VIX Futures Basis Trading:
The Calvados-Strategy 2.0
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Calvados *is an apple brandy from the French region of Lower Normandy (Basse-Normandie). It is sometimes abbreviated to* **Calva**. *Calvados is distilled from cider made from specially grown and selected apples, of which there are over 200 named varieties.*
http://en.wikipedia.org/wiki/Calvados_%28brandy%29

Abstract:

In [1] I developed the Sidre and Most-Strategy. The strategy relies on the typical term-structure of VIX futures. The Calvados is a refined and condensed version of these strategies which was developed in [2]. The starting point was a paper of Simon and Campasano (see [3]). Simon&Campasano demonstrate that the VIX futures basis does not have significant forecast power for the change in the VIX spot index, but does have forecast power for subsequent VIX futures returns. It is especially profitable to short VIX futures contracts when the basis is in contango. The original Calvados working paper ([2]) presented improved metrics and parameter settings of the Simon&Campasano approach. The current working paper improves the original work in several points and extends the historic backtest. The overall patterns of the original results are reassured and improved upon. The Calvados is traded in the Sybil-Fund. It is so far the pick of the bunch. One gets a lot of fun for a medium dose of risk.

Revision-1:

In Revision-1 the volume for all futures is determined by the VIX and not by the individual futures price as before. The previous setting had the effect, that short-term futures were traded with higher volume than those with longer maturity. This makes the comparison of the different formulas more difficult. It is also against the intuition of traders.

Acknowledgment:

Introduction:

VIX futures are a different beast. The VIX can not be (practically) replicated. Additionally the VIX is mean-reverting. The VIX volatility is almost an order higher than the S&P-500 and explodes in a market-crash. Hence VIX futures (and options) behave very different to commodity- or stock-index futures.
VIX futures trade in normal times in contango. If the VIX is currently at 17.0 and a VIX future is traded at 20.0, this does not mean that the VIX will tend towards 20.0 at expiry. The difference between the futures price and the underlying (the VIX) is called the basis.

For most futures the basis is determined by the carry of the replication strategy. In case of stock-index futures the carry is easily determined by the risk-free-rate and the dividends. As VIX futures can not be replicated, there is no carry-relation. The basis has almost no predictive power (see [3] and the references herein). The basis does not reflect the statistical properties of the VIX. It is a risk premium which can be harvested.

But the basis has predictive power for the subsequent futures-price. A (strong) positive basis predicts falling futures prices. It is hence profitable to go the VIX futures short. As with any risk-harvesting strategy, the goal is to find a good balance between risk and fun.

The Daily-Roll:

In [3] the daily-roll is defined as:

```
R(t) = (VXF(t) - VIX(t))/TTS(t)            (1)
```

```
VXF … VIX Future Price.
TTS … Trading Days till Settle (expiry).
```
Note: TTS should be called TDS, but I follow the convention in [3].

In other words, it is the basis divided by the number of trading days till expiry. The daily-roll is a (first-order) estimate of the daily expected win. It is first order, because it does not take the mean-reverting property of the VIX into account.

The trading-strategy in [3] is based upon equation (1).

The equation is for trading-purposes not without problems. A VXF at 33 and a VIX at 30 is according (1) the same as a VXF at 18 and the VIX at 15. Obviously it is much more comfortable to trade the 18/15 than the 33/30 basis. The daily-roll in (1) does not differentiate between these two cases.

Equation (2) addresses this problem. The basis is divided by the VIX level. This is in first order equal to the difference of the log-values. Hence one replaces also the TTS by log(TTS).

```
R(t) = ((VXF(t)-VIX(t))/VIX(t))/log(TTS(t)     (2)
```

For a TTS of 30 trading days, equation (1) gives for the 33/30 and 18/15 a daily-roll of 0.1. According to equation (2) the 33/30 basis gives a value of approx. 0.03. For 18/15 the daily roll is about 0.06. This reflects certainly better the different circumstances. But one wants in fact something like a Roll-Sharpe-Ratio.

```
R(t) = ((VXF(t) - VIX(t))/VXFVola(t))/TTS(t)  (3)
```

In (3) the basis is normalized by the volatility of the VIX future.

```
VXFVola(t) = sqrt(sum(DeltaVXF(t-i)^2)/10) i=0...9    (4)
```

If the futures price moved in the last 10 days a lot, the risk-adjusted-roll is smaller. If the movement is smooth, it is larger.

Equations (1) to (4) were introduced in [2]. This study introduces two additional measures. They are variations of equation (3). One measures the volatility (normalization factor) in different ways.

```
VXFVola(t) = sqrt(sum((Delta(logVXF(t-i))*100.0)^2))/10)  (5)
```

In (5) one sums up over the squared daily log-prices aka returns. Equation (4) adds the squared price differences. The returns are scaled up – as usual – with a factor of 100.0. An increase of the VXF from 30 to 31 is in (5) the same than a change from 15 to 15.5. In (4) the effect of the first increase is 4-times larger.

VXFVola(t) = Daily-Realized-Volatility(t)   (6)

Another possibility is to normalize with the daily realized volatility. The daily realized volatility is calculated with high-frequency data over the last 10 trading days. A whole gang of scientist has made up their career by writing about the realized HF-volatility. The classical one is the sum of 5-minutes intraday squared returns (see [4]). But there is the open question how to account for the overnight return (see [5]). The theoretical models assume a Brownian-motion. The Brownian is a diffusion model. But there are obviously also price jumps. For this paper the so called bi-power variation from [6] is used. Instead of squaring the 5-minutes returns, one multiplies the absolute value of the 5-minute return with the absolute return 5 minutes before. The effect of a single spike or the overnight return is damped but not completely filtered away. One has to scale the bivariate variation by PI/2 (1.570736). I have played around with the different realized volatility measures in the past. The bi-power variation looks best.

Note: Realized Volatility is like the IQ. It is by definition what the measure measures. There is no clear-cut criterion which one is best (see also the title of [8]). This is the foundation of the academic Realized-Volatility business.

In [3] the authors consider only the most nearby future. But according to the analysis in [1] and [2] it is sometimes advantageous to trade futures with longer maturity. These futures are less sensitive to sudden spikes of the VIX. With a similar daily roll (according to equation (1)) one would certainly prefer the longer maturity. The tail risk is much lower. Expression (1) favors short maturities. In expression (3) and its variants (5) and (6) the smoother behavior of longer maturities is taken into account.

