Trading the ES 1 Min Bars With
The Least Squares Velocity Strategy

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In previous working papers [Ref below] we examined a trading system that used the velocity of prices fit by a least squares straight line through "N" past prices, to determined buy and sell points. The reasoning behind this type of system was to only trade when the straight line slope or velocity was above a certain threshold. Many times during the day prices meandering around without a notable trend. At these times we do not wish to trade because of the whipsaws losses that occur from this type of price action. When a price trend finally starts, the velocity of that price trend moves above some minimum threshold value. Thus the velocity system would only issue a trade when certain velocity barriers were crossed.

The Least Squares polynomial is determined by minimizing the sum of the squares of the difference between the N prices and the value of the polynomial line.

$err^2(t)= [Price(t)-(a+b*t)]^2$ = error squared

$$\text{Minimize}(a,b) \sum_{t=1}^{t=N} err^2(t)$$

This mathematical technique has an exact solution and dates back to Gauss in the 1800's.

The Least Squares Velocity

Let us imagine a set of closing prices on a graph with time as the horizontal axis and price as the vertical axis. Let us further suppose that we have only twenty closing price dots at twenty time intervals. How can we draw a straight line through those twenty prices such that the sum of all the squared differences between the prices at each time interval and the straight line that is being fit to the data is minimized? This is called the "Least Squares Fit" line of the data (also referred to as the linear regression line). This mathematical technique is available in most of today's technical analysis software.

The formula for the straight line is:

y=a + b*t

where **a** is the initial value of the line, **b** is the slope of the line, and **t** is the time of the bar. The slope **b** is also called the **velocity**. Recall that velocity is defined as the change of position per unit time. Using the formula above at easy way to visualize dy/dt, the derivative of y with respect to t, t the velocity would be:

Velocity = [a+b*(t+1)] – [a+b*t] = b

If you are fitting the straight line to N prices then the "Best Fit" coefficients **a** and **b** can be solved for quite easily and are given by

a = [2(2N+1)/N(N-1)] $\sum_1^N p(t)$ **– [6/(N(N-1)]** $\sum_1^N t * p(t)$

b = Velocity = [12/N(N^2 –1)] $\sum_1^N t * p(t)$ **– [6/N(N-1)]** $\sum_1^N p(t)$

Where **p(t)** is the price at point **t** and **N** is the number of prices we are using to calculate the coefficients. Here **p(1)** is the first price in the series and **p(N)** is the last price in the series.

Here we will use the **velocity** of the least squares straight line to create a strategy. The least squares velocity has the advantage that it is a natural random price noise inhibitor. We can create a strategy such that unless the velocity is greater than some threshold we will not buy or sell. A large percentage of price noise generates a lot of back and forth movements of small magnitudes. With a lot of strategies this back and forth movement creates many false buy and sell signals. However using the least squares velocity we can filter many of the small price noise movements by requiring that the velocity be greater than some threshold before we act.

The Least Squares Velocity Strategy Defined

At each bar we calculate the least squares **velocity** or **b** from the formula above. 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.

Intraday Bars Exit Rule:
Close all positions 15 minutes before the ES close (no trades will be carried overnight).

First Trade of Day Entry Rule:
All trade signals before 30 minutes after the open are ignored. We've included this rule because with overnight trading there are often gaps in the open creating immediate strategy buys and sells. Many times these gaps are closed creating a losing whipsaw trade. In order to avoid the opening gap whipsaw trade problem we've delayed the first trade of the day for 30 minutes until after the opening

Discussion of S&P500 Index E-Mini Future Prices

The **S&P 500 Index E-Mini Future** (**ES**) is traded on the CME Futures Globex Exchange and is traded on a 23 hour basis. We have restricted our study to only trading the ES during the stock market hours of 8:30 to 1500 CST. To test this strategy we will use 1 minute bar prices of the ES futures contract for the four years from September 2, 2010 to October 3, 2014

Testing The Least Squares Velocity Strategy(LSqV) Using Walk Forward Optimization

There are three strategy inputs to determine:

1. ***N***, is the lookback period to calculate the **LSqV.**

2. ***vup***, the threshold amount that LSqV has to be greater than to issue a buy signal
3. ***vdn***, the threshold amount that LSqV has to be less than to issue a sell signal

We will test the LSqV strategy with the above ES 1 min bars on a ***walk forward basis***, as will be described below.

What Is A Walk Forward Optimization with In-Sample Section and Out-Of-Sample Sections?

Whenever we do a TS optimization on a number of different strategy inputs, TS 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 inputs. This is called a ***in-sample 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" or "data mining" it is important to see how the strategy inputs chosen from the in-sample section perform on out-of-sample data.

What do we mean by ***"curve fitting" or data mining?*** As a simple example, suppose you were taking a subway to work. In the subway car you are in, suppose you counted the number of blond women in that car and suppose the percent of blond women vs all other women hair colors was 80%. Being that you can't observe what is in the other subway cars, you would assume that all the other subway cars and perhaps all women had the same percentage of blond hair. This observation was due to chance. That is an example of curve fitting. The same goes for combinatorial searches. You are observing results from a finite sample of data without knowing the data outside the sample you examined.

