Trading 1Min Bar Crude Light Futures Using
The Fading Memory Polynomial Velocity Strategy Part 2

January 5 2012 –January 12 2018

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Disclaimer

The strategies, methods and indicators presented here are given for educational purposes only and should not be construed as investment advice. Be aware that the profitable performance presented here is based upon hypothetical trading with the benefit of hindsight and can in no way be assumed nor can it be claimed that the strategy and methods presented here will be profitable in the future or that they will not result in losses.

In a previous working paper http://meyersanalytics.com/publications2/CL1FadmVnc.pdf we showed how the application of the Nth Order Fading Memory Polynomial Velocity strategy(**FadmV**) could be used to develop a strategy to trade the Crude Light futures contract intraday. In that paper we used a walk forward method called the Walk Forward Metric Explorer (WFME) that selected the **FadmV** strategy inputs to be used in the out-of-sample section based upon certain in-sample section performance metrics. In this paper we will use a different method called the Walk Forward Strategy Inputs with Metric-Filters (WFINP) to select FadmV strategy inputs in the in-sample section to use in the out-of-sample section.

The n^{th} Order Fading Memory Adaptive Polynomial Velocity Defined

The adaptive n^{th} order Fading Memory Polynomial Velocity is constructed and plotted at each bar by solving for the coefficients $\mathbf{b_1}, \mathbf{b_2}, \mathbf{b_3}, \ldots \mathbf{b_n}$ **for** the discrete orthogonal Meixner polynomials at each bar using the exponential decay factor **α=(1-β)** and the equation for $\mathbf{b_j}$ shown in the **"Math"** appendix of this paper. Then next day estimated **Velocity(t+1)** is constructed from the equation shown in the "Math" appendix and plotted under the price chart.

The velocity of a 2^{nd}, 3^{rd} and 4^{th} order polynomial should change faster than the straight line (1^{st} order velocity). As observed from the 2^{nd} order velocity equation in the "Math" section, there is an acceleration component in the calculation of the velocity. This means that the 2^{nd} order velocity will reflect a change in the price trend much faster than the straight-line velocity which does not have an acceleration component. The same is true for 3^{rd} and 4^{th} order velocities. Whether higher order polynomial velocities are an advantage or not we will let the computer decide when we let the computer search for the "best" polynomial degree as described below.

At each bar, we calculate the nth order (1^{st} through 4^{th}) fading memory polynomial velocity from the formulas in the "Math" appendix. As we will show below, optimization will determine the order or degree for nth order polynomial velocity that will be used. When the velocity is greater than the threshold amount ***vup*** we will go long. When the velocity is less than the threshold amount ***-vdn*** we will go short.

Buy Rule:

IF Velocity is greater than the threshold amount ***vup*** then buy at the market.

Sell Rule:

IF Velocity is less than the threshold amount ***-vdn*** then sell at the market.

The strategy follows the velocity curve. When the velocity is greater than the threshold amount ***vup*** a buy signal is issued. The threshold **vup** serves as a noise filter. That is, price noise creates a lot of small back and forth velocity movement. Unless the velocity can break some threshold to the upside, no trade is issued and the move is considered price noise. The same logic holds for the sell threshold **vdn**.

Intraday Bars Exit Rule:

Close the position at 1429 EST when the open outcry pit session ends. (no trades will be carried overnight).

First Trade of Day Entry Rule:

All trade signals before the 9am EST open outcry pit session are ignored. We've included this rule because we observed that overnight Globex trading mostly consists of price movements with few sustainable trends. 60-70% of sustainable trends usually occur during the open outcry pit session hours.

To test this strategy, we will use one-minute bar prices of the mini Crude Light futures contract traded on the NYMEX WTI and Globex and known by the symbol CL for the 312 trading weeks from January 5, 2012 to January 26, 2018.

We will test the Fading Memory strategy with the above CL 1 min bars on a ***walk forward basis***, where the in-sample(IS) will be 30 calendar days and the out-of-sample(OOS) will be the next 7 calendar days following as will be described below. The 7-calendar day OOS periods will end on a Friday as will the 30-calendar day IS periods.

Testing the Polynomial Velocity Strategy Using Walk Forward Optimization

There will be four strategy parameters to determine:

1. **degree**, degree=1 for straight line velocity, degree=2 for 2nd order velocity, etc.
2. **alpha =(1-β)** The exponential decay weight for the Nth Order Fading Memory Polynomial calculation**.**
3. ***vup***, the threshold amount that velocity must be greater than to issue a buy signal
4. ***vdn***, the threshold amount that velocity must be less than to issue a sell signal

To create our walk forward files we will use the ***add-in*** software product called the Power Walk Forward Optimizer (PWFO). In TradeStation (TS) or MultiCharts(MC), we will run the PWFO strategy ***add-in*** along with the n^{th} Order Fading Memory Polynomial Velocity Strategy on the CL 1min data from January 5, 2012 to January 26, 2018. The PWFO will breakup and create 30-day calendar in-sample sections along with their corresponding one calendar week out-of-sample sections from the 312 weeks of CL (see Walk Forward Testing below) creating 312 out-of-sample weeks. As an example, the first in-sample section would be from 1/5/2012 to 2/3/2012 and the out-of-sample section would be the week following from 2/6/2012 to 2/10/2012. (all in-sample and out-of-sample sections always end on a Friday). We would then move everything ahead a week and the 2nd in-sample section would be from 1/12/2012 to 2/10/2012 and the week following out-of-sample section would be from 2/13/2012 to 2/7/2012 Etc.

The PWFO 312 in-sample/out-of-sample section dates are shown in **Table 1** below. We will then use another software product called the Walk Forward Strategy Inputs with Metric Filters Explorer (WFINP) on each of the 312 in-sample generated by the PWFO to find the best in-sample section performance ***filter*** that determines the strategy input parameters ***(degree, N, vup, vdn)*** that ***will be used on the out-of-sample data***. Detailed information about the PWFO and the WFINP can be found at www.meyersanalytics.com

For the in-sample data we will run the TC/MC optimization engine on the 312 weeks of CL 1 min bars with the following ranges for the nth order fading memory polynomial velocity strategy input variables.

1. **pw=degree from 1 to 4 in steps of 1.**
2. **N from 20 to 70 in steps of 10.**
3. **vup from 0.25 to 3 in steps of 0.25**
4. **vdn from 0.25 to 3 in steps of 0.25**
5. **Mult = 36, (See Appendix 2, the Normalization Multiplier)**

Note: I use **N** because it gives a better understanding of how many bars of past data are approximately being used. **N** and α **(α=1-β)** are approximately related by the formula **α=2/(1+N)**. **N** is converted to α by this formula in the Nth Order Fading Memory Polynomial calculation

This will produce ***3456*** different cases or combinations of the input parameters for each of the 312 PWFO output files.

What Is an In-Sample Section and Out-Of-Sample Section?

Whenever we do a TS optimization on many different strategy inputs, TS/MC generates a report of performance metrics (total net profits, number of losing trades, etc.) vs these different strategy inputs. If the report is sorted on say the total net profits(***tnp***) performance metric column then the highest ***tnp*** would correspond to a certain set of strategy inputs. This is called an ***in-sample*** or ***test section***. If we choose a set of strategy inputs from this report based upon some performance metric, we have no idea whether these strategy inputs will produce the same results on future price data or data they have not been tested on. Price data that is not in the in-sample section is defined as ***out-of-sample data***. Since the performance metrics generated in the in-sample section are mostly due to "curve fitting" (see **Minimizing Curve Fitted Performance Results** section below) it is important to see how the strategy inputs chosen from the in-sample section perform on out-of-sample data.

Walk Forward Out-of-Sample Testing

Walk forward analysis attempts to minimize the curve fitting of price noise by using the law of averages from the Central Limit Theorem on the out-of-sample performance. In Walk Forward analysis the data is broken up into many **in-sample** and **out-of-sample** sections. Usually for any strategy, one has some performance metric selection procedure, which we will call a filter**,** used to select the strategy input parameters from the in-sample optimization run. For instance, a ***filter*** might be all cases that have a profit factor (PF) greater than 1 and less than 3. For the number of cases left, we might select the cases that had the best percent profit. This procedure would leave you with one case in the in-sample section output and its associated strategy input parameters. Now suppose we ran our optimization on each of our many in-sample sections and applied our ***filter*** to each in-sample section output. We would then use the strategy input parameters found by the ***filter*** in each in-sample section on the out-of-sample section immediately following that in-sample section. The input parameters found in each in-sample section and applied to each out-of-sample section would produce independent net profits and losses for each of the out-of-sample sections. Using this method, we now have "x" number of independent out-of-sample section profit and losses from our **filter**. If we take the average of these out-of-sample section net profits and losses, then we will have an estimate of how our strategy will perform ***on average***. Due to the Central Limit Theorem, as our sample size increases, the spurious noise results in the out-of-sample section performance tend to average out to zero in the limit leaving us with what to expect ***on average*** from our strategy and filter. ***Mathematical note: This assumption assumes that the out-of-sample returns are from probability distributions that have a finite variance. More on this below.***

Why use the walk forward technique? Why not just perform an optimization on the whole price series and choose the strategy input parameters that give the best total net profits or profit factor? Surely the price noise cancels itself out with such a large number of in-sample trades. Unfortunately, nothing could be farther from the truth! Optimization is a misnomer and should really be called combinatorial search. As stated above, whenever we run a combinatorial search over many different combinations of strategy input parameters on noisy data on a fixed number of prices, ***no matter how many***, the best performance parameters found are guaranteed to be due to ***"curve fitting"*** the noise and signal.

Minimizing Curve Fitted Performance Results. What do we mean by "curve fitting"? The price series that we trade consists of random spurious price movements, which we call ***noise***, and repeatable price patterns (if they exist). When we run, for example, 5000 different strategy input parameter combinations, the best performance metrics will be from those strategy input combinations that are able to produce profits from the price pattern and the random spurious price movements. While the price patterns will repeat, the same random price movements will not. If the random price movements that were captured by a certain set of strategy input parameters were a large part of the total net profits, which they are in most price series, then choosing these "best profits" input parameters will produce losses when traded on future data from what looked like the holy grail in the optimization output run.

If we eliminate the in-sample optimization cases with the very best performance metric results we can eliminate many of the data mining strategy input parameters that fitted the past spurious and random price movements. As an example, let us choose the performance metric called the Profit Factor(**PF**). The **PF** is a good performance metric for eliminating the curve fitted strategy input parameters because the best performance usually has the highest Profit Factors. If we eliminate all cases that have PFs above a certain value, we can eliminate many of the curve fitted in-sample strategy input parameter cases. As another example, let us choose the performance metric $\mathbf{r^2}$.(**R2**). $\mathbf{r^2}$ is the in-sample equity curve straight line correlation coefficient generated by each set of strategy inputs in the in-sample section. The higher the in-sample $\mathbf{r^2}$ the higher the chance that the strategy inputs are fitting the price pattern AND the random price movements. If we eliminate all cases that have **R2**s above a certain value we can eliminate many of the curve fitted in-sample strategy input parameter cases. Thus, hypothetically, we can minimize, the curve fitted results by filtering out of the Walk Forward file's in-sample sections those strategy input parameters that have ***PFs*** greater than some chosen value and/or ***R2s*** of greater than some chosen value. This type of strategy input filter means that one would not be trading a given set of strategy inputs every out-of-sample week until the in-sample section before it has a **PF** and/or **R2** below our criteria values. This curve-fit minimization hypothesis requires testing to see if it works.