Graphic-1 shows the VIX and VIX futures prices from 2012-10-22 to 2013-01-14. Black is the VIX, yellow the Feb. 2013, green the March 2013 and blue the April 2013 future. The peak at 2012-12-28 is the effect of the fiscal-cliff.
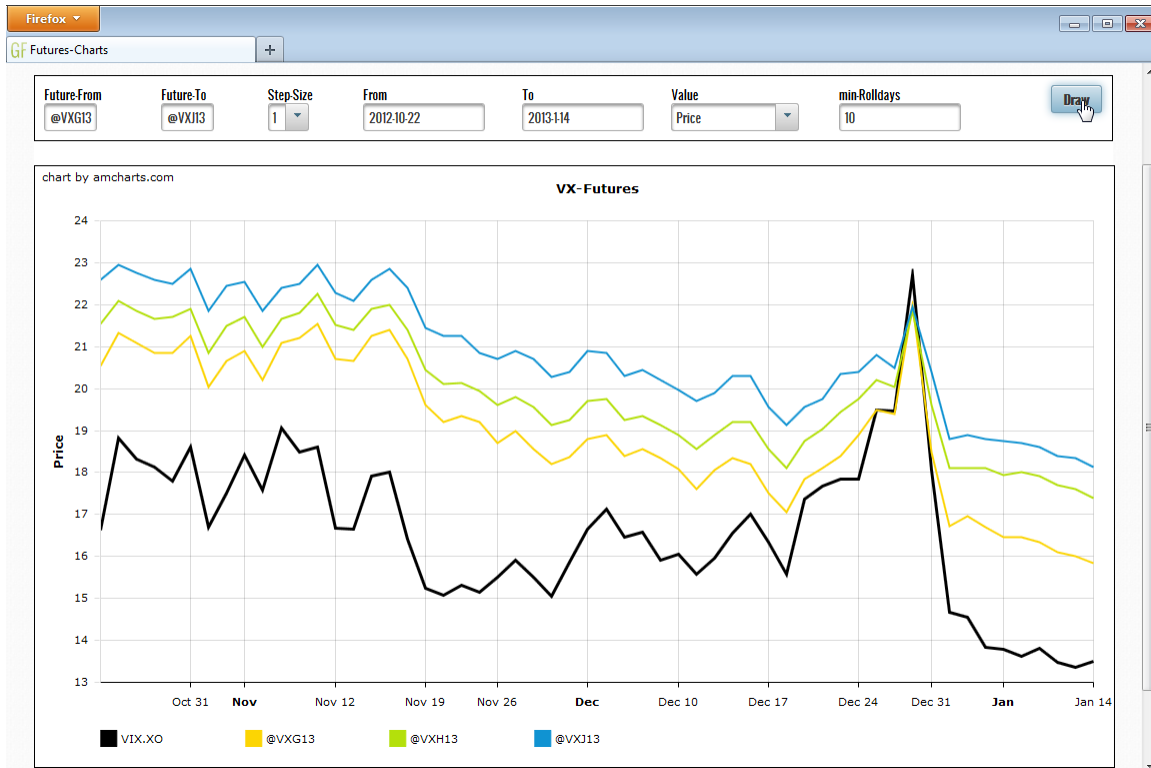
Graphic-1: VIX and VIX futures prices from 2012-10-12 to 2013-01-14
VIX (black), VXG13 (yellow) VXH13 (green), VXJ13 (blue).

Graphic-2 shows the Daily-Roll for the same futures according equation (1).
Graphic-3 for equation (2) and Graphic-4 for equation (3). The peak in Graphic-1 at
2012-12-28 is the effect of the fiscal-cliff.

Equation (1) favors short-term futures (the yellow line in Graphic-2). Equation (2)
strongly favors long-term futures (blue line Graphic-3). Equation (3) is only slightly
favorable to the long-term (Graphic-4). The same holds for equation (5). Equation (3)
normalizes with the delta-Price, equation (5) with delta-log(Price). The most neutral
measure is equation (6) in Graphics-6. Here one normalizes with the HF realized-
volatility.

