A broad hint from the VIX:
Timing the market with implied volatility.
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“Funeral by funeral, theory advances.”
(Paul Samuelson)

Abstract:
There is an own strand of academic literature which tries to extract from options prices the implied
distribution of indexes and stocks (see [1], [2] and the references herein). These papers are
mathematically over-sophisticated. The practical result – if any – is usually not very impressive.
This working-paper demonstrates, that one can achieve superior results with simple methods and
measures. Although these results form also interesting trading strategies, the primary focus of this study
is to test different VIX related measures in a simple two-asset allocation problem. These results should
also be useful in more complex allocation problems (see [3],[5],[6]).

Introduction:
In [1] the authors extract the implied S&P-500 distribution from market options prices. This
distribution is subsequently transformed to the corresponding risk-adjusted ones. Then, optimal
portfolios consisting of a risky (S&P-500) and a risk-free asset (LIBOR-rate) are formed and their out-
of-sample performance is evaluated. Extracting the implied S&P-500 distribution from option prices is
in an ideal world mathematically relatively straightforward. For real-data it is complex and unreliable.
One has to differentiate the options prices twice by their strike. But these prices are only available at a
few discrete points. Especially for (far) OTM options the prices are unreliable (see [3]). If one uses the
last sell price of a trading day, one compares prices at different times. The usual remedy is to use the
mean of bid and ask. But bid and asks are sometimes completely unrealistic. It is next to impossible to
adjust to these points a double-differentiable function (spline) which meets basic consistency criterions.
In a second attempt the authors of [1] use an estimation method from Bayesian statistics to calculate the
implied distribution. This method works slightly better.
The subsequent transformation to a risk-adjusted distribution is completely arbitrary. One has to
assume a utility function and risk-averse parameters. The results in [1] are also not very convincing.
The method gives – under some utility-measures – acceptable results in the 1990, but does not
significantly outperform the market in the last decade.

This work uses also a two-asset allocation problem. The market is represented by one of the ETFs SPY
(S&P-500), DIA (Dow-Jones), QQQ (Nasdaq-100) or IWM (Russel-2000). Instead of the risk-free rate
one invests in times of troubles in one of the treasury ETFs SHY (1-3y), IIE (3-7y), IEF (7-10y) or TLT
(20+ y). Especially the treasuries with longer maturity are not risk free at all. But they have a negative beta.
If one expects a rising market, one goes the index ETF long. In case of a negative outlook, one
shifts the money to the treasury ETF. The most interesting combination is with TLT. TLT has a beta of
approx. -0.5. If one stays too long on the sideline, one is hit twice. One misses the recovery of the
market and suffers from losses in TLT. The combination has also the highest potential. One does not
wait passively. If one times a crash correctly, one can realize a considerable win. The combination with
SHY is closer to the approach in [1].
The allocation in [1] is continuous. In this study the allocation is considerable simplified.
In the most basic strategy there are only 2 states. One holds 100% the market or 100% the treasury
ETF. In the 3-state setting, one holds either 100% the market, splits equally 50:50 or 100% the treasury. Like in a previous study [4] the calculation starts at 2007-03-26 and ends at 2013-04-22. One starts with a capital of 500,000$. For ease of calculation, the volume is truncated always down to the next integer. This could be considered as very small transaction costs. The transition is done at a daily basis at the close. The main purpose of this study is to examine the effectiveness of several VIX related triggers in a simple to follow trade setting.

**The Implied Volatility Term Structure:**

The Implied Volatility Term Structure is defined as:

\[
\text{IVTS}(t) = \frac{\text{VIX}(t)}{\text{VXV}(t)} \quad (1)
\]

VXV is the implied volatility of S&P-options with 3 month maturity. Besides the different maturity the calculation is the same as for the VIX. Under normal market conditions the VXV is larger than the VIX. Hence the IVTS is below 1.0. But in times of troubles the VIX goes up much faster and the IVTS is above 1.0. The behavior of the IVTS is closely related to the contango and backwardation condition of VIX Futures (see also below). The IVTS is used in several Sibyl-Working-Papers as a trade signal (see [3],[5],[6]).

Graphic-1 shows the results with 2 states. If the IVTS is above 1.0, one holds 100% TLT, below one is fully invested in the SPY. The strategy clearly outperforms the SPY (yellow). The IVTS-2 increases from the initial 500,000$ at 2007-03-26 to 852,539$ on 2013-04-22. This are 71.9%.