Finding the Best Set of Strategy Inputs with Metric Filters

The PWFO generates a number of performance metrics in the in-sample section. (Please see **http://meyersanalytics.com/Walk-Forward-Optimization.html** for a listing of these performance metrics).The question we are attempting to answer statistically, is which performance metric or combination of performance metrics (which we will call a ***filter***) applied to a given set of strategy inputs in the in-sample section will produce statistically valid profits in the sum of all out-of-sample sections. In other words, we wish to find the best set of strategy inputs with a ***metric filter*** applied in each in-sample section that give the "best" total out-of-sample results over all out-of-sample sections. This means if we applied our ***metric filter*** to the strategy inputs chosen in the in-sample section, we would only trade that set of strategy inputs in the next out-of-sample week if the ***metric filter*** satisfied our criteria. Else no trades would be made in the next out-of-sample section.

The Walk Forward Strategy Inputs with Metric Filters Explorer.

We wish to find ***one*** set of strategy inputs that we can trade in every out-of-sample section, but we will only trade that set of strategy inputs in the out-of-sample if and only if they satisfy our ***metric-filter***. Else we won't trade.

Let us define the in-sample ***metric-filter*** we will use here as the in-sample Profit Factor(**PF**) less than or equal to **x** and/or equity curve straight line correlation coefficient **r^2(R2)** less than or equal to **y**. That is **PF ≤ x and/or R2 ≤ y.**

What the we are going to do here is look at every combination in the in-sample section of each **strategy input** with **PF ≤ x and/or R2 ≤ y**. This will produce three **strategy input|metric-filter** combinations: **strategy input|PF ≤ x and R2 ≤ y|, strategy input|PF ≤ x|,** and **strategy input|R2 ≤ y|.** If the **strategy input|metric-filter** satisfies **the metric-filte**r condition in the in-sample section then we will use those strategy inputs to trade in the out-of-sample section. If not, then there will be no trades in the out-of-sample section.

We will look at all **metric-filter** combinations of **PF≤1.5 to 4 step 0.5 and R2≤60 to 80 step 10.** We will also look at the strategy input with no metric-filter. With 3456 different strategy input combinations this will give us 96,768 **strategy input|metric-filter** combinations. Each one of these 96,768 **strategy input|metric-filter** combinations will be applied to each in-sample section and their out-of-sample performance will be tabulated for all 312 PWFO files.

Below is a snippet of the output from a run of all 96,768 combinations sorted by **the total out-of-sample net profit** (**toNP**). The column definitions are defined in Figure 3 below. This example shows a partial output file from the WFINP program run on the PWFO files generated with the Nth Order Fading Memory Polynomial Strategy that was run on 1 contract of the Crude Light(CL) 1-minute bar futures for the 312 weeks from 2/10/2012 to 1/26/2018. The in-sample(IS) period is 30 calendar days and the out-of-sample(OOS) period is 7 calendar days or one week. Sundays were automatically skipped because this strategy only traded between 9am to 1429pm Exchange Time (EST).

From this run, we chose the filter on row 3 of the Figure above. That is, **2|70|0.5|3|900|1429|36|pf<2.5<|r2<60**. This is constructed as follows. For the strategy inputs **2|70|0.5|3|900|1429|36|** only those in-sample sections that have a **PF <= 2.5** and **R2 <=60** are used to trade in the following out-of-sample sections. If the in-sample PF > 2.5 and or R2>60 then the out-of-sample section following the in-sample section is not traded that period and is skipped. 24 out-of-sample periods were withheld from the total 312 oos weeks in the WFINP run. The WFINP only ran 288 weeks of oos files from 2/5/2012 to 8/11/2017. The reason 24 weeks were withheld from the WFINP run was twofold. ***One***, was that the previous working paper http://meyersanalytics.com/publications2/CL1FadmVnc.pdf had the same 288 weeks ending on 8/11/17 and we wanted to compare the results of this walk forward method with that of the previous paper. ***Two,*** 24 weeks were withheld to see how this filter would do on the withheld oos data. And compare how the previous paper did on the same withheld data.

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<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th><th>H</th><th>I</th><th>J</th><th>K</th><th>L</th><th>M</th><th>N</th></tr>
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Bootstrap Probability of Filter Results:
What is Bootstrap? Suppose each Pwfo file has 5000 rows and I chose one of the 5000 rows at random and record the net osnp (osnp-Number of trades*cost) for that random selection row. Now suppose I repeat this random selection for each of the 288 Pwfo files. Then I sum each of the 288 random net osnp's (after subtracting costs) to obtain a *random sum total oos net profits (RndmTONP)*. If I repeat this random row selection process of the 288 Pwfo files 5000 times, then I will have 5000 *RndmTONPs*. I then compute the average and standard deviation of these 5000 random *RndmTONPs*. and assume that these *RndmTONPs*.have a Normal distribution curve, I can calculate the probability that any filter's **toNP** could be obtained by chance. This random row selection technique is called "***Bootstrap***

The more filters you investigate in any given run the more chance you have of generating good filter results just by pure chance alone. We've run 96,768 Strategy Input|Metric-Filter combinations. Let's take our above example. **Column AH** lists the probability that the filters out-of-sample(**oos**) **toNP** was due to pure chance. **Row 1, Col N** lists the random bootstrap average for the 288 out-of-sample files of **($137.6)** with a **bootstrap** standard deviation in **Col O** of **$81.1**. (Note. The average for the random selection is the average weekly random oos net profit and is computed as the Average *RndmTONP*/288 periods) The average net period for the filter would **toNP/ (# of OOS)** periods traded or **76400/219=348.8**. The probability of obtaining our filters average weekly net profit of **348.8 is** $\mathbf{9.85x10^{-10}}$ which is **6** standard deviations from the **bootstrap** average. For our filter, in row 3, the expected number of cases that we could obtain by pure chance that would ***match or exceed*** **\$348.8 is** $\mathbf{1\text{-}(1\text{-}\ 9.85x10^{-10})^{96767} \approx 96767\ x\ 9.85x10^{-10} \approx 0.0001}$ where 96767 is the total number of different filters we looked at in this run. This number is much less than one, so it is improbable that the row 3 results are due to pure chance

Results

Table 1 on page 8 below presents a table of the 312 in-sample and out-of-sample windows, the selected optimum strategy inputs and the weekly out-of-sample results using the filter described above.

Figure 1 presents a graph of the equity and net equity curves generated by using the filter on the 312 weeks ending 2/10/12 to 8/11/17. The equity curves are plotted from the Equity and Net Equity columns in Table 1. Plotted on the equity curves are 2nd Order Polynomial fits. The blue line is the equity curve without commissions and the red dots on the blue line are new highs in equity. The brown line is the net equity curve with commissions and the green dots are the new highs in net equity. The grey line is the weekly CL prices superimposed on the equity chart.

Figure 2 Walk Forward Out-Of-Sample Performance for CL Fading Memory Polynomial Velocity Strategy
1-minute bar chart of CL from 8/10/17-8/11/2017

Figure 3 Partial output of the Walk Forward Strategy Inputs with Metric Filters(WFINP)
Run on the 312 PWFO files of the CL 1min bars Nth Order Fading Memory Velocity Strategy

Discussion of the Walk Forward Strategy Performance

When I select a filter, I look for a combination of the highest eq**R2**, the highest **KTau,** the lowest **Dev^2**, The lowest oos period until a new equity high(**Blw**), the smallest breakeven(**BE**), and the smallest losing oos period(**LLp**). I generally only look in the top 20 rows. These column definitions are explained in Figure 3 below.

In Figure 3 Row 3 of the spreadsheet filter output are some statistics that are of interest for our filter. **BE** is the break-even weeks. Assuming the trade average and standard deviation for this filter are from a normal distribution, this is how many weeks we need to trade this strategy so that we have a 98% probability that all equity paths sum of trade profit and losses after that number of weeks will be greater than zero. BE is 50 weeks for this filter. This means we would have to trade this strategy for at least 50 weeks to have a 98% probability that our equity would be positive. Another interesting statistic is **Blw**. Blw is the maximum number of weeks the OSNP equity curve failed to make a new high. Blw is 33 weeks for this filter. This means that 33 weeks was the longest time that the equity for this strategy failed to make a new equity high.

Using this filter, the strategy was able to generate $76,400 net equity after commissions and slippage trading one CL contract for the 288 weeks from 2/10/12 to 8/11/17. Note $20 roundtrip commission and slippage was subtracted from each trade and no positions were carried overnight. The average net profit after commissions and slippage in the weeks that were traded was $348.8/week. The largest losing week was ***-$4750***, the largest losing trade was ***-$2890*** and the largest drawdown was ***-$11,500***.

In observing Table 1 we can see that this strategy and filter made trades from a low of no trades/week to a high of 9 trades/week with an average of 5 trades/week on the weeks it did trade. The strategy seemed to wait for strong trends and then initiate a buy or sell. There were many weeks that had no trades. Out of the 288 out-of-sample weeks the filter only traded 219 of those weeks or 76% of the time with 53% of all trades profitable and 66% of all oos weeks traded were profitable. In observing the Equity Curve plot in Figure 1 we can see that the equity did quite well in both big down moves and range-based moves of the CL.

Lastly, and this is important, I look to see if the future excluded period net profit (***toNPx)*** is positive and the ***aoTRx*** is above the cost per trade. Why is this important? The series of oos profits and losses are similar to a Brownian Motion process with positive drift. Brownian motion follows a normal probability distribution with a finite variance. There are probability distributions that have infinite variances. One type of these distributions is the **Pareto distribution**, which is a power law probability distribution used in the description of social, scientific, geophysical, actuarial, and many other types of observable phenomena. The point I'm making here is even though our selection has a positive result we don't know for sure if the resulting process was from a probability distribution that has a finite variance or an infinite variance. If our distribution has a finite variance then it's most likely that future returns will be like the past. However, if we have sampled from a distribution that has an infinite variance then the future returns will not be like past returns and it's likely that we will encounter a "Black Swan" negative type of return in the future. Thus, I always look at the future excluded periods to see how the selection performed on data it had not seen. The Break Even(***BE)*** for the row 2 selection is 50. This means that if the series of oos profit and losses follow a Normal Distribution process then all the possible future paths of the sum of profit and losses have a 98% chance of being positive 50 periods in the future. This is only true for distributions with a finite variance. In addition, distributions with a finite variance and a kurtosis greater much greater than 3 will change the BE point. I have not yet found the mathematics to compute the effect of kurtosis on (BE).

Comparison of the Two Walk Forward Methods applied the Nth Order Fading Memory Strategy on CL 1min bars

Walk Forward Strategy Inputs with Metric Filters Explorer (WFINP) Ave File

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	CL1FadmVnd	s02/10/12	e08/11/17	#288	AnyTnp	#24								a(137.6)
2	pw|N|vup|vdn|xopn|xt|mult|<PF<R2	toGP	tONP	aoGP	aoTr	ao#T	std	skew	kur	t	oW|oL	%Wtr	%P	LLtr
3	2|70|0.5|3|900|1429|36|pf<2.5|r2<60	98500	76400	450	89.1	5	1551	(0.037)	3.86	4.29	1.19	53	66	-2890
4	2|70|0.5|3|900|1429|36|r2<60	97960	75620	443	87.7	5.1	1548	(0.030)	3.86	4.26	1.19	53	66	-2890
5	2|70|0.5|3|900|1429|36|pf<3.5|r2<60	97960	75620	443	87.7	5.1	1548	(0.030)	3.86	4.26	1.19	53	66	-2890
6	2|70|0.5|3|900|1429|36|pf<4|r2<60	97960	75620	443	87.7	5.1	1548	(0.030)	3.86	4.26	1.19	53	66	-2890

	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	AB	AC	AD	AE	AF	AG	AH
1	s81.1	f96767					c=$20						|	s08/18/17	e01/26/18	#24				t312
2	LLp	eqDD	wpr	lpr	#	%Ab2	eqA2	Dev^2	KTau	eqR2	Blw	BE	|	toGPx	toNPx	aoTRx	aoNTx	#x	tOnpNet	Prob
3	-4750	-11580	12	5	219	1.8	-1.46	6569	82	95	33	50	|	4860	4240	157	3.9	8	80640	9.85E-10
4	-4750	-11980	13	5	221	2	-1.48	6668	81	95	41	51	|	4860	4240	157	3.9	8	79860	1.63E-09
5	-4750	-11980	13	5	221	2	-1.48	6668	81	95	41	51	|	4860	4240	157	3.9	8	79860	1.63E-09
6	-4750	-11980	13	5	221	2	-1.48	6668	81	95	41	51	|	4860	4240	157	3.9	8	79860	1.63E-09

