Improving the S&P Dynamic VIX Futures Index: The Mojito 3.0 Strategy

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"My mojito in La Bodeguita, My daiquiri in El Floridita"
(Ernest Hemingway, http://en.wikipedia.org/wiki/Mojito).

Abstract:

The Mojito 2.0 strategy was developed in [1] and [2]. The Mojito is an improved version of the S&P Dynamic VIX futures index (see [3]). The general idea is to trade combinations of short- and mid-term VIX futures indexes. The Implied-Volatility-Term-Structure (IVTS) is used to define different volatility regimes. The weights of the short- and long-term VIX futures indexes are adjusted accordingly. It was recognized in [2] that there is linear relation between the VXX (short-term) and VXZ (mid-term) index ETFs. Hence the Mojito 2.0 switches only between a short, neutral or long VXX position.
This working-paper applies ideas from the HeroRATs strategy ([4]) to the Mojito. The HeroRATs introduced the new VIX-short-term-index VXST ([5]) and removed IVTS spikes with a median filter. The VXST contains for the Mojito no valuable information. But the median-5 filter is a clear improvement. This working paper improves also the regime-thresholds of the strategy.

Note: The median filter is a reaction to trading experience with the Mojito-2.0. The overall performance of the Mojito is excellent. But we lost due to IVTS spikes aka market-overreactions. The idea was first tried in the HeroRATs setting.

VIX based ETNs:

A very interesting addition to the ETF and ETN universe are VIX based ETNs. The VIX was introduced initially as a fear-gauge. The gauge was not tradeable. There is also no known practical method to replicate the VIX. In March 2004 the CBOE introduced VIX futures. As the VIX can't be replicated, there is – in contrast to most other futures – no known simple relation between the VIX and its futures. Additionally the VIX is mean-reverting. If the VIX is below its long-term mean, the futures tend to trade higher. If the VIX is above the mean, the futures trade lower. But the mean is probably not stationary. It changes over time. The only thing which can be said for certain: A very high VIX (>30) tends to fall and a low VIX (<15) tends to rise. The term-structure of the futures reflect this fact.
As the VIX can not be replicated, there are no direct VIX ETNs. The first successful VIX based ETN was the iPath VXX in Jan. 2009. The VXX replicates the short term VIX futures index constructed by S&P. One sells $1/30^{th}$ each day of the most nearby future (the 1^{st}) and buys the next (2^{nd}) future for this money. In this way the futures are rolled over on a day by day basis. In Feb. 2009 the VXZ was introduced. The VXZ is based on

the mid-term VIX futures. The roll-over is done between the 4th and 7th maturity. A portfolio of mid-term futures contains therefore 4th to 7th futures.
For both ETNs it is not the level, but the term structure of the VIX Futures which counts. If the 2nd future is more expensive than the 1st, the VXX looses. If the price of the 1st is higher, the VXX wins. The same holds for the VXZ. But this time the term-structure of the 4th and 7th future is relevant. Although only the term-structure is relevant, the movement of VXX and VXZ is nevertheless highly correlated with the movement of the VIX. The correlation of the daily returns between VIX and VXX is +0.92, between VIX and VXZ it's +0.88. But the volatility of VIX is about 1.75 larger than VXX and 3.5 times larger than VXZ. These relations are not fixed and depend on the VIX level. As a first approximation the VXX is a slightly and VXZ a medium damped VIX series.
The VIX is in turn highly negatively correlated with the S&P. At the end, if the S&P falls strongly the ETNs move up. But the relation depends also on the level of the VIX.
A more detailed description of the stylized facts of the short- and mid-term structure can be found in [5].

The Implied Volatility Term Structure:

The Implied Volatility Term Structure is generally defined as:

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IVTS(t) = Short-Term-IV(t)/Long-Term-IV(t)     (1)
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One selects on this curve points with readily available implied volatility measures.
This study considers for the *Short-Term-IV* the VXST (9-days IV calculated from weekly options), the VIX (1-month from monthly options) and the VX30.
The VX30 is the price 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 the first future has a maturity of 20 days, and the second a maturity of 50 days, one calculates the VX30 as 2/3 * future_1 + 1/3*future_2. VIX futures have an own inherent logic, but there is obviously a close relation with the implied volatility-surface of SPX options.
For the *Long-Term-IV* the VIX, the VXV (3-months from monthly options), the VX30, VX45 and the VX60 are used. The VX45 is the price of a VIX future with 45 days maturity. It is the weighted mean of the 2nd and 3rd future. The VX60 is the price of a VIX future with 60 days maturity. It is also a weighted mean of the 2nd and 3rd future. But the weights are different. The considered combinations are:

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VXST(t)/VIX(t)    (1a)
VXST(t)/VXV(t)    (1b)
VXST(t)/VX30(t)   (1c)
VIX(t)/VXV(t)     (1d)
VIX(t)/VX30(t)    (1e)
VIX(t)/VX45(t)    (1f)
VIX(t)/VX60(t)    (1g)
VX30(t)/VX45(t)   (1h)
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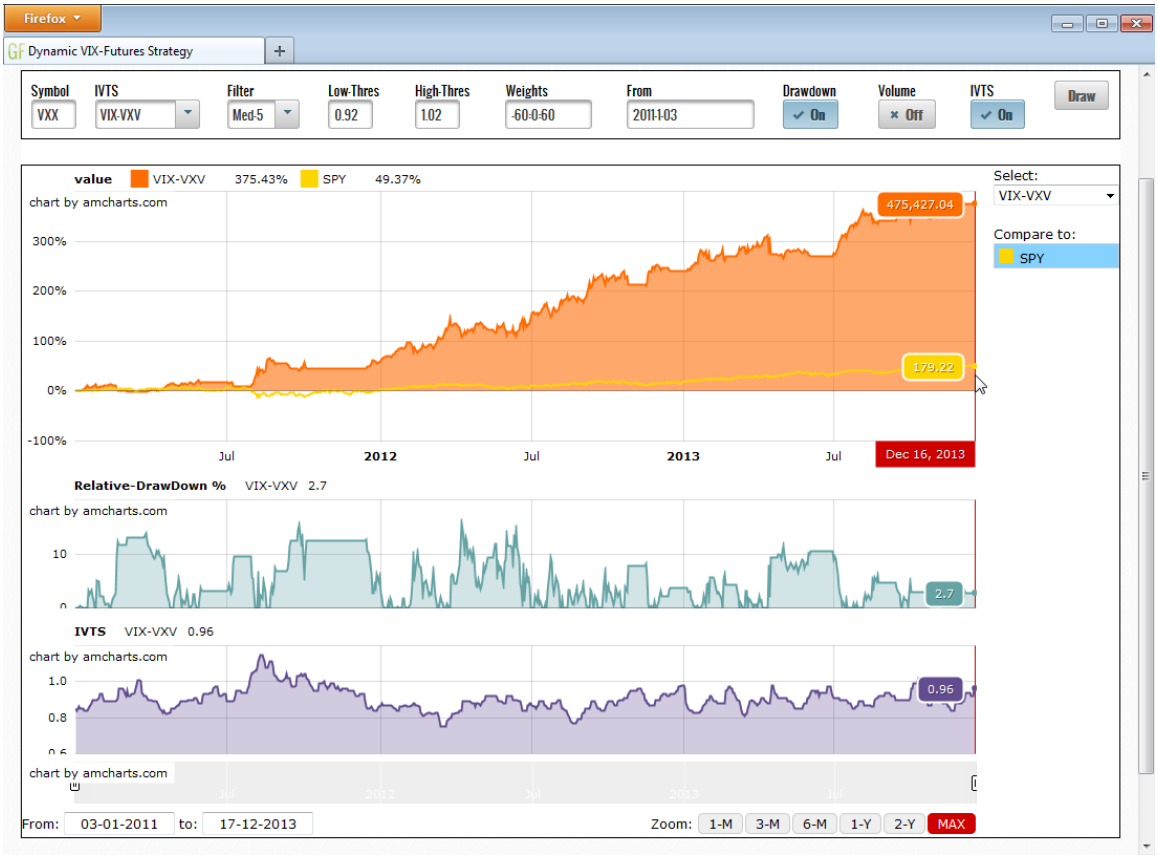
The VXST was introduced in Oct. 2013. CBOE provides a daily updated time series starting at 2011-01-03. In a first step the efficiency of (1a) to (1h) is compared since this date. In a second step the performance of the measures (1d) to (1h) are evaluated since 2009-03-01. The calculation ends at 2013-12-16 (the latest available daily data at this writing). Within the shorter period there is one larger crash in August 2011. The longer period contains additionally the flash crash.