Graphic-1: SPY-TLT 2 States. Orange IVTS signal, yellow SPY buy&hold.
The max. drawdown is 157.057$ at 2009-02-26. The SPY increases in the same period 26.2% and has a considerable larger drawdown in the 2008 crash (yellow line in Graphic-1).

But it should be noted, that the IVTS-2 strategy does not outperform the TLT (Graphic-2).

Graphic-2: SPY-TLT 2 States. Orange IVTS signal, yellow TLT buy&hold.

In [5] and [6] the IVTS is used to determine the weights for a long-short VXX and VXZ strategy. The ETF VXX replicates the short term VIX futures index constructed by S&P, the VXZ the mid-term futures index. In this study an IVTS value of 0.91 formed another critical threshold. Below 0.91 one is in a bull-market, between 0.91 and 1.00 the situation is unclear and above 1.00 the market is in turmoil.

The 3-state strategy invests below 0.91 100% in the market, between 0.91 and 1.00 the portfolio is equally weighted and above 1.00 one holds as before only the treasury. Graphic-3 compares the IVTS-3 strategy with the IVTS-2 of Graphic-1. Introducing an intermediate state clearly improves the performance and reduces the risk. The win increases from 71.9% to 82.3%. The max. drawdown is reduced considerably to 97.032$. The IVTS-3 switches earlier to the better hedged equally weighted portfolio. But it misses also potential win in the following recovery.

Graphic-4 shows the performance of the QQQ (Nasdaq-100) and TLT combination for IVTS-2. The IVTS-2 beats with 151.8% to 66.5% the QQQ by a wide margin. The max. drawdown is 162.386$ at 2008-10-27. But for this combination the IVTS-3 is not clearly better. The final win is 128.0% with a max. drawdown of 96.738 at 2012-05-14. Missing some of the recovery potential is for the QQQ more harmful than reducing the risk earlier. But the somewhat lower performance is compensated by the reduction of the drawdown.
Graphic-3: SPY-TLT. Orange IVTS 3 states, yellow IVTS 2 states.

Graphic-4: QQQ-TLT. Orange IVTS-2 states, yellow QQQ buy&hold.
The DIA-TLT performs very similar to the SPY-TLT pair. The IWM is in between the SPY and the QQQ case.

**The VIX Futures Term Structure:**

The IVTS is a very useful and easy tool. But one is restricted to a single maturity difference. Theoretically one could calculate a 2-months or 4-months equivalent of the VXV, but the payoff should be in comparison to the necessary effort minor. For the VIX and VXV the CME does the involved job and it is trivial to use the final result. But one can use the term structure of the VIX futures for a similar purpose. VIX futures have an own inherent logic, but there is obviously a close relation with the implied volatility-surface of SPX options.

Graphic-6 compares the IVTS with the VIX Futures-30 ratio in the second half of 2011. For the VIX Futures-30 ratio one divides the VIX by the value of a VIX future with a maturity of 30 calendar days. Usually such a future does not exist. In this case one calculates the weighted mean of the 1st and the 2nd nearest future. If e.g. the first future has a maturity of 20 days, and the second a maturity of 50 days, one calculates the VIX Futures 30 value as $2/3 \times \text{Future}_1 + 1/3\times\text{Future}_2$.

As can be seen in Graphic-6 the VIX Futures-30 ratio is quite similar to the IVTS. The Futures-30 ratio reacts slightly faster than the IVTS. In the summer 2011 crash the Futures-30 ratio moved already on Jul. 26 above the 1.0 threshold. The IVTS one day later. The yellow line goes down also somewhat faster at the right hand of the graphic. But the overall behavior is quite similar. One can use the VIX
Graphic-6: Orange IVTS, yellow VIX Futures-30 ratio, second half 2011

Graphic-7: SPY-TLT: Orange IVTS 3-states, yellow VIX Futures-30 3-states
Futures-30 ratio in the same way as a signal. The performance is almost identical for the 2 state strategy. For 3 states the difference is more pronounced. The VIX Futures-30 ratio performs somewhat better than the IVTS-3 for all markets. Graphic-7 shows the difference for the SPY-TLT pair. The win increases from 82.6% for the IVTS-3 to 91.8% for the Futures-30 ratio. The max. drawdown is also slightly reduced. The faster reaction of the Futures-30 ratio is a slight edge.

I have tried also a Futures maturity of 45- instead of 30-days. The ratio behaves slightly different, but the final trading result is close to the Futures-30 setting. It is always the fast response of the VIX which dominates the behavior. The decision to enter or leave the market is usually only 1 trading day apart.