Walk Forward Metric Explorer (WFME) Ave File

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	CL1FadmVnc	s02/10/12	e08/11/17	#288	AnyTnp	#24								a(136.5)
2	Filter-Metric	toGP	toNP	aoGP	aoTr	ao#T	std	skew	kur	t	oW|oL	%Wtr	%P	LLtr
3	t10mKr|pf>1.25|r2>50-tnp	88310	69430	355	93.5	3.8	1331	0.647	5.13	4.21	1.26	53	61	-2680
4	t10mKr|pf>1.5|r2>50-tnp	86440	67560	350	91.6	3.8	1339	0.651	5.14	4.11	1.26	53	60	-2680
5	t10mKr|pf>1.5|r2>60-tnp	86630	66630	352	86.6	4.1	1363	0.609	4.96	4.05	1.26	53	61	-2680
6	t10mKr||-tnp	82350	66230	342	102.2	3.3	1332	0.530	5.11	3.98	1.23	54	61	-2680

	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	s81.8	f48050					c=$20						|	s08/18/17	e01/26/18	#24				t312
2	LLp	eqDD	wpr	lpr	#	%Ab2	eqA2	Dev^2	KTau	eqR2	Blw	BE	|	toGPx	toNPx	aoTRx	aoNTx	#x	tOnpNet	Prob
3	-3780	-8120	8	7	249	4.5	-1.14	5370	86	96	31	59	|	(320)	(1560)	(5)	3.3	19	67870	1.93E-07
4	-3780	-10720	8	6	247	3.7	-1.3	5946	81	95	44	61	|	120	(1280)	2	3.5	20	66280	2.71E-07
5	-3780	-12480	8	7	246	3.8	-1.6	6666	78	93	46	63	|	120	(1280)	2	3.5	20	65350	3.21E-07
6	-3780	-7010	8	6	241	2.6	-1.32	5887	81	94	45	64	|	1500	660	36	2.6	16	66890	2.50E-07

In comparing the WFINP and WFME Ave files we see that the WFINP total oos net profits (toNP) were $7000 greater than the WFME. The drawdown (DD) and largest losing period(LLp) were a little worse in the WFINP when compared to the WFME. The kurtosis (kur) of the WFINP was much closer to 3 than the WFME which means the probability distribution and mean is much closer to normal distribution. The breakeven (BE) is less for the WFINP and is 50 vs 59 for the WFME. The WFINP showed a much smaller probability of the toNP being due to chance. Lastly the WFINP produced profits on the withheld data while the WFME produced losses. Being that the withheld data is only 24 weeks which is less than the maximum Blw and BE one cannot determine for sure whether the better performance on the withheld data by WFINP will hold.

Overall the WFINP is easier to implement given that one only must determine if the strategy inputs **2|70|0.5|3|900|1429|36|** generate a **PF <= 2.5** and a **R2 <=60** in the latest 30 calendar day period. If so, then we trade these strategy inputs next week. If not, we don't trade that week.

References

1. Efron, B., Tibshirani, R.J., (1993), "An Introduction to the Bootstrap", New York, Chapman & Hall/CRC.
2. Morrison, Norman "Introduction to Sequential Smoothing and Prediction", McGraw-Hill Book Company, New York, 1969.

Figure 1 Graph of Equity Curves Applying the Walk Forward Filter Each Week On CL 1min Bar Prices 02/05/12 – 8/11/17 – 01/26/18

Note: The blue line is the equity curve without commissions and the red dots on the blue line are new highs in equity.
The brown line is the equity curve with commissions and the green dots are the new highs in net equity
The grey line is the CL Weekly Closing prices superimposed on the Equity Chart.
The vertical dotted red line on the right separates the future excluded period equity from 8/18/17 to 1/26/18. This is what would have happened if you used 2|70|0.5|3|900|1429|36|pf<2.5<|r2<60 on future data not included in the WFINP run.

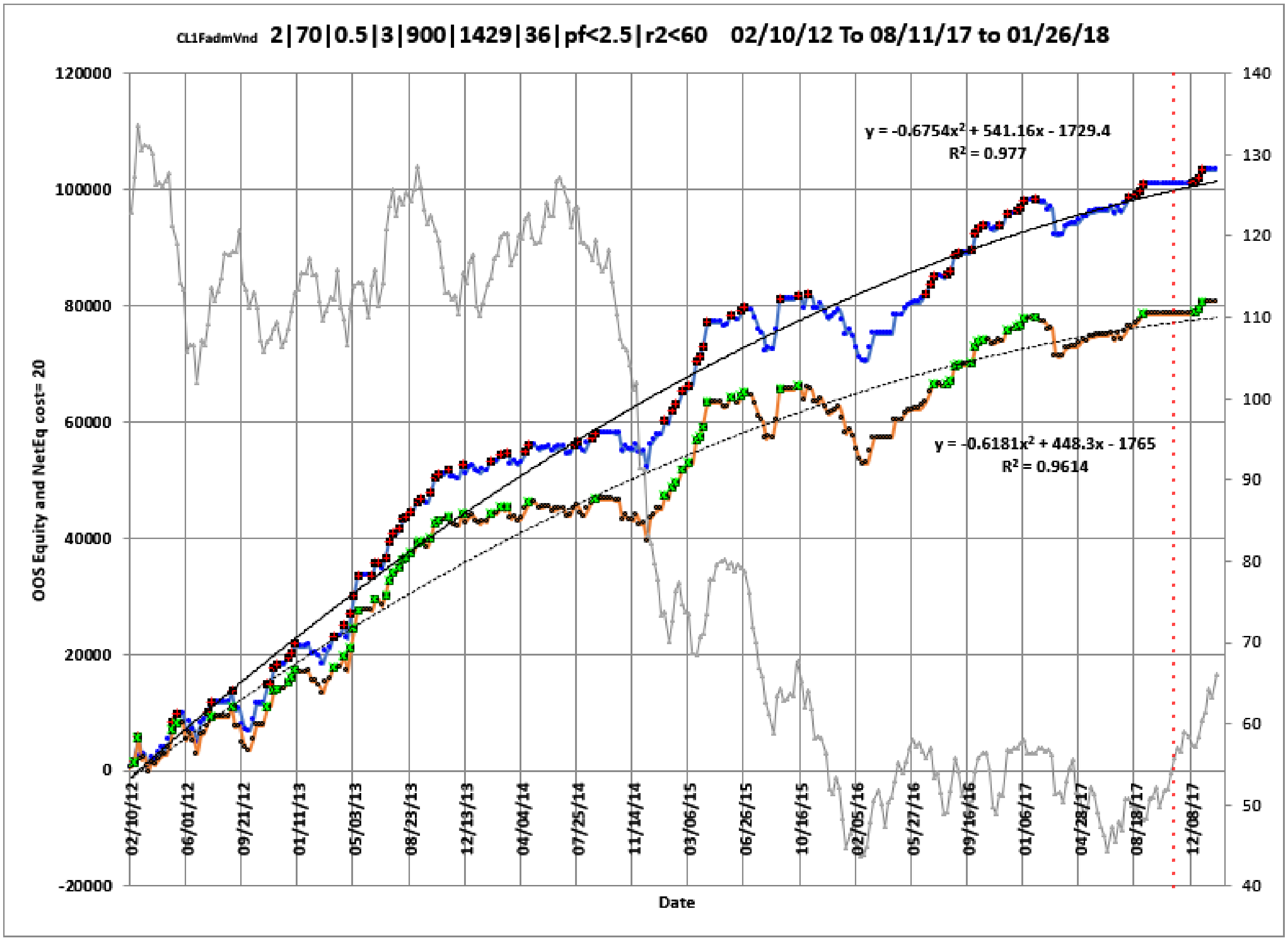

Figure 2 Walk Forward Out-Of-Sample Performance for CL Fading Memory Polynomial Velocity Strategy
1-minute bar chart of CL from 8/10/17-8/11/17

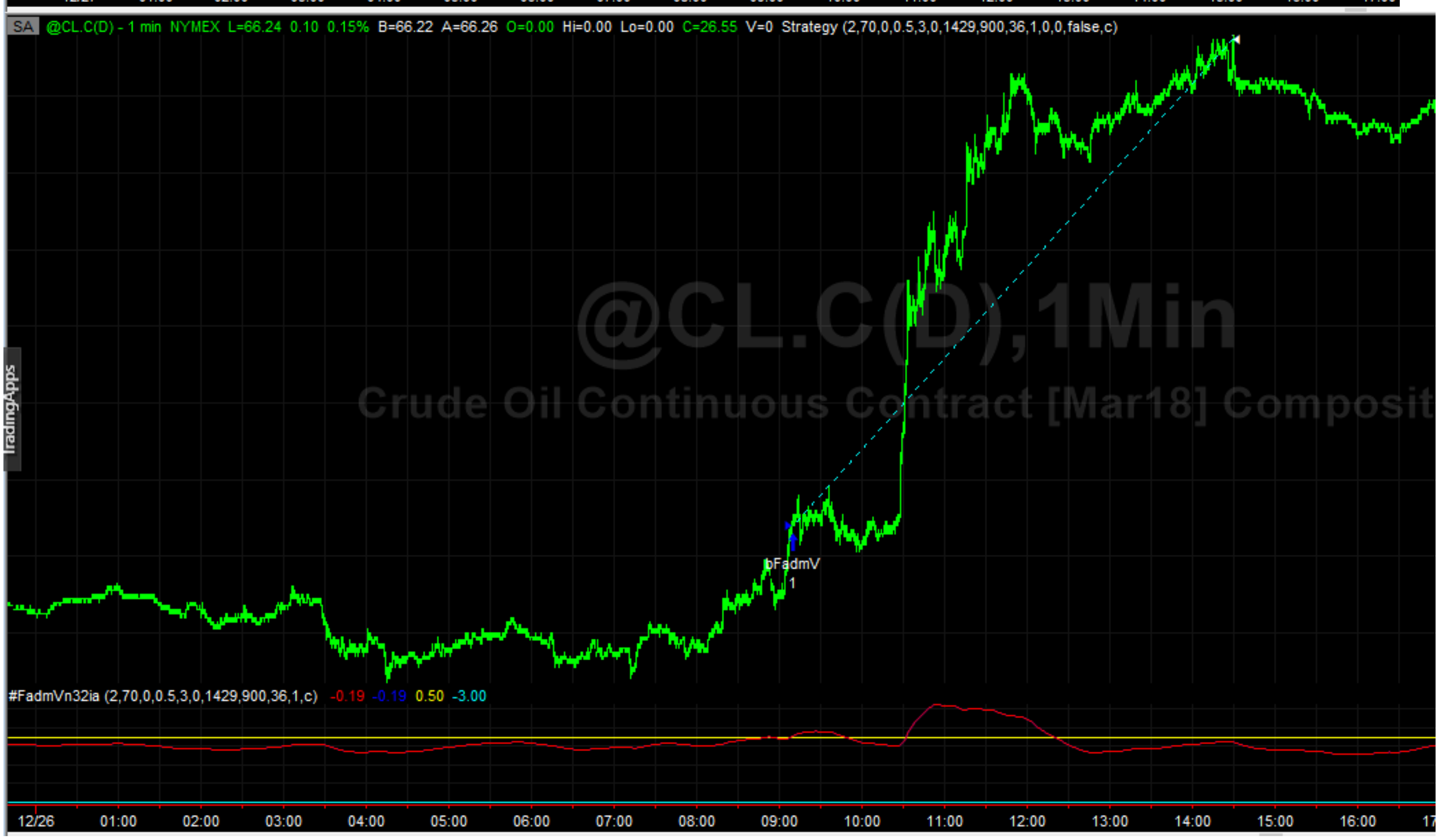

Figure 3_ Partial output of the Walk Forward Strategy Inputs with Metric Filters(WFINP)
CL1 min bars Nth Order Fading Memory Velocity Strategy