Although the shapes are for the different measures quite similar, the values differ due to
different normalization terms. The purpose of the different measures is: One wants to
exploit the futures term-structure in the most efficient way.
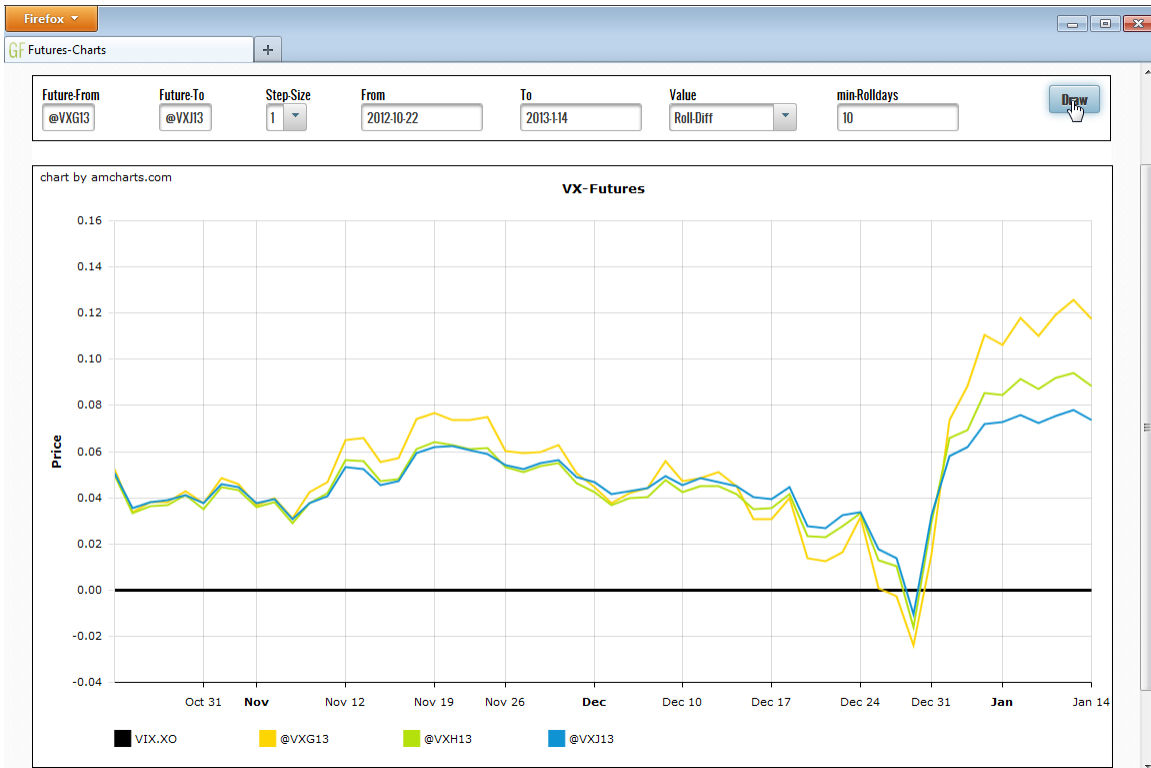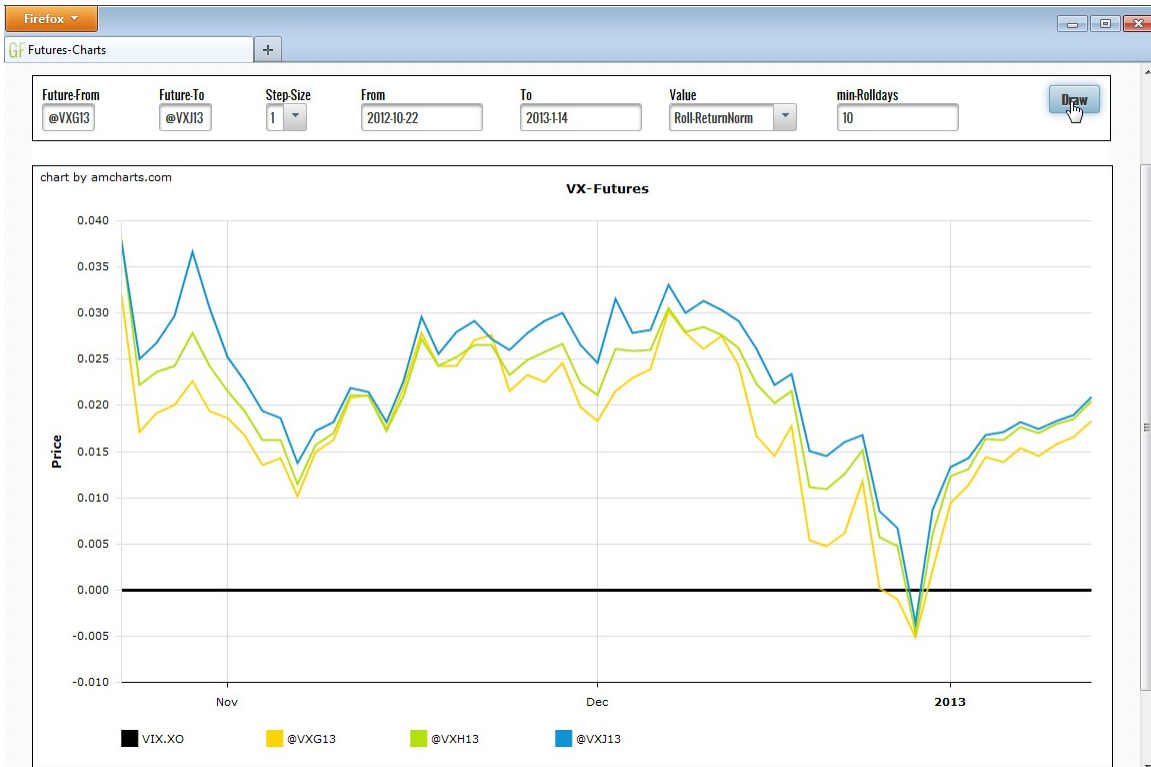
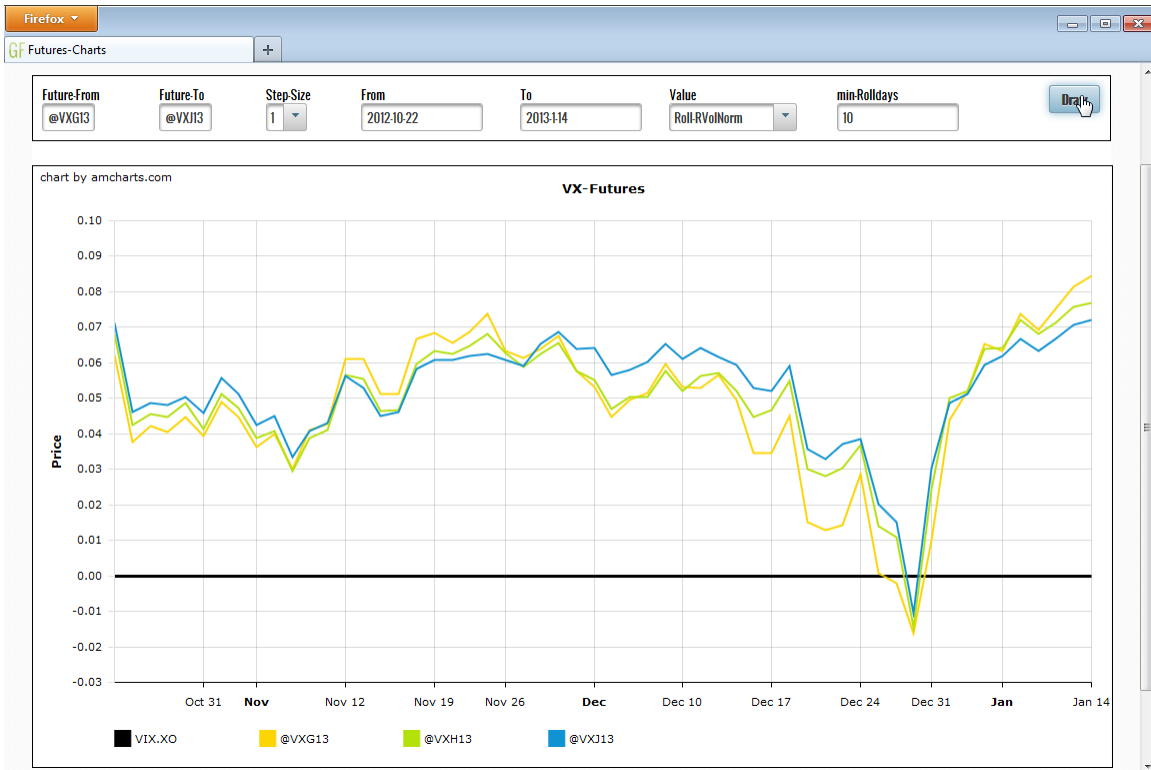Graphic-2: Daily-Roll according equation (1) from 2012-10-12 to 2013-01-14