**The VIX Futures 30-45 ratio:**
There is no stringent need to use the VIX as the basis of comparison. One can compare also futures with different maturities with each other. An interesting pair is to replace the VIX with the Futures-45. The Futures-30 value is usually a weighted combination of the 1st and 2nd Future. The Futures-45 gives either a larger weight to the 2nd or combines the 2nd and 3rd Future. Volatility is mean-reverting. Hence the Futures behave always smoother than the VIX.

![Graphic-8: Orange IVTS, yellow VIX Futures-30-45 ratio, second half 2011](image)

As can be seen in Graphic-8 the yellow Futures-30-45 ratio behaves much smoother than the IVTS. In the Aug. 2011 crash the critical threshold of 1.0 is reached 2 days later at Jul. 29. To sense the danger later is a disadvantage. But the ratio behaves in the recovery phase much smoother and avoids the sharp up- and downs. This avoids the whipsaw behavior of the IVTS triggered strategy. As can be seen in Graphic-9, the Futures-30-45 ratio performs in the recovery after the 24.Oct 2011 (red marker) much
Graphic-9: SPY-TLT: Orange IVTS 2-states, yellow VIX Futures-30-45 2-states

better than the IVTS based strategy. The final win increases from 71.9% to 90.7%. The max. drawdown is also somewhat reduced.

But the real boost of the Futures-30-45 ratio is for the 3-states strategy. In this case one has to modify the mixed threshold value. The ratio never falls below 0.91. The by far best setting is 0.97. If the ratio is below 0.97, one invests 100% in the market, between 0.97 and 1.0 one selects an equal weight and over 1.0 one is fully invested in the treasury.

As can be seen in Graphic-10, the final value of 141.1% is quite impressive. The strategy makes some losses in the 2008 crash, but it wins strongly in the August 2011 turmoil. The max. drawdown of the IVTS and the Futures-30-45 strategy are of the same size.

For the QQQ-TLT pair the final win is 192.5%. This improves the 128.0% of the IVTS-3 solution considerably (Graphic-11). The same relation holds for the DIA and the IWM.

In Graphic-12 the TLT is replaced by the SHY. The SHY is a low-risk, low-fun ETF. Also in this setting the Futures-30-45 ratio is for 3 states clearly superior. For 2 states the difference is less pronounced. The final win is of course with 71.5% for the Futures-30-45 ratio and with 47.9% for the IVTS much lower than for the SPY-TLT pair. Replacing the TLT with the much smoother SHY does not improve the drawdown. The drawdown is dominated by market-crashes. The -0.5 beta of the TLT even hedges in the mixed state better than the -0.05 beta of the SHY.

The picture is similar for the QQQ-SHY pair. The Futures-30_45 ratio is with 107.9% to 84.7% again much better. The same holds for DIA and IWM.
Graphic-10: SPY-TLT: Orange IVTS 3 states, yellow VIX Futures-30-45 3 states.

Graphic-11: QQQ-TLT: Orange IVTS 3 states, yellow VIX Futures-30-45 3 states.
Graphic-12: SPY-SHY: Orange IVTS 3-states, yellow VIX Futures-30-45 3-states

Graphic-13: QQQ-SHY: Orange IVTS 3-states, yellow VIX Futures-30-45 3-states
I have tried other ratios like 30_60. But the first try with 30_45 was by far the best choice. It is not obvious, why the 30_45 performs so well. The erratic behavior of the VIX is smoothed by the 30term. But there is no clear reason why 30_60 should be worse than 30_45. It is well known, that the time decay of options (theta) really starts at a maturity of 6 weeks. But it is unclear, why this effect has a significant influence on market-timing.

**Conclusion:**
It has be shown – once again – that the Implied-Volatility-Term-Structure contains relevant information about the market regime. Replacing the 3-month VXV by VIX Futures has only a minor effect. But moving up the VIX Futures term-structure and comparing 30- to 45-days maturity Futures changes the situation. The 30-45 boosts the trading behavior significantly. Initially the intention of this study was just to compare the different measures. For this reason the usual description like Donkey-, Mojito-, Johnny-Walker strategy was omitted. But the market - TLT pair with a 3-states portfolio seems even to be interesting as a trading strategy. There is the open question, if the Futures 30-45 ratio improves also the other strategies mentioned in the references.

**Further work:**
Test the Futures-30-45 ratio for all strategies which use the IVTS.

**References:**