<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th><th>H</th><th>I</th><th>J</th><th>K</th><th>L</th><th>M</th><th>N</th></tr>
<tr><td>1</td><td>CL1FadmVnd</td><td>s02/10/12</td><td>e08/11/17</td><td>#288</td><td>AnyTnp</td><td>#24</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>a(137.6)</td></tr>
<tr><td>2</td><td>pw|N|vup|vdn|xopn|xt|mult|<PF<R2</td><td>toGP</td><td>tONP</td><td>aoGP</td><td>aoTr</td><td>ao#T</td><td>std</td><td>skew</td><td>kur</td><td>t</td><td>oW|oL</td><td>%Wtr</td><td>%P</td><td>LLtr</td></tr>
<tr><td>3</td><td>2|70|0.5|3|900|1429|36|pf<2.5|r2<60</td><td>98500</td><td>76400</td><td>450</td><td>89.1</td><td>5</td><td>1551</td><td>(0.037)</td><td>3.86</td><td>4.29</td><td>1.19</td><td>53</td><td>66</td><td>-2890</td></tr>
<tr><td>4</td><td>2|70|0.5|3|900|1429|36|r2<60</td><td>97960</td><td>75620</td><td>443</td><td>87.7</td><td>5.1</td><td>1548</td><td>(0.030)</td><td>3.86</td><td>4.26</td><td>1.19</td><td>53</td><td>66</td><td>-2890</td></tr>
<tr><td>5</td><td>2|70|0.5|3|900|1429|36|pf<3.5|r2<60</td><td>97960</td><td>75620</td><td>443</td><td>87.7</td><td>5.1</td><td>1548</td><td>(0.030)</td><td>3.86</td><td>4.26</td><td>1.19</td><td>53</td><td>66</td><td>-2890</td></tr>
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<tr><td>9</td><td>2|70|0.5|3|900|1429|36|pf<1.5|r2<60</td><td>77740</td><td>58820</td><td>416</td><td>82.2</td><td>5.1</td><td>1554</td><td>0.033</td><td>4</td><td>3.66</td><td>1.18</td><td>53</td><td>64</td><td>-2890</td></tr>
<tr><td>10</td><td>2|50|0.5|2.75|900|1429|36|pf<3.5|r2<60</td><td>84400</td><td>58640</td><td>382</td><td>65.5</td><td>5.8</td><td>1607</td><td>(0.173)</td><td>4.15</td><td>3.53</td><td>1.24</td><td>50</td><td>65</td><td>-2920</td></tr>
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<tr><td>2</td><td>LLp</td><td>eqDD</td><td>wpr</td><td>lpr</td><td>#</td><td>%Ab2</td><td>eqA2</td><td>Dev^2</td><td>KTau</td><td>eqR2</td><td>Blw</td><td>BE</td><td>|</td><td>toGPx</td><td>toNPx</td><td>aoTRx</td><td>aoNTx</td><td>#x</td><td>tOnpNet</td><td>Prob</td></tr>
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<tr><td>4</td><td>-4750</td><td>-11980</td><td>13</td><td>5</td><td>221</td><td>2</td><td>-1.48</td><td>6668</td><td>81</td><td>95</td><td>41</td><td>51</td><td>|</td><td>4860</td><td>4240</td><td>157</td><td>3.9</td><td>8</td><td>79860</td><td>1.63E-09</td></tr>
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<tr><td>11</td><td>-5550</td><td>-10460</td><td>14</td><td>6</td><td>221</td><td>-3.7</td><td>-1</td><td>5272</td><td>78</td><td>96</td><td>35</td><td>74</td><td>|</td><td>5970</td><td>5150</td><td>146</td><td>4.1</td><td>10</td><td>63790</td><td>3.35E-07</td></tr>
<tr><td>12</td><td>-5550</td><td>-10460</td><td>14</td><td>6</td><td>221</td><td>-3.7</td><td>-1</td><td>5272</td><td>78</td><td>96</td><td>35</td><td>74</td><td>|</td><td>5070</td><td>4150</td><td>110</td><td>4.2</td><td>11</td><td>62790</td><td>3.35E-07</td></tr>
</table>

The WFINP AVE File Output Cols are defined as follows

- **Row 1, Columns:**

  A=The PWFO Stub, **B**=File Start Date, **C**=File End Date, **D**= Number of oos periods (in this example weeks), **N**= Bootstrap average, **O**= Bootstrap Standard Deviation, **P**=Number of filters run, **U**= Cost/trade

- **Row 1 and Row 2 Columns AB,AC,AD,AE,AF** Future Results Not Included in the WFINP64 Run. These set of results show how it would turn out if the Strategy Inputs/Filter was used on pwfo files not included in the WFINP64 run.

  Row 1 Col AB: Future PWFO File Start Date
  Row 1 Col AC: Future PWFO File End Date
  Row 1 Col AD: Future Number of PWFO Files not included in the WFINP64 run (in this example weeks)
  Row 1 Col AH: Number of Total oos+future PWFO Files

  Row 2 Col AB: ***toGPx*** Total gross profit for the 24 future excluded periods(for this run periods = weeks).
  Row 2 Col AC: ***toNPx*** Total Net profit(toGP-Number Of Trade Weeks*cost) for the 24 future excluded periods.
  Row 2 Col AD: ***aoTrx*** Average profit per trade for the 24 future excluded periods
  Row 2 Col AE: ***aoNTx*** Average number of trades per week for the 24 future excluded periods
  Row 2 Col AF: ***#x*** The number of the 24 future excluded periods this strategy/filter traded. Note for some periods there can be no strategy inputs/filter that satisfy the Strategy Inputs/Filter criteria and no trades will be made during that period.

- **Row 2 to Last Row Columns: A through AH**

  Col A: ***The Strategy Input/Filter Names***

Example Row 3: **2|70|0.5|3|900|1429|36|pf<2.5|r2<60**: The inputs **2|70|0.5|3|900|1429|36|** for all in-sample files that have **PF≤2.5 and/or R2 ≤60**.

Col B: ***toGP***

Total out-of-sample(oos) gross profit for these 288 oos periods(for this run periods = weeks).

Col C: ***toNP***

Total out-of-sample(oos) Net profit(toGP-Number Of Trade Weeks*cost) for the 288 oos periods.

Col D: ***aoGP***

Average oss gross profit for the 288 oos periods

Col E: ***aoTr***

Average oos profit per trade

Col F: ***ao#T***

Average number of oos trades per week

Col G: ***std***

The standard deviation of the 288 oos period profits and losses

Col H: ***skew***

The Skew statistic of the 288 oos period profits and losses

Col I: ***kur***

The kurtosis statistic of the 288 oos period profits and losses

Col J: ***t***

The student t statistic for the 288 oos periods. The higher the t statistic the higher the probability that this result was not due to pure chance

Col K: ***oW|oL***

Ratio of average oos winning trades divided by average oos losing trades .

Col L: ***%Wtr***

The percentage if oos winning trades

Col M: ***%P***

percent of all oos periods that were profitable.

Col N: ***LLtr***

The largest losing oos trade in all oos periods

Col O: ***LLp***

The largest losing oos period

Col P: ***eqDD***

The oos equity drawdown

Col Q: ***wpr***

The largest number of winning oos periods (weeks) in a row.

Col R: ***lpr***

The largest number of losing oos periods in a row

Col S: ***#***

The number of oos periods this filter produced any profit or loss. Note for some oos periods there can be no strategy inputs that satisfy a given filters criteria and no trades will be made during that period.

Col T: ***eqTrn***

The straight line trend of the oos equity curve in $/oos period.

Col U: ***eqV^2***

The velocity of a 2nd order polynomial that is fit to the equity curve.

Col V: ***Dev^2***

A measure of equity curve smoothness. The square root of the average (equity curve minus a straight line)^2)

Col W: ***KTau^2***

The Kendall rank coefficient is often used as a test statistic in a statistical hypothesis test to establish whether two variables may be regarded as statistically dependent. This test is non-parametric, as it does not rely on any assumptions on the distributions of X or Y or the distribution of (X,Y)

Col X: ***eqR2***

The correlation coefficient(R^2) of a straight line fit to the equity curve.

Col Y: ***Blw***

The maximum number of oos periods the oos equity curve failed to make a new high.

Col Z: ***BE***

Break even in oos periods. Assuming the average and standard deviation are from a normal distribution, this is the number of oos periods you would have to trade to have a 98% probability that your oos equity is above zero.

Col AB: ***toGPx***

Total gross profit for the 24 future excluded periods(for this run periods = weeks).

Col AC: ***toNPx***

Total Net profit(toGP-Number Of Trade Weeks*cost) for the 24 future excluded periods.

Col AD: ***aoTrx***

Average profit per trade for the 24 future excluded periods

Col AE: ***aoNTx***

Average number of trades per week for the 24 future excluded periods

Col AF: ***#x***

The number of the 24 future excluded periods this strategy/filter traded. Note for some periods there can be no strategy inputs/filter that satisfy the Strategy Inputs/Filter criteria and no trades will be made during that period.

Col AG: ***tOnpNet***

toNP+toNPx = Total Net Profits of oos+future periods

Col AH: ***Prob***

The probability that the filters oos toNP was due to pure chance. Row 1 lists the random bootstrap average for the 288 out-of-sample files of ($137.6) with a bootstrap standard deviation of $81.1. (Note. The average for the random selection is computed as the Average Random toNP/288) The average net weekly for the filter would be the filter toNP/ (# of OOS) periods traded or 76400/219=348.8. The probability of obtaining our filters average weekly net profit of 348.8 is $9.85x10^{-10}$ which is 6 standard deviations from the bootstrap average. For our filter, in row 3 , the expected number of cases that we could obtain by pure chance that would match or exceed $348.8 is $[1-(1- 9.85x10^{-10})$^96767 ~= 96767 x $9.85x10^{-10}$ = 0.00001 where 96767 is the total number of different filters we looked at in this run. This number is much less than one so it is improbable that our result was due to pure chance

Table 1 Walk Forward Out-Of-Sample Performance Summary for CL Nth Order Fading Memory Polynomial Velocity Strategy

CL-1 min bars 1/5/2012 - 8/11/2017 – 01/26/18. *8/18/17 – 01/18/18* are the excluded periods

Filter = 2|70|0.5|3|900|1429|36|pf<2.5<|r2<60. This is constructed as follows. For the strategy inputs **2|70|0.5|3|900|1429|36|** only those in-sample sections that have a **PF <= 2.5** and **R2 <=60** are used to trade in the following out-of-sample sections.

osnp = Weekly Out-of-sample gross profit in $
NOnp$20 = Weekly Out-Of-Sample Net Profit in $ = **osnp-ont*20**.
ont = The number of trades in the out-of-sample week
ollt = The largest losing trade in the out-of-sample section in $.
odd = The drawdown in the out-of-sample section in $.
EQ=Equity = Running Sum of weekly out-of-sample gross profits $
NetEq=Net Equity = running sum of the weekly out-of-sample net profits in $
Note: Blank rows indicate that no out-of-sample trades were made that week