Graphic-3: Daily-Roll according equation (2) from 2012-10-12 to 2013-01-14
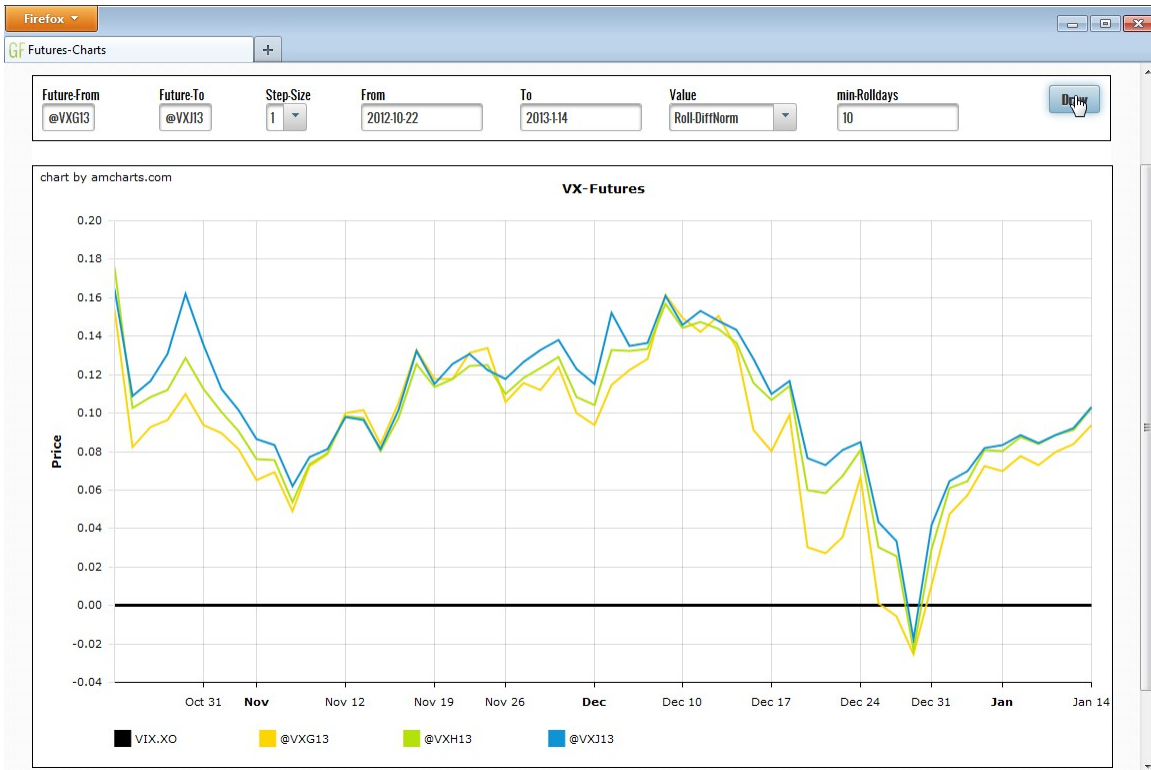
Graphic-4: Daily-Roll according equation (3) from 2012-10-12 to 2013-01-14

Graphic-5: Daily-Roll according equation (5) from 2012-10-12 to 2013-01-14

Graphic-6: Daily-Roll according equation (6) from 2012-10-12 to 2013-01-14

The Trading Strategy:

The trading-strategy in [3] is: One selects the most nearby future if the daily roll is above a given enter-threshold. The future is held a maximum of 5 trading days. It is sold back premature, if the daily-roll falls below the stop-threshold or if there are less than 10 trading-days till maturity.

The **Calvados** strategy modifies these rules. One selects from all the futures the best one (with the largest daily-roll). The maximum maturity is 93 trading days (about 4 months). For longer maturities volume is low and hence the bid-ask-spread increases. The best daily-roll must be as in the original paper larger than the enter-roll. But the position is hold as long as the daily-roll is above the stop-threshold. If the maturity is less than 10 trading days, the future is sold back. The calculations assume an initial value of 500.000$. This arbitrary value was used in previous working-papers. It is kept for comparison reasons. The calculation is for the last 4 years from 2010-01-12 to 2014-01-17.

Note: In Revision-1 the calculation is simply extended to the most recent trading day.

The volume is calculated by

```
Volume = -(Index*Leverage*0.01)/(VIX*1000.0).
```

The standard leverage is 60%. If the index is at 500.000, and the VIX is at 15, one would go 20 VIX Futures short.

Note: In the original version, in place of the VIX the VIX futures price was used. This has the effect, that futures with shorter maturity are traded with higher volume than more distant ones. This makes the comparison of the strategies more difficult. It is also not very logical to trade more volatile futures with higher volume. The new formula generally increases the volume and hence also the profit and risk.

There are 3 major adverse events in the considered time-range. The first is the flash crash at 2010-05-06. The next dangerous moment was the Japanese earthquake in March 2011. The third the crash in summer 2011.