As in [1] and [2] one starts with an initial index of 100.00$. The market-regimes are defined by a low- and high IVTS threshold. The thresholds depend on the IVTS combination. If the IVTS is below the low-threshold, one goes 60% of the index value the VXX short. If the IVTS is between the low- and high-threshold one stays on the sideline. If the IVTS is above the high-threshold, one switches to a long VXX position with a weight of 60%. The weights differ slightly from [2]. In Mojito 2.0 were 4 states. The low-regime is also 60% short, the two intermediate states are short with 16% and 3%, the high-regime goes 79% long. The current setting is a simplification of the old approach and reflects also trading experience. The 60% is a legacy of the first versions which traded combinations of the VXX and the slower moving VXZ. One can of course increase the leverage to 100%. But the VXX has 2-3 times the volatility of the SPX and there is even with the 60% weights enough fun. It seems to be advisable to reduce the risk somewhat.
Trading-Note: There are no trading-activities in the high-state. But one has to re-balance in the low state to keep the 60% ratio. This was done in the historic simulation. It makes in the long run a huge difference.

The calculation is done each day with close-prices. In real trading live one does this shortly before the close. According the trading experience in the Sibyl Fund there is in the long run no systematic difference between the real- and the theoretic behavior.
But it was noticed that the Mojito suffers from IVTS spikes. It is well known from image-processing that median-filters are very efficient to filter out salt and pepper distortions (salt and pepper are the image processing terms for spikes). The median-3 filter uses for the trading decision at time t the median of IVTS(t), IVTS(t-1) and IVTS(t-2). The median-5 filter extends the median calculation from IVTS(t) back to IVTS(t-4). The median-3 is able to filter a single-day spike away. The median-5 filter is robust to a 2-days spike or 2 single-days spikes. The general idea is to ignore short-term market overreactions. The downside is that any filter delays the reaction to long-term market turnarounds.

Statistical Note: The median is the second-best combination of robustness and minimum delay. The best is the recursive-median filter. For the recursive-filter, one uses for the old values not the original but the already filtered data. One can apply the recursive median only in symmetric-filter applications. In case of the median-3 filter one takes for time-t the values of t-1, t, t+1. Medical- or image-processing applications are symmetric problems. But in our case one can't wait for tomorrow's IVTS for trading today. One can smooth the median-filtered values again with the median-filter and gets – after several passes – a stable result. The recursive-filter is already after the first pass stable (see [6])

Graphic-1 shows the performance of the IVTS (1d) VIX-VXV with the thresholds 0.92 and 1.02. The IVTS is smoothed with the median-5 filter. One sees the effect of the median-5 in the blocky appearance of the bottom IVTS chart.