In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
01/05/12	to	02/03/12	02/06/12	to	02/10/12	460	320	7	-1170	-1590	460	320
01/12/12	to	02/10/12	02/13/12	to	02/17/12	1020	920	5	-970	-970	1480	1240
01/19/12	to	02/17/12	02/20/12	to	02/24/12	4250	4170	4	0	0	5730	5410
01/26/12	to	02/24/12	02/27/12	to	03/02/12	(3430)	(3590)	8	-1810	-3770	2300	1820
02/02/12	to	03/02/12	03/05/12	to	03/09/12	410	310	5	-690	-760	2710	2130
02/09/12	to	03/09/12	03/12/12	to	03/16/12	(2300)	(2440)	7	-2100	-4520	410	(310)
02/16/12	to	03/16/12	03/19/12	to	03/23/12	1720	1600	6	-790	-790	2130	1290
02/23/12	to	03/23/12	03/26/12	to	03/30/12	(200)	(320)	6	-1150	-1210	1930	970
03/01/12	to	03/30/12	04/02/12	to	04/06/12	910	790	6	-1530	-3050	2840	1760
03/08/12	to	04/06/12	04/09/12	to	04/13/12	910	810	5	-1310	-1310	3750	2570
03/15/12	to	04/13/12	04/16/12	to	04/20/12						3750	2570
03/22/12	to	04/20/12	04/23/12	to	04/27/12	1390	1290	5	-350	-350	5140	3860
03/29/12	to	04/27/12	04/30/12	to	05/04/12	3080	2960	6	-180	-180	8220	6820
04/05/12	to	05/04/12	05/07/12	to	05/11/12	1440	1320	6	-590	-590	9660	8140
04/12/12	to	05/11/12	05/14/12	to	05/18/12						9660	8140
04/19/12	to	05/18/12	05/21/12	to	05/25/12						9660	8140
04/26/12	to	05/25/12	05/28/12	to	06/01/12	(2900)	(3040)	7	-910	-2900	6760	5100
05/03/12	to	06/01/12	06/04/12	to	06/08/12	1500	1360	7	-880	-1220	8260	6460
05/10/12	to	06/08/12	06/11/12	to	06/15/12	(1370)	(1470)	5	-2410	-2410	6890	4990
05/17/12	to	06/15/12	06/18/12	to	06/22/12	(2130)	(2230)	5	-2610	-3770	4760	2760
05/24/12	to	06/22/12	06/25/12	to	06/29/12	3320	3180	7	-1030	-1030	8080	5940
05/31/12	to	06/29/12	07/02/12	to	07/06/12	480	360	6	-320	-650	8560	6300
06/07/12	to	07/06/12	07/09/12	to	07/13/12	1400	1280	6	-1470	-1610	9960	7580
06/14/12	to	07/13/12	07/16/12	to	07/20/12	1730	1590	7	-1630	-2460	11690	9170
06/21/12	to	07/20/12	07/23/12	to	07/27/12						11690	9170
06/28/12	to	07/27/12	07/30/12	to	08/03/12						11690	9170
07/05/12	to	08/03/12	08/06/12	to	08/10/12						11690	9170
07/12/12	to	08/10/12	08/13/12	to	08/17/12						11690	9170
07/19/12	to	08/17/12	08/20/12	to	08/24/12						11690	9170
07/26/12	to	08/24/12	08/27/12	to	08/31/12	1910	1770	7	-430	-760	13600	10940
08/02/12	to	08/31/12	09/03/12	to	09/07/12	(3320)	(3500)	9	-1580	-4530	10280	7440
08/09/12	to	09/07/12	09/10/12	to	09/14/12	180	80	5	-620	-620	10460	7520
08/16/12	to	09/14/12	09/17/12	to	09/21/12	(2680)	(2840)	8	-1710	-2710	7780	4680
08/23/12	to	09/21/12	09/24/12	to	09/28/12	(830)	(950)	6	-1180	-1400	6950	3730
In-Sample Dates			**Out-of-Sample Dates**			**osnp**	**NOnp$20**	**ont**	**ollt**	**odd**	**EQ**	**NetEq**
08/30/12	to	09/28/12	10/01/12	to	10/05/12	(220)	(340)	6	-1230	-1760	6730	3390
09/06/12	to	10/05/12	10/08/12	to	10/12/12	1850	1730	6	-660	-740	8580	5120
09/13/12	to	10/12/12	10/15/12	to	10/19/12	2820	2640	9	-670	-700	11400	7760
09/20/12	to	10/19/12	10/22/12	to	10/26/12						11400	7760
09/27/12	to	10/26/12	10/29/12	to	11/02/12						11400	7760
10/04/12	to	11/02/12	11/05/12	to	11/09/12	3330	3190	7	-1180	-1180	14730	10950
10/11/12	to	11/09/12	11/12/12	to	11/16/12	90	(30)	6	-800	-800	14820	10920
10/18/12	to	11/16/12	11/19/12	to	11/23/12	2880	2780	5	0	0	17700	13700
10/25/12	to	11/23/12	11/26/12	to	11/30/12	480	380	5	-380	-610	18180	14080
11/01/12	to	11/30/12	12/03/12	to	12/07/12						18180	14080
11/08/12	to	12/07/12	12/10/12	to	12/14/12						18180	14080
11/15/12	to	12/14/12	12/17/12	to	12/21/12	1100	980	6	-600	-600	19280	15060
11/22/12	to	12/21/12	12/24/12	to	12/28/12	900	820	4	-530	-880	20180	15880
11/29/12	to	12/28/12	12/31/12	to	01/04/13	1640	1560	4	-460	-550	21820	17440
12/06/12	to	01/04/13	01/07/13	to	01/11/13	(540)	(640)	5	-710	-1040	21280	16800
12/13/12	to	01/11/13	01/14/13	to	01/18/13						21280	16800
12/20/12	to	01/18/13	01/21/13	to	01/25/13						21280	16800
12/27/12	to	01/25/13	01/28/13	to	02/01/13	290	150	7	-950	-1360	21570	16950
01/03/13	to	02/01/13	02/04/13	to	02/08/13	(1550)	(1650)	5	-1360	-1910	20020	15300
01/10/13	to	02/08/13	02/11/13	to	02/15/13	120	(20)	7	-1070	-1680	20140	15280

In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
01/17/13	to	02/15/13	02/18/13	to	02/22/13	(650)	(770)	6	-1930	-1930	19490	14510
01/24/13	to	02/22/13	02/25/13	to	03/01/13	(1270)	(1370)	5	-630	-1270	18220	13140
01/31/13	to	03/01/13	03/04/13	to	03/08/13	2120	2020	5	0	0	20340	15160
02/07/13	to	03/08/13	03/11/13	to	03/15/13	680	580	5	-480	-530	21020	15740
02/14/13	to	03/15/13	03/18/13	to	03/22/13	2000	1920	4	-560	-560	23020	17660
02/21/13	to	03/22/13	03/25/13	to	03/29/13						23020	17660
02/28/13	to	03/29/13	04/01/13	to	04/05/13						23020	17660
03/07/13	to	04/05/13	04/08/13	to	04/12/13	1960	1860	5	-10	-10	24980	19520
03/14/13	to	04/12/13	04/15/13	to	04/19/13	(2380)	(2520)	7	-1670	-2760	22600	17000
03/21/13	to	04/19/13	04/22/13	to	04/26/13	4250	4150	5	0	0	26850	21150
03/28/13	to	04/26/13	04/29/13	to	05/03/13	3310	3190	6	-790	-790	30160	24340
04/04/13	to	05/03/13	05/06/13	to	05/10/13	3290	3190	5	-540	-540	33450	27530
04/11/13	to	05/10/13	05/13/13	to	05/17/13						33450	27530
04/18/13	to	05/17/13	05/20/13	to	05/24/13						33450	27530
04/25/13	to	05/24/13	05/27/13	to	05/31/13						33450	27530
05/02/13	to	05/31/13	06/03/13	to	06/07/13	40	(100)	7	-760	-1670	33490	27430
05/09/13	to	06/07/13	06/10/13	to	06/14/13	2080	1980	5	-110	-110	35570	29410
05/16/13	to	06/14/13	06/17/13	to	06/21/13	30	(90)	6	-510	-510	35600	29320
05/23/13	to	06/21/13	06/24/13	to	06/28/13	(900)	(1040)	7	-1660	-3230	34700	28280
05/30/13	to	06/28/13	07/01/13	to	07/05/13	1900	1820	4	-630	-630	36600	30100
06/06/13	to	07/05/13	07/08/13	to	07/12/13	2710	2610	5	-80	-80	39310	32710
06/13/13	to	07/12/13	07/15/13	to	07/19/13	1430	1330	5	-830	-830	40740	34040
06/20/13	to	07/19/13	07/22/13	to	07/26/13						40740	34040
06/27/13	to	07/26/13	07/29/13	to	08/02/13	870	770	5	-830	-1400	41610	34810
07/04/13	to	08/02/13	08/05/13	to	08/09/13	1600	1480	6	-990	-1050	43210	36290
07/11/13	to	08/09/13	08/12/13	to	08/16/13	420	280	7	-800	-1580	43630	36570
07/18/13	to	08/16/13	08/19/13	to	08/23/13	900	780	6	-1140	-1140	44530	37350
07/25/13	to	08/23/13	08/26/13	to	08/30/13						44530	37350
08/01/13	to	08/30/13	09/02/13	to	09/06/13	1740	1660	4	-900	-900	46270	39010
08/08/13	to	09/06/13	09/09/13	to	09/13/13	410	310	5	-190	-190	46680	39320
08/15/13	to	09/13/13	09/16/13	to	09/20/13	(50)	(150)	5	-760	-1230	46630	39170
08/22/13	to	09/20/13	09/23/13	to	09/27/13	(780)	(880)	5	-840	-1130	45850	38290
08/29/13	to	09/27/13	09/30/13	to	10/04/13	1860	1760	5	-720	-900	47710	40050
09/05/13	to	10/04/13	10/07/13	to	10/11/13	2600	2480	6	-300	-300	50310	42530
09/12/13	to	10/11/13	10/14/13	to	10/18/13	610	510	5	-840	-840	50920	43040
In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
09/19/13	to	10/18/13	10/21/13	to	10/25/13						50920	43040
09/26/13	to	10/25/13	10/28/13	to	11/01/13						50920	43040
10/03/13	to	11/01/13	11/04/13	to	11/08/13	760	680	4	-60	-60	51680	43720
10/10/13	to	11/08/13	11/11/13	to	11/15/13	(1210)	(1310)	5	-1980	-1980	50470	42410
10/17/13	to	11/15/13	11/18/13	to	11/22/13	(30)	(150)	6	-1010	-1410	50440	42260
10/24/13	to	11/22/13	11/25/13	to	11/29/13	(240)	(320)	4	-570	-640	50200	41940
10/31/13	to	11/29/13	12/02/13	to	12/06/13	2320	2220	5	-110	-110	52520	44160
11/07/13	to	12/06/13	12/09/13	to	12/13/13	(1520)	(1620)	5	-690	-1530	51000	42540
11/14/13	to	12/13/13	12/16/13	to	12/20/13	1080	980	5	-390	-390	52080	43520
11/21/13	to	12/20/13	12/23/13	to	12/27/13	380	320	3	-210	-210	52460	43840
11/28/13	to	12/27/13	12/30/13	to	01/03/14	(930)	(970)	2	-700	-930	51530	42870
12/05/13	to	01/03/14	01/06/14	to	01/10/14	(430)	(470)	2	-260	-430	51100	42400
12/12/13	to	01/10/14	01/13/14	to	01/17/14	560	460	5	-320	-320	51660	42860
12/19/13	to	01/17/14	01/20/14	to	01/24/14	(80)	(160)	4	-560	-560	51580	42700
12/26/13	to	01/24/14	01/27/14	to	01/31/14	1590	1490	5	0	0	53170	44190
01/02/14	to	01/31/14	02/03/14	to	02/07/14						53170	44190
01/09/14	to	02/07/14	02/10/14	to	02/14/14	(30)	(130)	5	-550	-850	53140	44060
01/16/14	to	02/14/14	02/17/14	to	02/21/14	1190	1110	4	-150	-150	54330	45170
01/23/14	to	02/21/14	02/24/14	to	02/28/14	(350)	(450)	5	-490	-780	53980	44720