Graphic-7 shows the best result for equation (1). The best enter-roll is 0.07. One closes the position once the roll has fallen below 0.03. The final value is 2.968.300$ or +496.7%. The VIX reaches its maximum in the summer 2011 crash at 2011-08-08 (red line in Graphic-7). The strategy performs during this crash well. It is since 2011-07-13 at the sideline. One watches also the flash-crash from this comfortable position. But one looses somewhat in the fore- and aftershocks. There is of course no premature warning for the Japanese earthquake. One looses the first day and closes the position. The largest relative drawdown is at 2012-05-18 with 29.7%. Nothing really dramatic happened at this time. The VIX just went up somewhat.
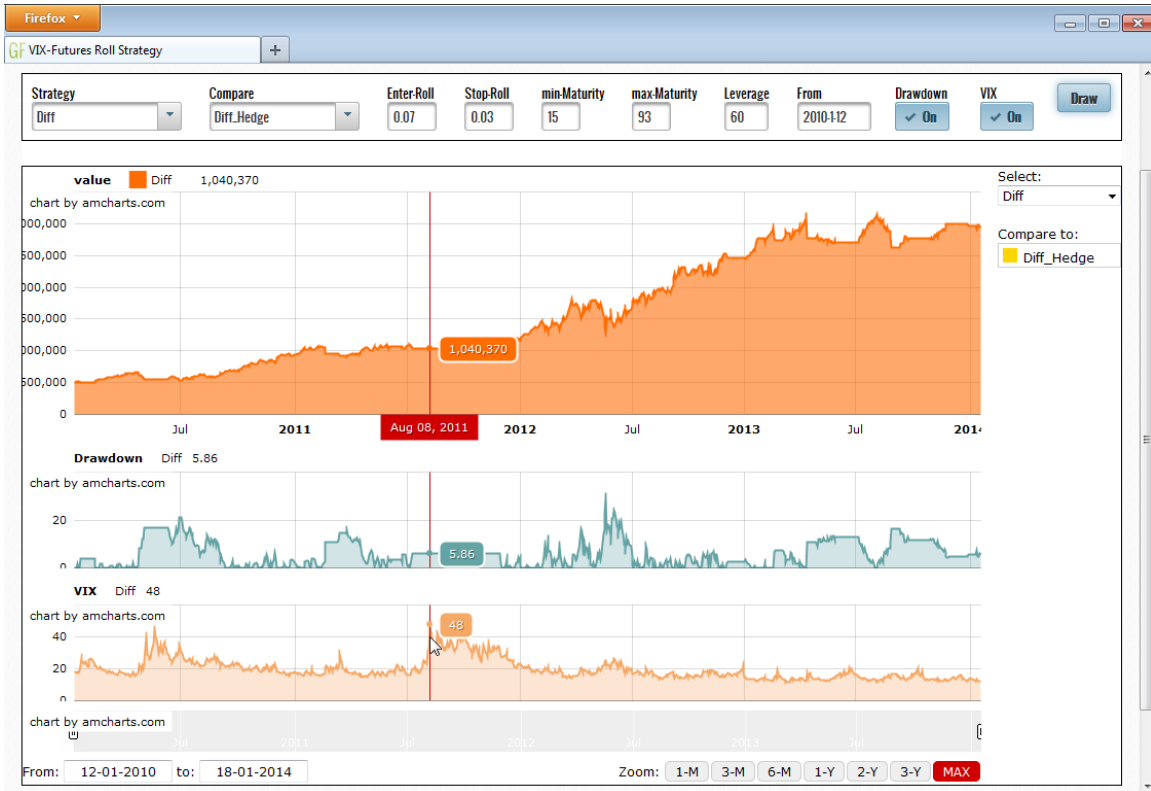
Graphic-7: Roll-Strategy with 0.07/0.03 Enter/Stop and Equation (1)
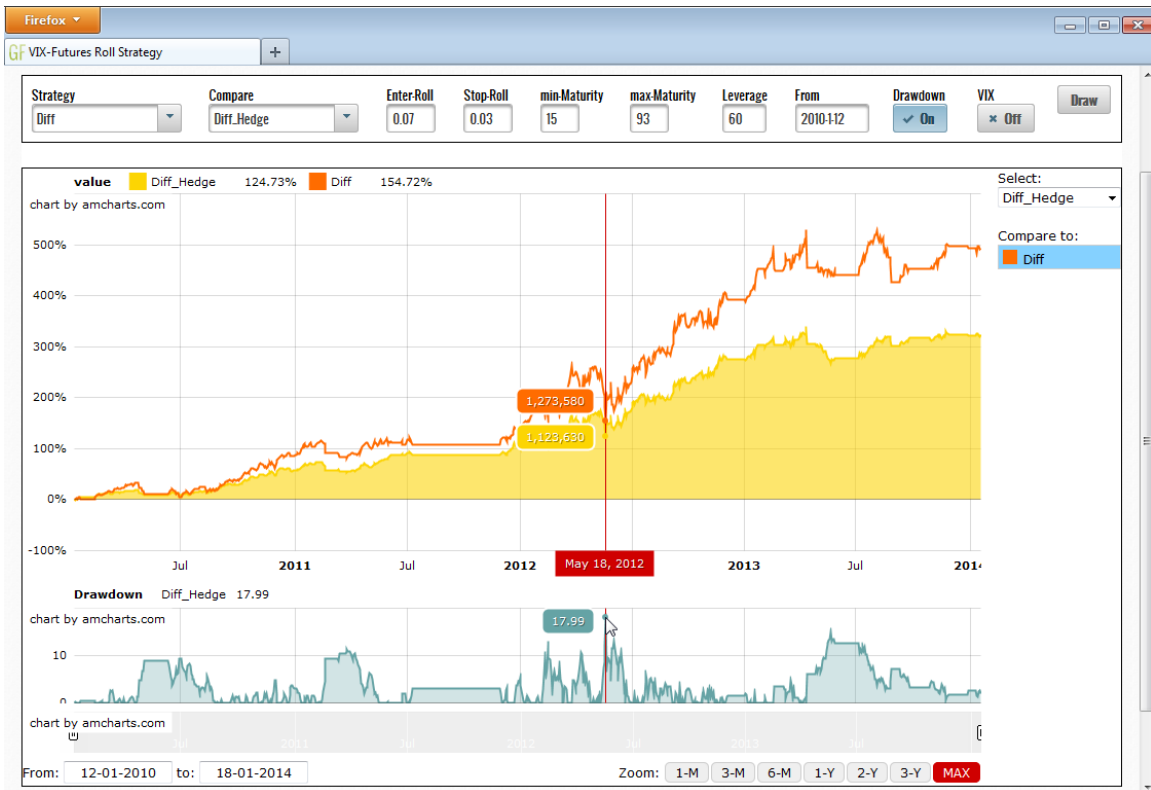
Graphic-8: Hedged Roll-Strategy (yellow) with 0.07/0.03 Enter/Stop and Equation (1)

Hedging the VIX futures with the SPX:

The VIX and the SPX are highly negative correlated. The correlation is typically between -0.7 and -0.75. But the relation is non-linear. The VIX explodes in times of troubles.
It is nevertheless tempting to hedge the VIX futures with SPX-eMinis. For this purpose the following equation is formulated in [3].

```
DeltaVXF(t) = b0 + b1*SPXRet(t) + b2*SPXRet(t)*TTS(t)    (7)
```

DeltaVXF … Daily change of VIX future.
SPXRet   … Daily-Return of SPX.
TTS   … Trading days till settlement.

The daily-change of the VXF is according to equation (7) a linear function of the SPX return and the product of the SPX return and the trading days till settlement. One expects $b1$ to be negative. The parameter $b2$ should be positive. The parameter accounts for the smoother behavior of futures with longer maturity. The authors estimate $b1 = -0.714$ and $b2 = 0.0127$.
From (7) they get the hedging-ratio HR as:

```
HR(t) = (1000*(b1 * b2*TTS(t))/(0.01*SPX(t)*50)        (8)
```

The factors 1000 and 50 are the $-multipliers for VIX- and the SPX-eMini futures. The factor 0.01 is necessary, because returns are usually calculated in percent. With the values estimated above, one typically hedges the most nearby future with one eMini-contract.