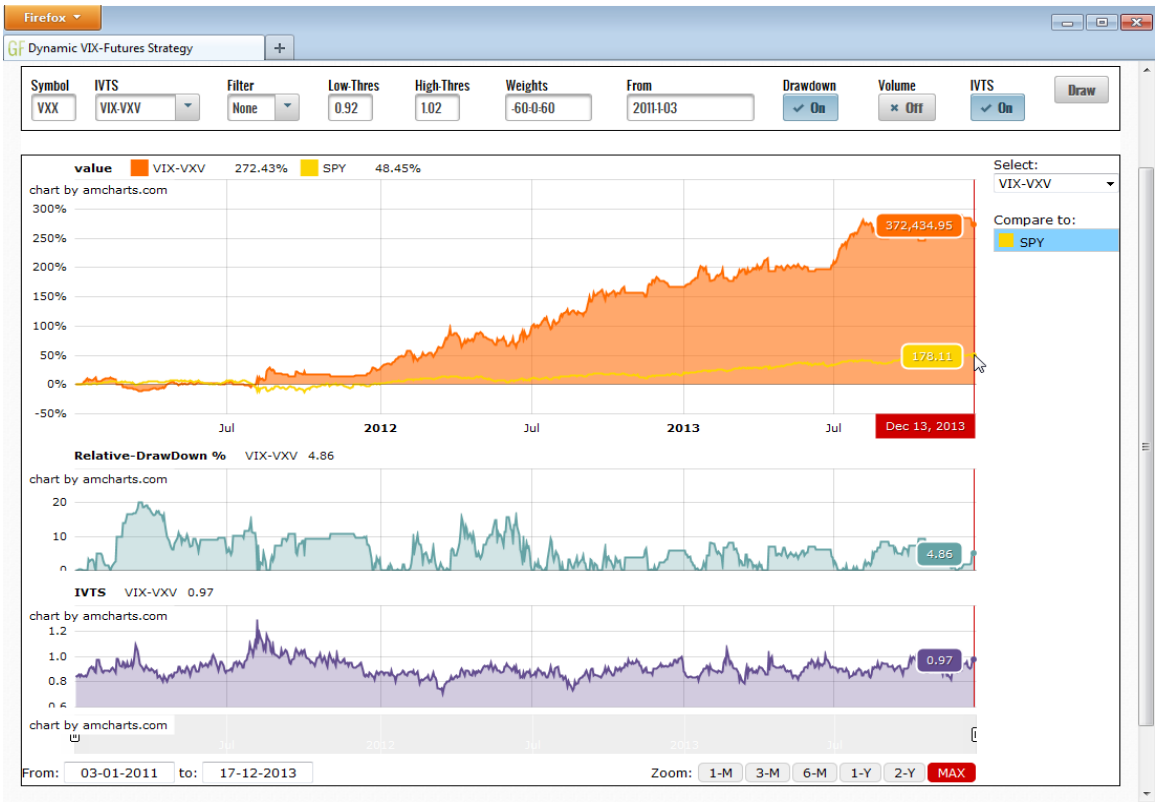


Graphic-1: VIX-VXV with median-5 filter. 2011-01-03 to 2013-12-16

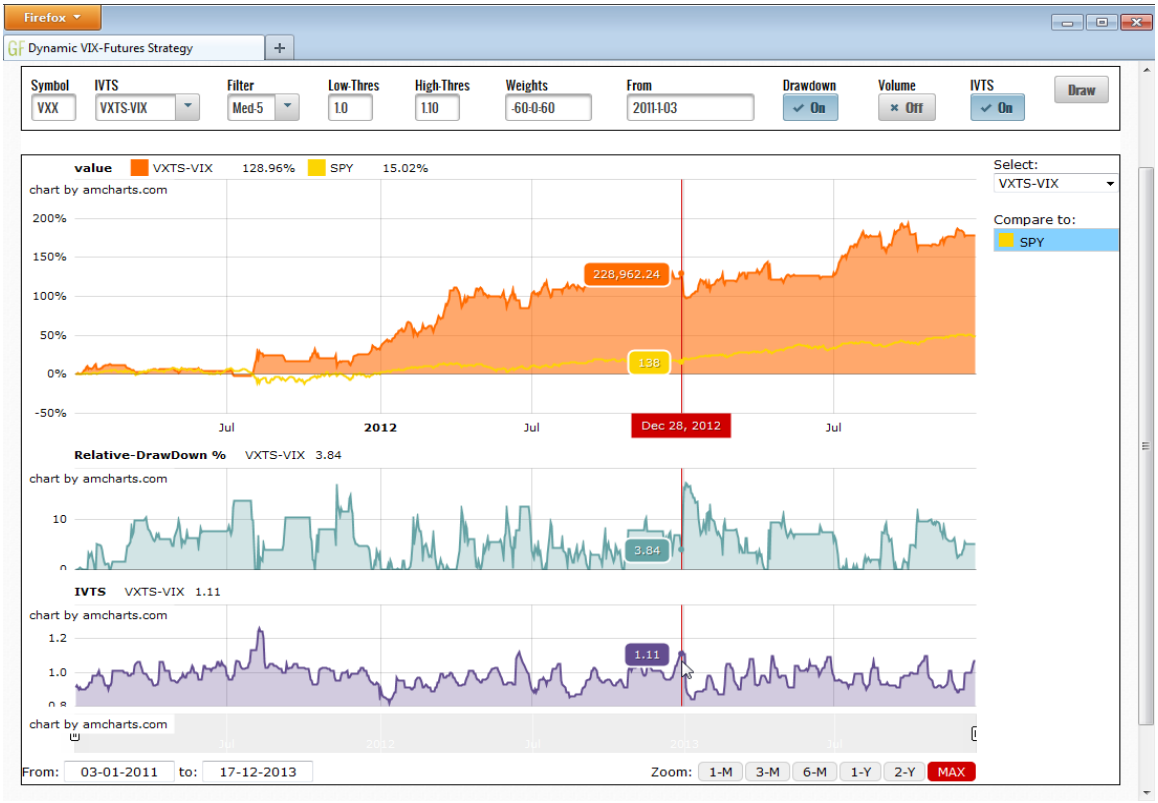
The final win is an impressive 375.4%. The SPY (yellow chart) gains in the same period 49.4%. The maximum relative drawdown is 15.3% on 2012-04-10. The max. relative drawdown of the SPY is in the same period 18.6% on 2011-10-03. This marks the end of the summer 2011 crash.