In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
01/30/14	to	02/28/14	03/03/14	to	03/07/14	590	510	4	-610	-610	54570	45230
02/06/14	to	03/07/14	03/10/14	to	03/14/14	(1850)	(1950)	5	-920	-1910	52720	43280
02/13/14	to	03/14/14	03/17/14	to	03/21/14	520	420	5	-550	-550	53240	43700
02/20/14	to	03/21/14	03/24/14	to	03/28/14	(710)	(810)	5	-560	-750	52530	42890
02/27/14	to	03/28/14	03/31/14	to	04/04/14	380	300	4	-370	-370	52910	43190
03/06/14	to	04/04/14	04/07/14	to	04/11/14	1870	1770	5	-270	-270	54780	44960
03/13/14	to	04/11/14	04/14/14	to	04/18/14	1210	1130	4	0	0	55990	46090
03/20/14	to	04/18/14	04/21/14	to	04/25/14						55990	46090
03/27/14	to	04/25/14	04/28/14	to	05/02/14						55990	46090
04/03/14	to	05/02/14	05/05/14	to	05/09/14	(900)	(1000)	5	-950	-1100	55090	45090
04/10/14	to	05/09/14	05/12/14	to	05/16/14	240	140	5	-210	-210	55330	45230
04/17/14	to	05/16/14	05/19/14	to	05/23/14	200	100	5	-400	-400	55530	45330
04/24/14	to	05/23/14	05/26/14	to	05/30/14	160	100	3	-200	-200	55690	45430
05/01/14	to	05/30/14	06/02/14	to	06/06/14	(800)	(900)	5	-870	-940	54890	44530
05/08/14	to	06/06/14	06/09/14	to	06/13/14	440	340	5	-570	-720	55330	44870
05/15/14	to	06/13/14	06/16/14	to	06/20/14	270	190	4	-290	-480	55600	45060
05/22/14	to	06/20/14	06/23/14	to	06/27/14	80	(20)	5	-360	-360	55680	45040
05/29/14	to	06/27/14	06/30/14	to	07/04/14	(1360)	(1440)	4	-720	-1360	54320	43600
06/05/14	to	07/04/14	07/07/14	to	07/11/14	270	210	3	-400	-400	54590	43810
06/12/14	to	07/11/14	07/14/14	to	07/18/14	1410	1310	5	0	0	56000	45120
06/19/14	to	07/18/14	07/21/14	to	07/25/14	450	350	5	-1000	-1000	56450	45470
06/26/14	to	07/25/14	07/28/14	to	08/01/14	(1130)	(1210)	4	-1450	-1610	55320	44260
07/03/14	to	08/01/14	08/04/14	to	08/08/14	(470)	(550)	4	-940	-940	54850	43710
07/10/14	to	08/08/14	08/11/14	to	08/15/14	1370	1290	4	-70	-130	56220	45000
07/17/14	to	08/15/14	08/18/14	to	08/22/14	930	850	4	-140	-140	57150	45850
07/24/14	to	08/22/14	08/25/14	to	08/29/14	850	750	5	-240	-300	58000	46600
07/31/14	to	08/29/14	09/01/14	to	09/05/14						58000	46600
08/07/14	to	09/05/14	09/08/14	to	09/12/14						58000	46600
08/14/14	to	09/12/14	09/15/14	to	09/19/14						58000	46600
08/21/14	to	09/19/14	09/22/14	to	09/26/14						58000	46600
08/28/14	to	09/26/14	09/29/14	to	10/03/14						58000	46600
09/04/14	to	10/03/14	10/06/14	to	10/10/14	(120)	(220)	5	-940	-1800	57880	46380
09/11/14	to	10/10/14	10/13/14	to	10/17/14	60	(60)	6	-2890	-2890	57940	46320
09/18/14	to	10/17/14	10/20/14	to	10/24/14	(3130)	(3270)	7	-2520	-3850	54810	43050
09/25/14	to	10/24/14	10/27/14	to	10/31/14	810	710	5	-620	-1000	55620	43760
10/02/14	to	10/31/14	11/03/14	to	11/07/14	(550)	(650)	5	-1570	-1570	55070	43110
In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
10/09/14	to	11/07/14	11/10/14	to	11/14/14	0	(100)	5	-1170	-1520	55070	43010
10/16/14	to	11/14/14	11/17/14	to	11/21/14	1010	910	5	-370	-630	56080	43920
10/23/14	to	11/21/14	11/24/14	to	11/28/14	(1590)	(1710)	6	-1200	-2940	54490	42210
10/30/14	to	11/28/14	12/01/14	to	12/05/14	280	160	6	-1120	-2430	54770	42370
11/06/14	to	12/05/14	12/08/14	to	12/12/14	(2800)	(2900)	5	-1650	-2800	51970	39470
11/13/14	to	12/12/14	12/15/14	to	12/19/14	3940	3780	8	-1170	-1450	55910	43250
11/20/14	to	12/19/14	12/22/14	to	12/26/14	810	750	3	-330	-330	56720	44000
11/27/14	to	12/26/14	12/29/14	to	01/02/15	1080	980	5	0	0	57800	44980
12/04/14	to	01/02/15	01/05/15	to	01/09/15						57800	44980
12/11/14	to	01/09/15	01/12/15	to	01/16/15	2370	2230	7	-1710	-1890	60170	47210
12/18/14	to	01/16/15	01/19/15	to	01/23/15	(500)	(600)	5	-800	-1310	59670	46610
12/25/14	to	01/23/15	01/26/15	to	01/30/15	2180	2080	5	-830	-1040	61850	48690
01/01/15	to	01/30/15	02/02/15	to	02/06/15	1090	970	6	-580	-970	62940	49660
01/08/15	to	02/06/15	02/09/15	to	02/13/15						62940	49660
01/15/15	to	02/13/15	02/16/15	to	02/20/15	2350	2250	5	-820	-820	65290	51910
01/22/15	to	02/20/15	02/23/15	to	02/27/15						65290	51910
01/29/15	to	02/27/15	03/02/15	to	03/06/15	960	860	5	-730	-1430	66250	52770
02/05/15	to	03/06/15	03/09/15	to	03/13/15						66250	52770

In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
02/12/15	to	03/13/15	03/16/15	to	03/20/15	4060	3960	5	0	0	70310	56730
02/19/15	to	03/20/15	03/23/15	to	03/27/15	910	790	6	-1270	-1750	71220	57520
02/26/15	to	03/27/15	03/30/15	to	04/03/15	1710	1630	4	-440	-570	72930	59150
03/05/15	to	04/03/15	04/06/15	to	04/10/15	4200	4080	6	-680	-980	77130	63230
03/12/15	to	04/10/15	04/13/15	to	04/17/15						77130	63230
03/19/15	to	04/17/15	04/20/15	to	04/24/15						77130	63230
03/26/15	to	04/24/15	04/27/15	to	05/01/15						77130	63230
04/02/15	to	05/01/15	05/04/15	to	05/08/15						77130	63230
04/09/15	to	05/08/15	05/11/15	to	05/15/15	(740)	(840)	5	-1100	-1720	76390	62390
04/16/15	to	05/15/15	05/18/15	to	05/22/15	300	220	4	-420	-420	76690	62610
04/23/15	to	05/22/15	05/25/15	to	05/29/15	1680	1600	4	-780	-860	78370	64210
04/30/15	to	05/29/15	06/01/15	to	06/05/15	(530)	(650)	6	-910	-2160	77840	63560
05/07/15	to	06/05/15	06/08/15	to	06/12/15	(330)	(430)	5	-690	-690	77510	63130
05/14/15	to	06/12/15	06/15/15	to	06/19/15	1580	1460	6	0	0	79090	64590
05/21/15	to	06/19/15	06/22/15	to	06/26/15	490	350	7	-950	-1200	79580	64940
05/28/15	to	06/26/15	06/29/15	to	07/03/15	(300)	(360)	3	-420	-420	79280	64580
06/04/15	to	07/03/15	07/06/15	to	07/10/15						79280	64580
06/11/15	to	07/10/15	07/13/15	to	07/17/15	(1530)	(1630)	5	-1300	-2590	77750	62950
06/18/15	to	07/17/15	07/20/15	to	07/24/15	(2100)	(2180)	4	-1190	-2100	75650	60770
06/25/15	to	07/24/15	07/27/15	to	07/31/15	(440)	(540)	5	-590	-1180	75210	60230
07/02/15	to	07/31/15	08/03/15	to	08/07/15	(3000)	(3100)	5	-1170	-3000	72210	57130
07/09/15	to	08/07/15	08/10/15	to	08/14/15	470	410	3	-260	-360	72680	57540
07/16/15	to	08/14/15	08/17/15	to	08/21/15	(210)	(310)	5	-720	-760	72470	57230
07/23/15	to	08/21/15	08/24/15	to	08/28/15	3170	3070	5	-930	-1970	75640	60300
07/30/15	to	08/28/15	08/31/15	to	09/04/15	5400	5240	8	-730	-950	81040	65540
08/06/15	to	09/04/15	09/07/15	to	09/11/15						81040	65540
08/13/15	to	09/11/15	09/14/15	to	09/18/15						81040	65540
08/20/15	to	09/18/15	09/21/15	to	09/25/15						81040	65540
08/27/15	to	09/25/15	09/28/15	to	10/02/15						81040	65540
09/03/15	to	10/02/15	10/05/15	to	10/09/15	740	640	5	-1670	-1670	81780	66180
09/10/15	to	10/09/15	10/12/15	to	10/16/15	(10)	(90)	4	-790	-790	81770	66090
09/17/15	to	10/16/15	10/19/15	to	10/23/15	(2280)	(2400)	6	-600	-2280	79490	63690
09/24/15	to	10/23/15	10/26/15	to	10/30/15	2350	2250	5	-240	-280	81840	65940
10/01/15	to	10/30/15	11/02/15	to	11/06/15	(360)	(460)	5	-830	-1310	81480	65480
10/08/15	to	11/06/15	11/09/15	to	11/13/15	(1980)	(2080)	5	-880	-1980	79500	63400
10/15/15	to	11/13/15	11/16/15	to	11/20/15	0	(100)	5	-1010	-1400	79500	63300
10/22/15	to	11/20/15	11/23/15	to	11/27/15	670	610	3	-40	-40	80170	63910
In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
10/29/15	to	11/27/15	11/30/15	to	12/04/15	(1330)	(1450)	6	-1460	-2050	78840	62460
11/05/15	to	12/04/15	12/07/15	to	12/11/15	(1120)	(1220)	5	-840	-1420	77720	61240
11/12/15	to	12/11/15	12/14/15	to	12/18/15	410	310	5	-700	-1210	78130	61550
11/19/15	to	12/18/15	12/21/15	to	12/25/15	560	480	4	-100	-100	78690	62030
11/26/15	to	12/25/15	12/28/15	to	01/01/16	570	510	3	-360	-360	79260	62540
12/03/15	to	01/01/16	01/04/16	to	01/08/16	(1770)	(1910)	7	-920	-1960	77490	60630
12/10/15	to	01/08/16	01/11/16	to	01/15/16	(2580)	(2740)	8	-1430	-2830	74910	57890
12/17/15	to	01/15/16	01/18/16	to	01/22/16	750	670	4	-710	-1390	75660	58560
12/24/15	to	01/22/16	01/25/16	to	01/29/16	(1000)	(1140)	7	-1220	-2050	74660	57420
12/31/15	to	01/29/16	02/01/16	to	02/05/16	(2040)	(2180)	7	-1000	-2080	72620	55240
01/07/16	to	02/05/16	02/08/16	to	02/12/16	(1570)	(1670)	5	-1800	-3420	71050	53570
01/14/16	to	02/12/16	02/15/16	to	02/19/16	(790)	(870)	4	-1040	-1040	70260	52700
01/21/16	to	02/19/16	02/22/16	to	02/26/16	270	170	5	-1420	-1420	70530	52870
01/28/16	to	02/26/16	02/29/16	to	03/04/16	2220	2120	5	-130	-130	72750	54990
02/04/16	to	03/04/16	03/07/16	to	03/11/16	2330	2210	6	-320	-320	75080	57200
02/11/16	to	03/11/16	03/14/16	to	03/18/16	0	0	0	0	0	75080	57200
02/18/16	to	03/18/16	03/21/16	to	03/25/16	0	0	0	0	0	75080	57200