The parameters $b1 = -0.714$ and $b2 = 0.0127$ make only sense if one restricts trading to short maturities. For maturities greater than 56 trading days the ratio gets positive. Hence one does not hedge anymore, but has double exposure to SPX crashes.
For the Calvados the parameters were set in [2] to $b1 = -0.6$ and $b2 = 0.006$. Actually I calculated for each roll-threshold-pair and for equation (1) to (3) the optimal parameter setting for the win/max. drawdown ratio. The settings differed a lot. But such an optimization is cheating. One optimizes in hindsight. One can not estimate the parameters like in equation (6) because TTS() differs in a wide range and depends on the trading-path.
Setting $b1 = -0.6$ and $b2 = 0.006$ is a reasonable and justifiable choice, which gives also acceptable results. The hedging ratio is for 17 trading days about equal to the original parameter setting. For shorter maturities the original parameter values have a (absolute) larger hedging ratio, for longer ones the adjusted values of -0.6/0.006.
For this study I kept the original parameters from [2]. They worked reasonable in real trading-life. This study should also confirm (or reject) the original results. Graphic-8 shows the performance of the hedged-strategy for equation (1) with the same enter- and stop-roll of 0.07/0.03 like in Graphic-7. The orange line is for comparison the performance of the naked strategy. The overall win reduces from 496.7% to 321.7%. But the max. relative drawdown at 2012-05-18 drops also from 29.7% to 18.0%. The hedged version has the same performance than the naked one with a leverage of 75%. The max. relative drawdown is with 22.3% still considerable smaller than the 29.7%.

Graphics-9 and -10 show the result if one uses equation (2). The enter-roll is 0.06, the stop-roll 0.03. The performance is with 285.6% for the naked and 202.2% for the hedged strategy considerable lower. But the graph is also much smoother. The max. relative drawdown is 17.7% for the naked and 11.6% for the hedged version.

Note: The results differed even more for the original volume calculation. Equation (1) favors the most nearby future, (2) the long maturities. One traded futures with lower volatility with lower volume. The volume effect is eliminated in the new setting. The different performance is now the sole result of the different volatility.

The overall performance of (1) and (2) are the same, if one increases the leverage for the second case to 81%. The max. relative drawdown is for the 81% leverage 23.4%. Equation (2) has on a risk-adjusted basis an edge.

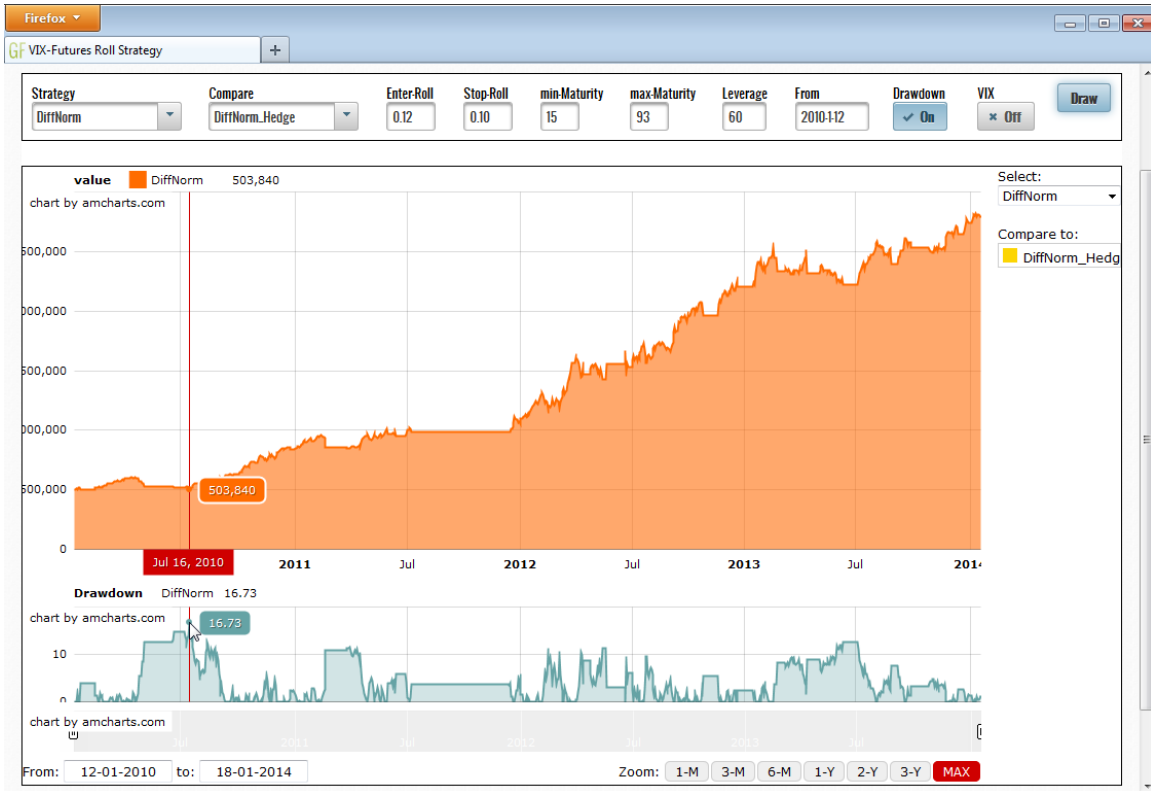Graphic-9: Roll-Strategy with 0.06/0.03 Enter/Stop and Equation (2)
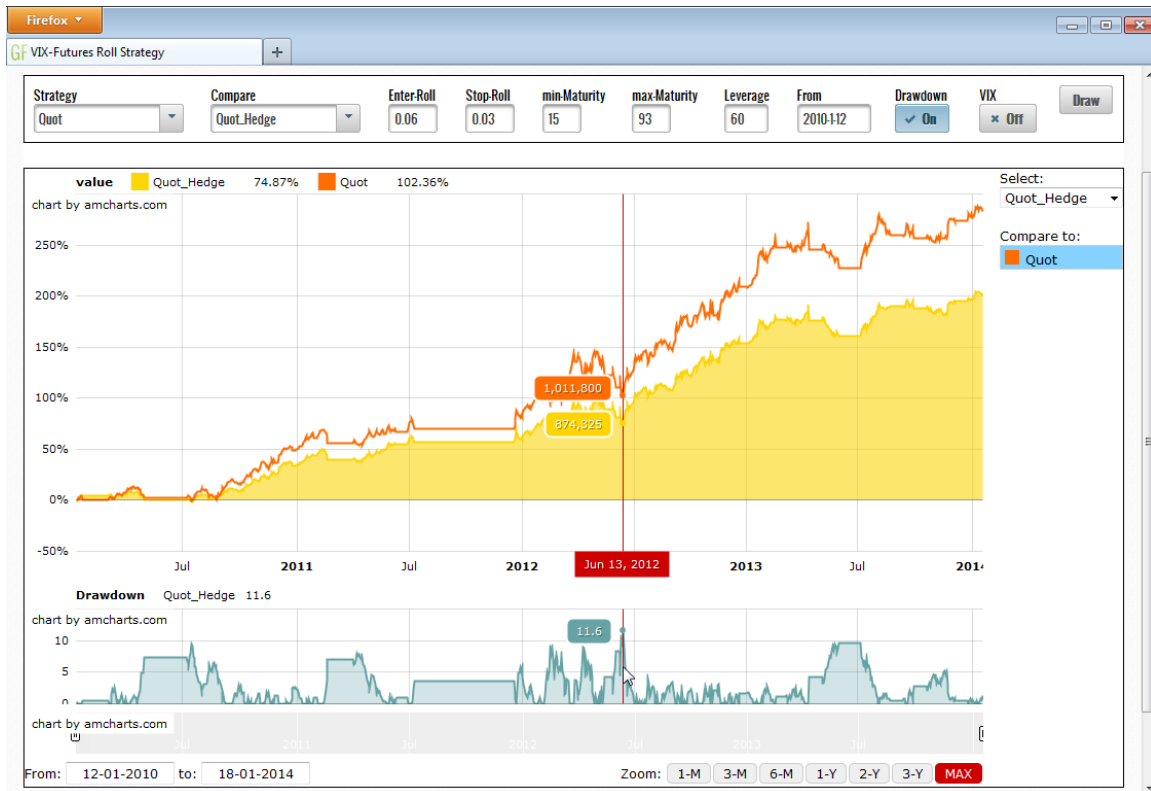
Graphic-10: Hedged Roll-Strategy (yellow) with 0.06/0.03 Enter/Stop and Equation (2)