Graphic-2 shows the same calculation without the median filter. The performance drops to 272.4% and the max. relative drawdown increases to 20%. The median-3 filter is in between. This result is in agreement with the results in [4]. During the shorter time period the median-5 filter improves the performance in almost all market situations. But this is not the case for the longer time period. The filtered version is worse in the recovery phase after the flash crash (see below).

The IVTS (1a) VXST/VIX was in [4] the best performing measure. It has the fastest response. The VXST is the implied volatility of the weekly SPX options with a maturity of 9-days. Graphic-3 shows the performance with a median-5 filter and the thresholds 1.0 and 1.10. The performance is with 178.7% clearly worse. The max. relative drawdown



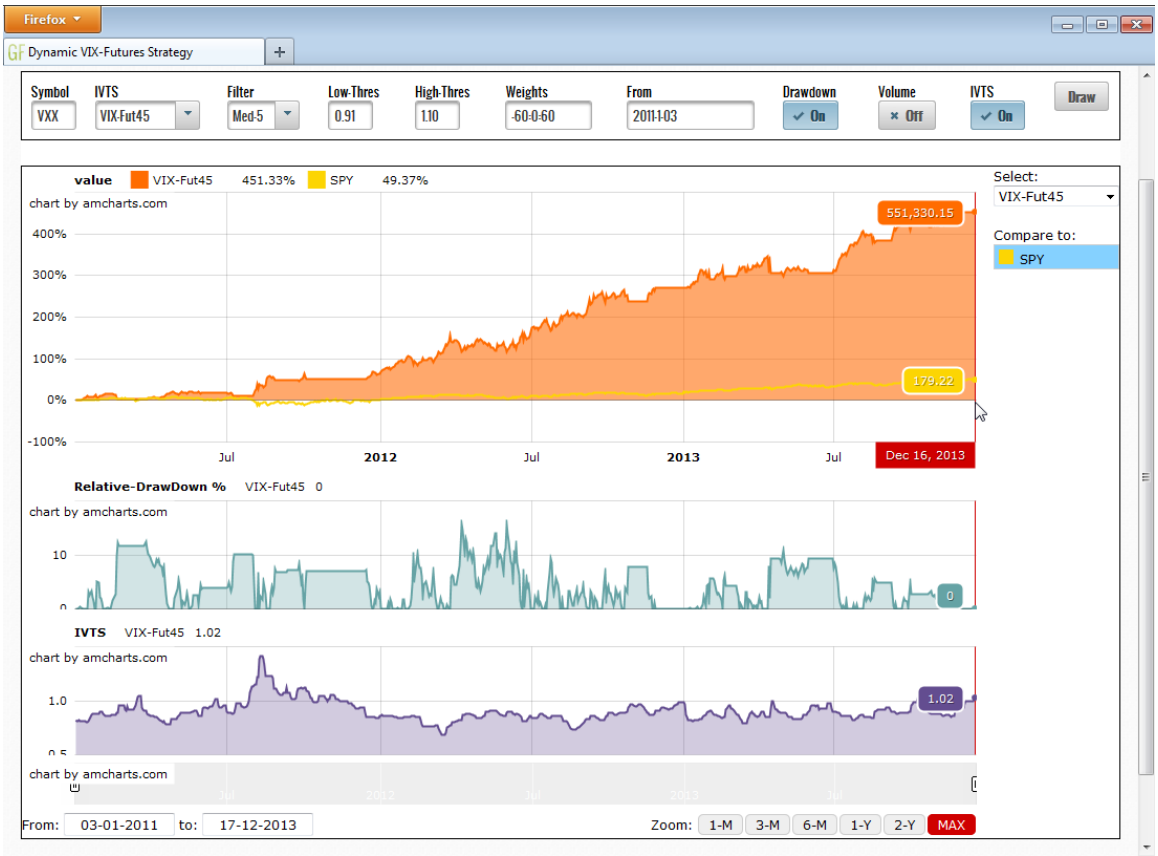
Graphic-2: VIX-VXV without filter. 2011-01-03 to 2013-12-16