In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
02/25/16	to	03/25/16	03/28/16	to	04/01/16	0	0	0	0	0	75080	57200
03/03/16	to	04/01/16	04/04/16	to	04/08/16	0	0	0	0	0	75080	57200
03/10/16	to	04/08/16	04/11/16	to	04/15/16						75080	57200
03/17/16	to	04/15/16	04/18/16	to	04/22/16	3220	3120	5	-530	-580	78300	60320
03/24/16	to	04/22/16	04/25/16	to	04/29/16						78300	60320
03/31/16	to	04/29/16	05/02/16	to	05/06/16						78300	60320
04/07/16	to	05/06/16	05/09/16	to	05/13/16	1160	1060	5	-260	-430	79460	61380
04/14/16	to	05/13/16	05/16/16	to	05/20/16	550	450	5	-390	-390	80010	61830
04/21/16	to	05/20/16	05/23/16	to	05/27/16	310	210	5	-210	-210	80320	62040
04/28/16	to	05/27/16	05/30/16	to	06/03/16	170	90	4	-750	-750	80490	62130
05/05/16	to	06/03/16	06/06/16	to	06/10/16						80490	62130
05/12/16	to	06/10/16	06/13/16	to	06/17/16	670	570	5	-360	-360	81160	62700
05/19/16	to	06/17/16	06/20/16	to	06/24/16	840	760	4	-480	-480	82000	63460
05/26/16	to	06/24/16	06/27/16	to	07/01/16	1580	1500	4	-610	-610	83580	64960
06/02/16	to	07/01/16	07/04/16	to	07/08/16	1500	1400	5	-1130	-1130	85080	66360
06/09/16	to	07/08/16	07/11/16	to	07/15/16						85080	66360
06/16/16	to	07/15/16	07/18/16	to	07/22/16						85080	66360
06/23/16	to	07/22/16	07/25/16	to	07/29/16	(320)	(420)	5	-1030	-1050	84760	65940
06/30/16	to	07/29/16	08/01/16	to	08/05/16	550	470	4	-1180	-1180	85310	66410
07/07/16	to	08/05/16	08/08/16	to	08/12/16	700	560	7	-930	-1860	86010	66970
07/14/16	to	08/12/16	08/15/16	to	08/19/16	2670	2570	5	0	0	88680	69540
07/21/16	to	08/19/16	08/22/16	to	08/26/16	260	160	5	-630	-630	88940	69700
07/28/16	to	08/26/16	08/29/16	to	09/02/16						88940	69700
08/04/16	to	09/02/16	09/05/16	to	09/09/16						88940	69700
08/11/16	to	09/09/16	09/12/16	to	09/16/16						88940	69700
08/18/16	to	09/16/16	09/19/16	to	09/23/16	550	450	5	-540	-540	89490	70150
08/25/16	to	09/23/16	09/26/16	to	09/30/16	3020	2920	5	-190	-190	92510	73070
09/01/16	to	09/30/16	10/03/16	to	10/07/16	800	700	5	-50	-50	93310	73770
09/08/16	to	10/07/16	10/10/16	to	10/14/16	410	350	3	-500	-500	93720	74120
09/15/16	to	10/14/16	10/17/16	to	10/21/16						93720	74120
09/22/16	to	10/21/16	10/24/16	to	10/28/16						93720	74120
09/29/16	to	10/28/16	10/31/16	to	11/04/16	(850)	(890)	2	-510	-850	92870	73230
10/06/16	to	11/04/16	11/07/16	to	11/11/16	370	270	5	-260	-310	93240	73500
10/13/16	to	11/11/16	11/14/16	to	11/18/16	610	510	5	-970	-970	93850	74010
10/20/16	to	11/18/16	11/21/16	to	11/25/16	(10)	(90)	4	-540	-690	93840	73920
10/27/16	to	11/25/16	11/28/16	to	12/02/16	1950	1850	5	-200	-200	95790	75770
11/03/16	to	12/02/16	12/05/16	to	12/09/16						95790	75770
11/10/16	to	12/09/16	12/12/16	to	12/16/16						95790	75770
In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
11/17/16	to	12/16/16	12/19/16	to	12/23/16	660	580	4	-280	-280	96450	76350
11/24/16	to	12/23/16	12/26/16	to	12/30/16	420	380	2	0	0	96870	76730
12/01/16	to	12/30/16	01/02/17	to	01/06/17	1170	1070	5	-230	-230	98040	77800
12/08/16	to	01/06/17	01/09/17	to	01/13/17						98040	77800
12/15/16	to	01/13/17	01/16/17	to	01/20/17						98040	77800
12/22/16	to	01/20/17	01/23/17	to	01/27/17	200	100	5	-480	-480	98240	77900
12/29/16	to	01/27/17	01/30/17	to	02/03/17	(320)	(420)	5	-430	-480	97920	77480
01/05/17	to	02/03/17	02/06/17	to	02/10/17	(270)	(310)	2	-160	-270	97650	77170
01/12/17	to	02/10/17	02/13/17	to	02/17/17	(30)	(110)	4	-410	-510	97620	77060
01/19/17	to	02/17/17	02/20/17	to	02/24/17	(1140)	(1200)	3	-610	-1140	96480	75860
01/26/17	to	02/24/17	02/27/17	to	03/03/17	330	270	3	-500	-500	96810	76130
02/02/17	to	03/03/17	03/06/17	to	03/10/17	(4750)	(4850)	5	-2530	-4770	92060	71280
02/09/17	to	03/10/17	03/13/17	to	03/17/17	10	(70)	4	-110	-110	92070	71210
02/16/17	to	03/17/17	03/20/17	to	03/24/17	140	60	4	-200	-310	92210	71270
02/23/17	to	03/24/17	03/27/17	to	03/31/17	1440	1340	5	-150	-150	93650	72610
03/02/17	to	03/31/17	04/03/17	to	04/07/17	240	160	4	-130	-130	93890	72770

In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
03/09/17	to	04/07/17	04/10/17	to	04/14/17	160	140	1	0	0	94050	72910
03/16/17	to	04/14/17	04/17/17	to	04/21/17						94050	72910
03/23/17	to	04/21/17	04/24/17	to	04/28/17	550	470	4	-100	-100	94600	73380
03/30/17	to	04/28/17	05/01/17	to	05/05/17	720	680	2	-110	-110	95320	74060
04/06/17	to	05/05/17	05/08/17	to	05/12/17	(80)	(180)	5	-510	-510	95240	73880
04/13/17	to	05/12/17	05/15/17	to	05/19/17	760	700	3	-10	-10	96000	74580
04/20/17	to	05/19/17	05/22/17	to	05/26/17						96000	74580
04/27/17	to	05/26/17	05/29/17	to	06/02/17	300	220	4	-230	-230	96300	74800
05/04/17	to	06/02/17	06/05/17	to	06/09/17						96300	74800
05/11/17	to	06/09/17	06/12/17	to	06/16/17						96300	74800
05/18/17	to	06/16/17	06/19/17	to	06/23/17						96300	74800
05/25/17	to	06/23/17	06/26/17	to	06/30/17	620	520	5	-430	-430	96920	75320
06/01/17	to	06/30/17	07/03/17	to	07/07/17	(1270)	(1390)	6	-920	-1950	95650	73930
06/08/17	to	07/07/17	07/10/17	to	07/14/17	1340	1240	5	-440	-440	96990	75170
06/15/17	to	07/14/17	07/17/17	to	07/21/17	(990)	(1070)	4	-890	-990	96000	74100
06/22/17	to	07/21/17	07/24/17	to	07/28/17	1460	1360	5	0	0	97460	75460
06/29/17	to	07/28/17	07/31/17	to	08/04/17	1040	940	5	-530	-530	98500	76400
07/06/17	to	08/04/17	08/07/17	to	08/11/17						98500	76400
07/13/17	to	08/11/17	08/14/17	to	08/18/17	550	470	4	-1200	-1200	99050	76870
07/20/17	to	08/18/17	08/21/17	to	08/25/17	640	560	4	0	0	99690	77430
07/27/17	to	08/25/17	08/28/17	to	09/01/17	1190	1090	5	-380	-380	100880	78520
08/03/17	to	09/01/17	09/04/17	to	09/08/17	0	(60)	3	-170	-330	100880	78460
08/10/17	to	09/08/17	09/11/17	to	09/15/17						100880	78460
08/17/17	to	09/15/17	09/18/17	to	09/22/17						100880	78460
08/24/17	to	09/22/17	09/25/17	to	09/29/17						100880	78460
08/31/17	to	09/29/17	10/02/17	to	10/06/17						100880	78460
09/07/17	to	10/06/17	10/09/17	to	10/13/17						100880	78460
09/14/17	to	10/13/17	10/16/17	to	10/20/17						100880	78460
09/21/17	to	10/20/17	10/23/17	to	10/27/17						100880	78460
09/28/17	to	10/27/17	10/30/17	to	11/03/17						100880	78460
10/05/17	to	11/03/17	11/06/17	to	11/10/17						100880	78460
10/12/17	to	11/10/17	11/13/17	to	11/17/17						100880	78460
10/19/17	to	11/17/17	11/20/17	to	11/24/17						100880	78460
10/26/17	to	11/24/17	11/27/17	to	12/01/17						100880	78460
11/02/17	to	12/01/17	12/04/17	to	12/08/17	130	50	4	-450	-450	101010	78510
11/09/17	to	12/08/17	12/11/17	to	12/15/17	330	250	4	-250	-250	101340	78760
11/16/17	to	12/15/17	12/18/17	to	12/22/17	770	690	4	0	0	102110	79450
11/23/17	to	12/22/17	12/25/17	to	12/29/17	1250	1190	3	-80	-80	103360	80640
11/30/17	to	12/29/17	01/01/18	to	01/05/18						103360	80640
In-Sample Dates			Out-of-Sample Dates			osnp	NOnp$20	ont	ollt	odd	EQ	NetEq
12/07/17	to	01/05/18	01/08/18	to	01/12/18						103360	80640
12/14/17	to	01/12/18	01/15/18	to	01/19/18						103360	80640
					01/26/18						103360	80640

Appendix 1: *n*th Order Fading Memory Polynomial Next Bar's Forecast Math

What is The Nth Order Fading Memory Polynomial ?

This is a mathematical technique that fits a nth order polynomial to the last ***T*** price bars but calculates the coefficients of the polynomial such that the error between the current nth order polynomial and the current bar is weighted much higher than the error between the price T bars ago and the value of the nth order polynomial T bars ago. As an example, if the latest price is at time t and the price made a turn at time bar t-10 , then we do not want prices prior to t-10 affecting the current polynomial fit as much. As will be shown the most familiar case of this fading memory technique is the exponential moving average. The fading memory technique is in contrast to the Least Squares Polynomial fit, which weights all past errors between the polynomial and the price bar equally.