Graphic-11 and -12 show the result for equation (3) with an enter-roll of 0.12 and a stop-roll of 0.10. The thresholds are considerable larger than for equation (1) and (2). This reflects the simple fact, that the daily Delta-VXF is usually smaller than 1.0.

The overall performance of the naked version is 460.3% with a max. relative drawdown of 16.7% at 2010-07-16. The strategy suffered somewhat in the aftershocks of the flash-crash. The performance is almost as good as for equation (1), with a much lower drawdown. For the hedged-version one gets a performance of 273.7% and a max. relative drawdown of 11.3% at 2010-07-16. Equation (3) has on a risk-adjusted base a clear edge over equation (1). One has only slightly to increase the leverage of equation (3) to get the same (or better) performance.

The superior result can be relative easily explained. The basis decreases in times of (forthcoming) troubles. At the same time the volatility/swings of the futures go up. This decreases the measure further. It reacts faster than the first 2 measures. But this is also the reason for the problems in the flash-crash aftershocks. Equation (3) suffers somewhat from whipsaw effects.

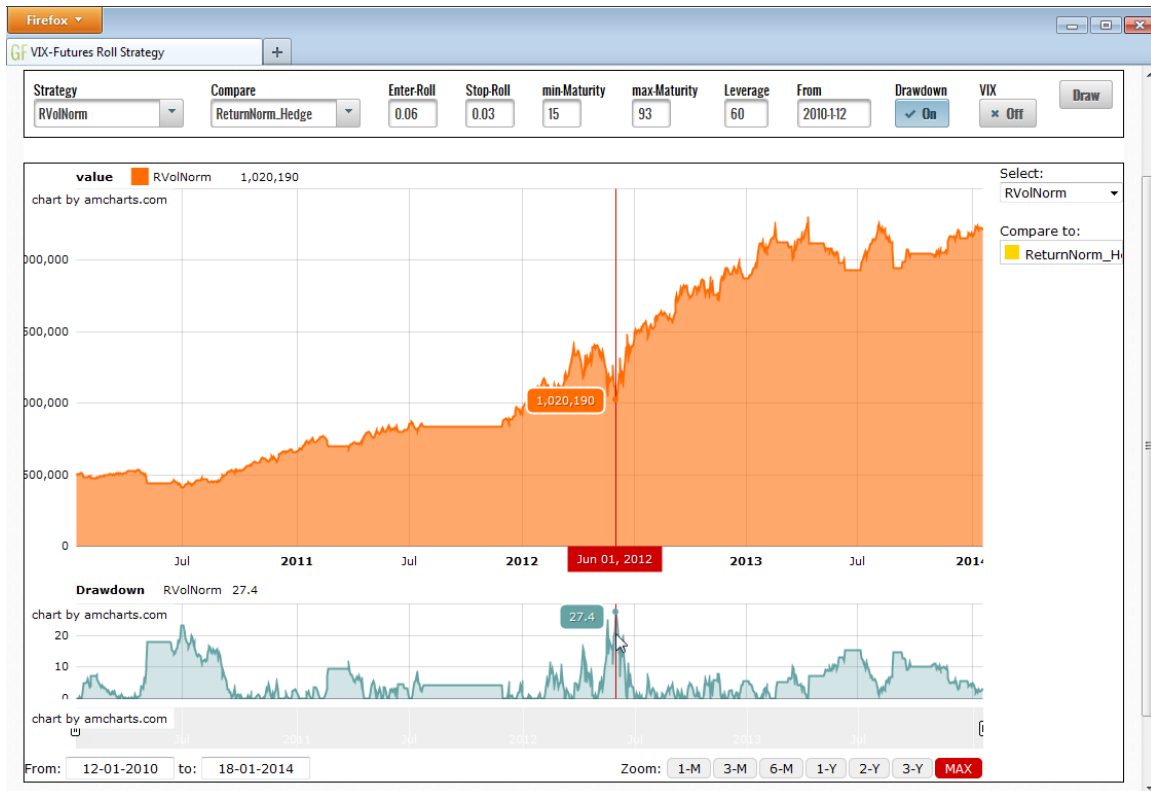Graphic-11: Roll-Strategy with 0.12/0.10 Enter/Stop and Equation (3)
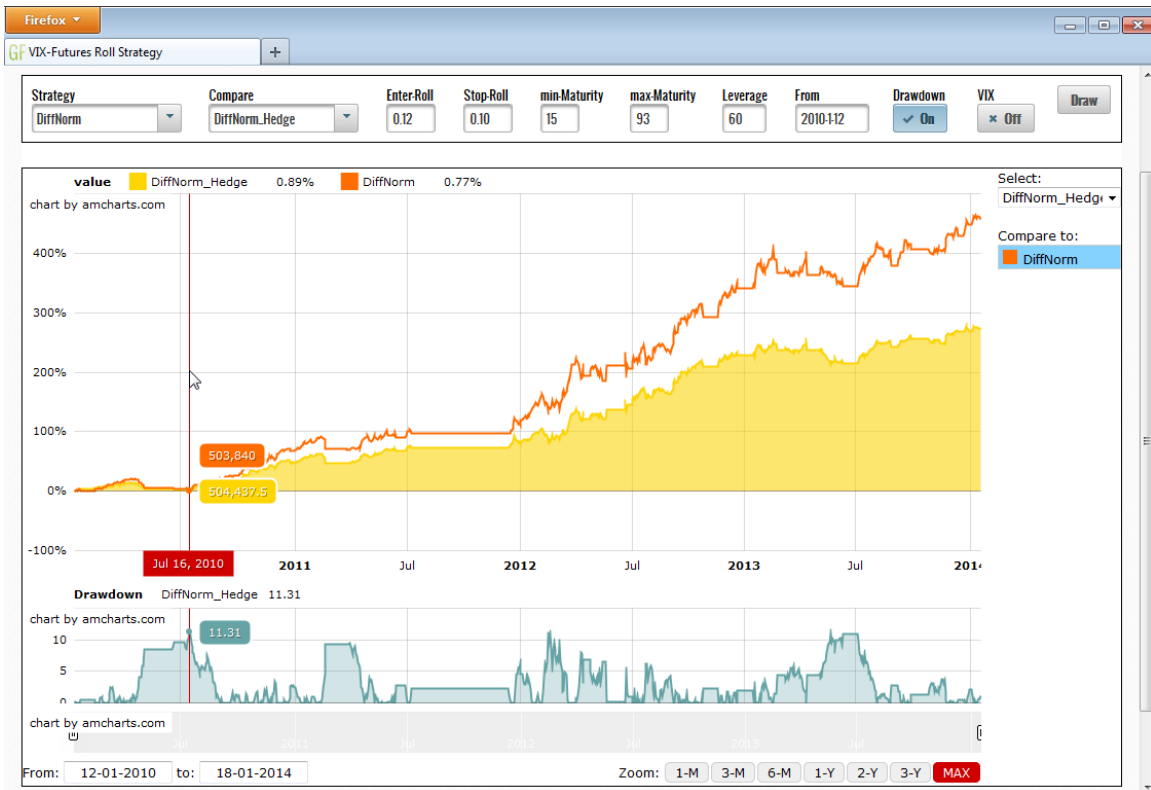
Graphic-12: Hedged Roll-Strategy (yellow) with 0.12/0.10 Enter/Stop and Equation (3)

Graphic-13 shows the performance of equation (5). One normalizes with the daily-return. The enter-roll is 0.025, the stop-roll 0.01. The values are smaller than for equation (1), because the daily-return of VIX futures is usually larger than 1%. The overall performance is for the naked version 452.2% with a maximum relative drawdown of 28.3% at 2012-06-01. For the hedged version (not shown) it is 267.2% with a max. relative drawdown of 16.3%. This is in both dimensions – return and drawdown - worse than equation (3).

Graphic-13: Roll-Strategy with 0.025/0.01 Enter/Stop and Equation (5)

Graphic-14 shows the performance of equation (6). One normalizes with the realized volatility of the VIX future. The enter-roll is 0.06, the stop-roll 0.03. This is with an overall performance for the naked version of 334.7% and a max. relative drawdown of 27.4% clearly the worst strategy. Using the additional intraday information does not pay off. This result is somewhat surprising. I expected at least the same result than with equation (6). But I noticed also in previous work, that using HF realized volatility does not improve trading performance. This is in strong contrast to claims of the HF realized volatility gang.