Graphic-3: VXST-VIX with median-5 filter. 2011-01-03 to 2013-12-16

happens on 2013-01-04 (red-line). At the end of 2012 there was one of these infamous chicken-games about the US-depth ceiling. Short-Term volatility went before New Year's Eve sharply up. The agreement was reached a few minutes before the start of the new year. The Implied-Volatility went down sharply after the deal was reached. The position was on the wrong side. The median-5 filter makes things worse. But the overall effect of the median-5 filter is clearly beneficial.
The VIX/VXV based Mojito was staying at the end of 2012 on the sideline and suffered no losses.
The relative poor performance of the VXST measures (1a) to (1c) is no big surprise. The VXX is based on the term-structure of the VIX futures which are in turn based on the monthly SPX options. They VXX can be considered as a derivative of the third order. The weekly options are related, but it is a game of it's own.

The best IVTS measure is (1f) with VIX/VX45. The thresholds are 0.91 and 1.10. The overall win is 451.3% with a max. relative drawdown of 15.7% (see Graphic-4). In previous studies the VIX/VX30 (1e) was slightly better.
The high threshold is with 1.10 quite large. But this is in agreement with trading experience. The short position in the low-regime is the cash-cow. The VXX is – like Put options – an insurance against market drops. The short VXX cashes in the insurance premium. It pays only to go long in very turbulent market conditions.



Graphic-4: VIX-VX45 with median-5 filter. 2011-01-03 to 2013-12-16

Table-1 lists the thresholds and the performance of all IVTS measures with the median-5 filter. The median-5 filter improves in each case the performance. The second last row is the performance of a short only VXX position.

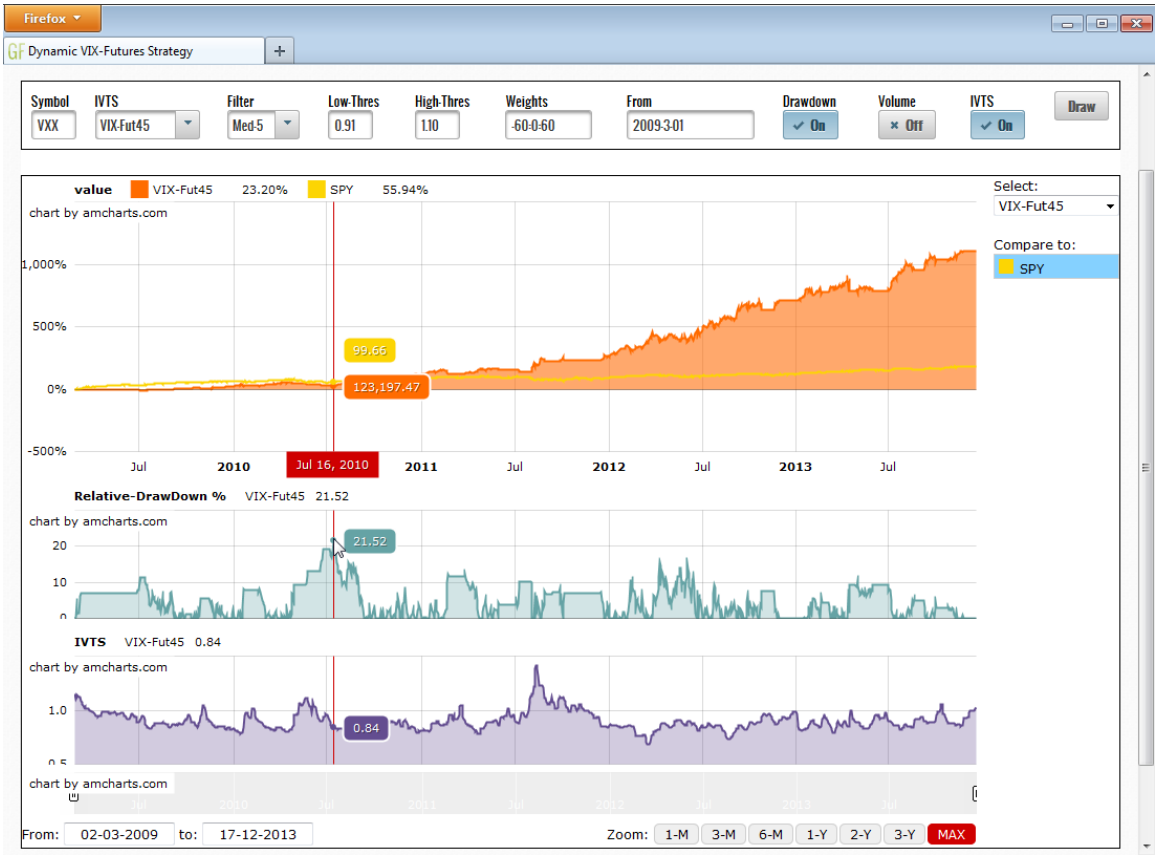
IVTS	Low-Threshold	High-Threshold	P&L	Drawdown
VXST/VIX	1.00	1.10	+178.7%	17.0%
VXST/VXV	1.02	1.12	+217.9%	23.1%
VXST/VX30	1.04	1.15	+260.8%	23.1%
VIX/VXV	0.92	1.02	+375.4%	15.3%
VIX/VX30	0.92	1.10	+380.8%	15.7%
VIX/VX45	0.91	1.10	+451.3%	15.7%
VIX/VX60	0.90	1.08	+362.4%	23.1%
VX30/VX45	1.00	1.04	+382.8%	23.1%
Short VXX	-	-	148.2%	51.7%
SPY	-	-	+49.4%	18.6%