Consider a time series x(t) where t is an integer value (a price bar number) like the number of days or minutes, etc from some starting time. Suppose we want to find at some given time some *n*th-degree polynomial that fits the data well at current and recent prices but ignores the fit as we move into the distant past. One way to construct this type of fit would be to weight the past data with a number that got smaller and smaller the further back in time we went. If we let the polynomial function be represented by the symbol **p(t-τ)** where **p(t-0)** is the current value of the polynomial, **p(t-1)** is the previous value of the polynomial, etc., then an error function can be formed that consists of the weighted sum of the squared difference between the price series **x(t-τ)** and the polynomial p(t-τ) given by

$$\textbf{error} = \sum \beta^{\tau}(x(t-\tau) - p(t-\tau))^2 \quad \tau=0 \text{ to } \infty \qquad (1)$$

where $0 < \beta < 1$ **and** β^{τ} is much much less than **1** for large **τ.**

It turns out that if we let the nth degree polynomial **p(t-τ)** be constructed as a linear combination of orthogonal polynomials called Meixner polynomials then minimizing the error with respect to the coefficients of the orthogonal polynomials yields the best estimate of **x(t-τ)** as $x_{est}(t-\tau)$ and given by the equation

$$x_{est}(t-\tau) = (1-\beta)\sum_{k=0}^{n} \beta^k b_{k,t} \Phi_k(t)|_{\tau} \qquad (2)$$

Where

$$\Phi_n(t) = \sum_{k=0}^{n} \binom{n}{k}\binom{t}{k} z^k$$

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

$$b_{j,t} = \sum_{k=0}^{\infty} \beta^k \Phi_j(k) x(t-k)$$

$$\mathbf{z = 1 - 1/\beta}$$

where n is the polynomial degree, $\Phi_k(\tau)$ are the Meixner polynomials of degree k (k=0 to n), and $b_k(t)$ are the coefficients that minimize the error of equation (1). Generally the summation for $b_j(t)$ can be terminated when β^k <<1.

Appendix 1: n^{th} Order Fading Memory Polynomial Next Bar's Forecast Math

For the exact mathematical solutions that produce equation (2) and the mathematical descriptions of the Meixner polynomials refer to Reference 1.

To yield the 1 day ahead prediction the above equation becomes;

$$x_{est}(t+1)=(1-\beta)\sum \beta^k b_{k,t}\Phi_k(-1) \quad k=0 \text{ to } n \qquad (3)$$

After some algebraic manipulation with the Meixner polynomials the $\mathbf{b_{k,t}}$ coefficients satisfy the following recursive relationship.(see Reference 1)

$$b_{k,t}=\beta\, b_{k,t-1} + b_{k-1,t} - b_{k-1,t-1}$$

One case is of immediate interest where the polynomial is a constant, that is n=0.

For this case the solution to equation (3) can be found after some algebraic manipulation to be:

$$X0_{est}=\beta * X0_{est}[1] + (1-\beta) * x(t) \qquad (4)$$

Where $\mathbf{X0_{est}[1]}$ is the previous estimated value, **x(t)** is the current bar's price and where the 0 in $\mathbf{X0_{est}}$ indicates that we are estimating a polynomial of degree 0 or simply a constant. If a change of variables is made letting $\alpha=(1-\beta)$ then equation (4) becomes:

$$X0_{est}=(1-\alpha) * X0_{est}[1] + \alpha * x(t) \qquad (5)$$

This is the familiar formula for the exponential moving average.

Higher orders of ***n*** don't yield such compact solutions as the case where ***n***=0 .equations

$$P_F(T+1) = (1-\beta)*[b_{0,t}\,\phi_{0|t=-1} + \beta b_{1,t} * \phi_{1|t=-1} + \beta^2 b_{2,t} * \phi_{2|t=-1} + \ldots + \beta^n b_{n,t} * \phi_{n|t=-1}]$$

$$\text{Velocity} = (dP_F/dt)_{(T=-1)} = (1-\beta)[\beta b_{1,t} *(d\phi_1/dt)_{|t=-1} + \beta^2 b_{2,t} *(d\phi_2/dt)_{|t=-1} + \ldots + \beta^n b_{n,t} *(d\phi_n/dt)_{|t=-1)}]$$

The n^{th} Order Fading Memory Forecast Next Bar's Velocity Strategy Defined

The least squares forecast is constructed by solving for the coefficients $\mathbf{b_0, b_1, b_2, \ , \ , b_n}$ recursively at each bar using the last **T** bars of closing prices and the Discrete Orthogonal Meixner Polynomial equations above. Then **Velocity** = $\mathbf{dP_F(T+1)/dt}$ is constructed from the velocity equation above and plotted under the price chart. In general what we will be doing is following the plotted curve of **Velocity** which is calculated at each bar from the previous T bars. When the velocity is greater than a threshold amount ***vup*** we will go long. When the velocity is less than a threshold amount ***-vdn*** we will go short.

Buy Rule:
IF Velocity is greater than the threshold amount ***vup*** then buy at the market.

Sell Rule:
IF Velocity is less than the threshold amount ***-vdn*** then sell at the market.

References

Appendix 1: n^{th} Order Fading Memory Polynomial Next Bar's Forecast Math

1. Morrison, Norman "Introduction to Sequential Smoothing and Prediction", McGraw-Hill Book Company, New York, 1969.

Appendix 2 -The *Normalization Multiplier*

What is the Multiplier ?

The n^{th} Order Fading Memory Polynomial, also called here an n^{th} Order Polynomial, is the least square fit of a polynomial of the form $\mathbf{P_F(T+1) = (1-\beta)*[b_{0,t}\,\phi_{0|t=-1} + \beta b_{1,t}*\phi_{1|t=-1} + \beta^2 b_{2,t}*\phi_{2|t=-1} + \ldots + \beta^n b_{n,t}*\phi_{n|t=-1}]}$ to a ***Fading*** number of past data points. Where **t** is discrete time bars. Time could be daily bars or one minute bars. We use the term "Fading Memory" because we weight the past data with a number that gets smaller and smaller the further back in time we go. It is assumed that the time bars occur at fixed intervals of time so tic bars would not be appropriate for this analysis. Suppose we want to find at some given time some *n*th-degree polynomial that fits the data well at current and recent prices but ignores the fit as we move into the distant past. One way to construct this type of fit would be to weight the past data with a number that got smaller and smaller the further back in time we went. This type of error minimization is mathematically solvable and is widely used in science and mathematics. Once the $\mathbf{b_n}$ coefficients are found then the next bar's estimate **(T+1)** of the n^{th} order polynomial Acceleration and acceleration can be easily found by the equations below.

Velocity = $\mathbf{(dP_F/dt)_{(T=-1)} = (1-\beta)[\beta b_{1,t}*(d\phi_1/dt)_{|t=-1} + \beta^2 b_{2,t}*(d\phi_2/dt)_{|t=-1} + \ldots + \beta^n b_{n,t}*(d\phi_n/dt)_{|t=-1)}]}$

$\mathbf{0<\beta<1}$

Please see the ***n*^th^** **Order Fading Memory Polynomial Next Bar's Forecast Math** section for a more detailed explanation.

For any tradable, the inputs to the polynomial are the **polynomial degree(aka Order)** and exponential decay constant β. When we plot the velocity, we notice that the amplitude, and the maximum and minimum values of and standard deviation of the velocity vary quite significantly with different polynomial degree and β inputs.

Below is a table of the standard deviation of the 312156 calculated Velocity values for different **degree** and β inputs. The lookback period **N (number of bars of past data)** is approximately related to α **(α=1-β)** by the formula **α=2/(1+N)**. I use **N** because it gives a better understanding of how many bars of past data are approximately being used. We used 1 min bars of the Crude Light future from 1/5/2012 to 8/11/2017 to generate this table.

@CL.C 1 min bars Date Range 1120102 to 1170811
Total Number of Bars=1917847 Norm=0
Trading Times Constraint Start Time=900 EndTime=1430
FadmVn Multiplier to Scale Velocity pw and N Range to One Std

pw	N	Std	1/Std	Std*Mult
1	20	0.00757329	132.043	0.865148
1	30	0.00615409	162.494	0.703023
1	40	0.00531118	188.282	0.606733
1	50	0.00473725	211.093	0.541168
1	60	0.00431417	231.794	0.492837
1	70	0.00398518	250.93	0.455254
		pw=1 Ave	196.106	
2	20	0.0131743	75.9054	1.50499
2	30	0.0106961	93.4923	1.22188
2	40	0.00922913	108.353	1.05431
2	50	0.00822868	121.526	0.940018
2	60	0.00748949	133.52	0.855575
2	70	0.00691445	144.625	0.789885
		pw=2 Ave	112.904	
3	20	0.0181217	55.1823	2.07017
3	30	0.0146857	68.0934	1.67765
3	40	0.0126693	78.9307	1.4473

3	50	0.0112991	88.5025	1.29077
3	60	0.0102876	97.2042	1.17523
3	70	0.0095003	105.26	1.08528
		pw=3 Ave	82.1955	
4	20	0.0227218	44.0107	2.59566
4	30	0.0183648	54.4519	2.09794
4	40	0.0158306	63.1686	1.80844
4	50	0.0141183	70.8303	1.61282
4	60	0.0128565	77.7816	1.46869
4	70	0.0118752	84.2093	1.35658
		pw=4 Ave	65.742	

The standard deviation varies from 0.003 to 0.022. The problem may get worse when we want to find good inputs for other tradables. Other tradables, because of their scales and tick size have much different Velocity ranges then the CL for the same degree and N. Thus the search ranges have to be different for each different tradable, N and degree.

To solve this problem and to have a standard search space for each tradable, I created a **Mult** input for each FadmVn Velocity strategy and indicator .. If each tradable's Velocity is multiplied by a number such that the standard deviation of that tradable's Velocity is close to one standard deviation then the search space for vup and vdn for each tradable would be 0 to 3 standard deviations and we wouldn't have to change the optimization search space every time we wanted to examine a new stock or future. The complicated equations that I use to normalize the ranges to one standard deviation for degree and N were derived using the software TableCurve 3D, automated surface and equation discovery. These equations are independent of the tradable and only depend on the polynomial degree and N. If you do not wish to use these equations then set iNorm=0 as above and use the average multiplier and larger ranges and search increments .

How to Find The Mult.

Here is how to use the #**FadmVMultStd**. First load your chart with as much data as you are going to use. *Click* on **Insert-> Indicator**. Select the #**FadmVMultStd.** Modify the inputs to the indicator or just leave them at their default values. A table will be produced as shown below. Notice that since the strategy is only trading from 900 EST to 1430EST the #**FadmVMultStd** only calculates the velocity STDs during that time window.

```
@CL.C 1 min bars Date Range 1120102 to 1170811
Total Number of Bars=1917847 Norm=1
Trading Times Constraint Start Time=900 EndTime=1430
FadmVn Multiplier to Scale Velocity pw and N Range to One Std
```

pw	N	Std	1/Std	Std*Mult
1	20	0.0277973	35.9748	0.992863
1	30	0.0280167	35.693	1.0007
1	40	0.0282222	35.4331	1.00804
1	50	0.0284016	35.2093	1.01445
1	60	0.0285572	35.0175	1.02
1	70	0.0286896	34.8559	1.02473
		pw=1 Ave	35.3639	
2	20	0.027696	36.1063	0.989246
2	30	0.0278901	35.8551	0.996177
2	40	0.0280888	35.6014	1.00327
2	50	0.0282565	35.3901	1.00927
2	60	0.028395	35.2175	1.01421
2	70	0.0285106	35.0747	1.01834
		pw=2 Ave	35.5408	

Appendix 2 -The *Normalization Multiplier*

3	20	0.0274987	36.3654	0.982198
3	30	0.0276403	36.1791	0.987256
3	40	0.0278323	35.9295	0.994113
3	50	0.0280063	35.7063	1.00033
3	60	0.0281532	35.52	1.00558
3	70	0.0282754	35.3665	1.00994
		pw=3 Ave	35.8444	
4	20	0.0273592	36.5508	0.977216
4	30	0.0274274	36.4599	0.979651
4	40	0.0275958	36.2374	0.985665
4	50	0.0277678	36.0129	0.99181
4	60	0.027918	35.8191	0.997176
4	70	0.0280453	35.6566	1.00172
		pw=4 Ave	36.1228	
		Mult=	**35.718**	

For each tradable chart:

1. Apply the **FadmVMultStd** indicator to your chart.
2. Find the Multiplier as shown above.
3. Record the multiplier value and delete the indicator from your chart.
4. **Apply that multiplier to the Mult input** with **iNorm=1** in the strategy.
5. Do the parameter search for vup & vdn in the default range 0.25 to 3 by 0.25 .