Graphic-14: Roll-Strategy with 0.06/0.03 Enter/Stop and Equation (6)

Long-Roll-Trading:

The basis is in times of troubles inverted. The spot is above the futures. This reflects the mean-reverting behavior of the VIX. One can turn the trading position around. If the daily-roll is below a given threshold one goes the futures long. The strategy is the same than above, only the sign of the volume and the thresholds are inverted. This reversal was proposed in [3]. The results in [2] were not really convincing. The reversal happens only in high VIX regimes. The strategy is risky and one sails against the wind. The long-roll was hence not traded in the past and was also in the current simulations clearly worse than the short strategy. It is best to stay in turbulent times on the sideline.

Filtering the Basis:

In recent working papers ([7], [8]) the implied volatility term structure IVTS was used as a trading signal. The performance is considerable improved by filtering the IVTS with a median-5 filter. The purpose is to filter out short spikes. I tried a median-3 and a median-5 filter here too. But it does not work. The sawtooth effect which hampers the strategies in [6] and [7] does not happen here in the same amount. Filtering has only a slight edge for equation (3) in the flash-crash aftershocks. But overall it is clearly worse. One is with the filter too late in and especially too late out of the market.

Conclusion:

The best strategy is Graphic-12. **Using the normalized roll equation (3) for calculating the daily-roll and setting the enter- and stop-roll to 0.12/0.10**. This is the same result than in [2]. Hedging does not eliminate the risk, but it considerable smooths the performance. One can either trade with reduced risk or increase the leverage to get the same performance (with still reduced risk) than the naked version. **Hedging pays off.** This is also inline with the previous results and trading experience. **This strategy is dubbed the Calvados 2.0**.

Implementing the Calvados 2.0 is quite straightforward. The short eMinis are readjusted only infrequently. The adjustment is relative insensitive to the movement of the market. It depends primarily on the time-decay. The historic simulation does not account for trading-costs. But there are only a few transactions involved. Incorporating trading costs is usually a (complicated) guesswork. It would certainly not change the overall picture. In fact the major problem of any historic simulation is: One drives a car by looking in the rear mirror.

The Calvados 2.0 is not a free lunch. But it is certainly an interesting extension of the trading toolbox.

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