Table-1: Thresholds and Performance from 2011-01-03 to 2013-12-16

From the beginning:

The VXX started trading on 2009-01-30. The VXZ 3 weeks later. After finding reasonable thresholds for the last 3 years I tested the performance of (1d) to (1h) in the time period from 2009-03-01 till now. One can't perform the test for the VXST measures, because there are no data available. Usually one does such a test the other way round. One optimizes the parameters in a first step for an in-sample time-period and tests the performance out-of sample for newer data. But I was following the method used in [4]. The major event in the first period is the flash crash at 2010-05-06. The flash crash lasted a few minutes, but the implied volatility was for weeks relative high.
Note: During the flash-crash there was no implied-volatility at all. Options trading practically stopped.
Graphic-5 shows the performance of the best measure (1f) VIX/VX45. The overall performance is a whopping 1107.3% with a max. relative drawdown of 21.5% at 2010-07-16. The unfiltered measure is over the whole period with 810.4% (much) worse, but the max. relative drawdown is only 18.7% at 2010-06-13. The median-filter does not perform well in the aftershock waves of the flash crash. The poor performance is overcompensated in the later stages. But the measure (1e) VIX/VX30 does not catch-up until now. This is the only case where the unfiltered signal beats the smooth one.

Table-2 below lists the thresholds and the performance of the IVTS measures (1d) to (1h) with the median-5 filter, the short only VXX and the SPY in the longer time-period.



Graphic-5: VIX-VX45 with median-5 filter. 2009-03-01 to 2013-12-16

IVTS	Low-Threshold	High-Threshold	P&L	Drawdown
VIX/VXV	0.92	1.02	+731.4%	19.8%
VIX/VX30	0.92	1.10	+804.9%	22.6%
VIX/VX45	0.91	1.10	+1107.3%	21.5%
VIX/VX60	0.90	1.08	+947.1%	23.1%
VX30/VX45	1.00	1.04	+1193.6%	42.4%
Short VXX	-	-	+763.7%	51.7%
SPY	-	-	+178.9%	18.6%

Table-2: Thresholds and Performance from 2009-03-01 to 2013-12-16

Conclusion:

The VXST is for the Mojito of no use. One should stick to the already existing IVTS measures. IVTS (1f) VIX/VX45 with the thresholds of table-1 seems to be the best setting. The median-5 filter had some problems in handling the flash-crash aftershock waves. But it is in the long run a considerable improvement. The Mojito 2.0 is so far one of the cash-cows of the Sibyl-Fund. Mojito 3.0 should give this strategy an additional twist.

References:

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[5] Carol Alexander, Dimitris Korovilas: Understanding ETN's on VIX Futures.
[6] Stork M.: Median Filters Theory and Applications.