12.9%	3.6%	4.6%	5.4%	1.1%	1.6%	2.9%	2.1%
Amount	1,500	2,079	7,006	15,743	3,948	6,456	9,233	1,928	3,349	6,500	4,747

Table 16: UX1 short strategy yearly statistics, 2005-2015

Short UX1 - Long UX3	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Initial Value	100,000	107,590	112,880	123,220	128,550	146,890	160,440	158,790	164,290	162,390	158,940
Final Value	107,590	112,880	123,220	128,550	146,890	160,440	158,790	164,290	162,390	158,940	156,790
Total Return	7.6%	4.9%	9.2%	4.3%	14.3%	9.2%	-1.0%	3.5%	-1.2%	-2.1%	-1.4%
Total Return - month	0.6%	0.4%	0.7%	0.4%	1.1%	0.7%	-0.1%	0.3%	-0.1%	-0.2%	-0.1%
Average Return	0.6%	0.4%	0.8%	0.5%	1.1%	0.8%	-0.1%	0.3%	-0.1%	-0.2%	-0.1%
Standard Deviation	1.2%	1.1%	2.2%	6.0%	1.7%	1.8%	2.4%	1.1%	0.9%	1.3%	0.9%
Skewness	0.8	-0.2	1.4	-0.3	-0.3	-0.9	-1.6	1.0	-0.1	-0.2	-0.2
Kurtosis	0.2	1.8	5.4	2.2	0.0	1.4	3.6	0.5	0.0	2.1	-1.3
Win/loss Ratio	0.7	0.7	0.8	0.5	0.7	0.8	0.6	0.6	0.4	0.4	0.5
Max Drawdown - value	-1,570	-3,380	-3,800	-940	-23,170	-5,550	0	-15,150	-3,450	0	-11,600
Max Drawdown - %	-1.6%	-3.1%	-3.3%	-0.8%	-17.8%	-3.6%	0.0%	-9.3%	-2.1%	0.0%	-6.9%
Sharpe Ratio	0.48	0.33	0.33	0.08	0.66	0.39	-0.04	0.24	-0.13	-0.16	-0.15
VaR 5%	1.4%	1.5%	2.8%	9.3%	1.6%	2.3%	4.0%	1.5%	1.6%	2.2%	1.7%
Amount	1,396	1,578	3,200	11,489	2,097	3,348	6,420	2,423	2,654	3,647	2,645

Table 17: Combined UX1 short UX3 long yearly statistics, 2005-2015