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 input parameters from the optimization run. For instance, a ***filter*** example 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 or 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 your 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 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*.

Why use the walk forward technique? Why not just perform an optimization on the whole price series and choose the 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 prices and 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 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. 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 inputs parameter combinations , the best performance parameters will be from those strategy input variables that are able to produce profits from the price pattern ***and*** the random spurious movements While the price patterns will repeat, the same spurious price movements will not. If the spurious price movements that were captured by a certain set of input parameters were a large part of the total net profits, as they are in real intraday price series, then choosing these input parameters will produce losses when traded on future data. These losses occur because the spurious price movements will not be repeated in the same way. This is why strategy optimization or combinatorial searches with no out-of-sample testing cause loses when traded in real time from something that looked great in the in-sample section.

In order to gain confidence that our input parameter selection method using the optimization output of the in-sample data will produce profits, we must test the input parameters we found in the in-sample section on out-of-sample data. In addition, we must perform the in-sample/out-of-sample analysis many times. Why not just do the out-of-sample analysis once or just 10 times? Well just as in Poker or any card game, where there is considerable variation in luck from hand to hand, walk forward out-of-sample analysis give considerable variation in week-to-week out-of-sample profit "luck". That is, by pure chance we may have chosen some input parameter set that did well in the in-sample section data ***and*** the out-of-sample section data. In order to minimize this type of "luck", statistically, we must repeat the walk forward out-of-sample (oos) analysis over many (>30) in-sample/out-of-sample sections and take an average over all out-of-sample sections. This average gives us an expected out-of-sample return and a standard deviation of out-of-sample returns which allows us to statistically estimate the expected equity and its range for N out-of-sample periods in the future

Finding The Strategy Parameters Using Walk Forward Optimization
There are three strategy parameters to find *N, vup and vdn.*

For the test data we will run the TradeStation optimization engine on **ES** 1min price bars from 9/2/2010 to 10/3/2014 with the following optimization ranges for the Least squares velocity strategy inputs. I will create 209 30 day in-sample periods each followed by a 7 day out-of-sample period (See Figure 1 for the in-sample/out-of-sample periods).

1. N from 10 to 70 in steps of 10
2 vup from 0.2 to 3.6 steps of 0.2
3 vdn from 0.2 to 3.6 in steps of 0.2
4 Mult=1.48*√N Note: this normalizes the Velocity range for each N to one standard deviation. Else the Velocity would have different ranges for different N and it would be

difficult to find a vup and vdn that worked for all N ranges. See Appendix for a detailed explanation.

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This will produce 2268 different input combinations or cases of the strategy input parameters for each of the 209 in-sample/out-of-sample files for the two years of 1min bar ES data.

The question we are attempting to answer statistically is which best performance metric or combination of best performance metrics (which we will call a ***filter***) applied to the in-sample section will produce in-sample strategy inputs that produce statistically valid profits in the out-of-sample section. In other words we wish to find a performance metric ***filter*** that we can apply to the in-sample section that can give us strategy inputs that will produce, on average, good trading results in the future.

When TS does an optimization over many combinations of inputs, it creates output page that has as its rows each strategy input combination and as it's columns various trading performance measures such as Profit Factor, Total Net Profits, etc. An example of a simple filter would be to choose the strategy input optimization row in the in-sample section that had the highest Net Profit or perhaps a row that had the best Profit Factor with their associated strategy inputs. Unfortunately it was found that this type of simple metric performance filter very rarely produces good out-of-sample results. More complicated metric filters can produce good out-of-sample results minimizing spurious price movement biases in the selection of strategy inputs.

Here is an *example* of a better more complicated ***filter*** that was used in this paper. We require that the number of trades (**NT**) in the in-sample section be less than 50 trades per month. Since there are 21 trading days per month this is like restricting our filter to strategy values that only generate 2.5 trades a day or less on average. We require this so that we can minimize costs and stay with the major intraday trends. Of course, this is just the author's preference for this strategy. After using the **NT** filter, as described, there can still be 100's of rows left in the in-sample section. From experience, it is known that most curve fitted strategy results have high Profit Factors (PF). So for our filter we will restrict the in-sample PF <= 2. After using the **NT-PF** filter, as described, there can still be 100's of rows left in the in-sample section. There is a performance metric called **The Coefficient Of Correlation of Straight Line Fit To The Equity Curve(eqR2)**. Let us choose the 1**0** rows in the in-sample section that contain the **maximum eqR2**values from the rows that are left from the **NT-PF** screen. In other words we sort ***eqR2*** from high to low, eliminate the rows that have **NT**>50, and **PF>2** and then choose the largest ***eqR2*** 10 Rows of whatever is left. This particular filter will now leave 10 cases or rows in the in-sample file that satisfy the above filter conditions. We call this filter **t10eqR2|p<2|<50** where **t10eqR2** means the top or maximum **10 eqR2** rows left ***after*** the **NT-PF** filter. Suppose for this filter, within the 10 in-sample rows that are left, we want the row that has the highest metric called **The Medium Of All (Final Trade Profit minus Maximum Trade Rundown) m(p-rd)** in the in-sample section**.** We abbreviate this final filter as **t10eqR2|p<2|<50-m(p-rd)** . For each in-sample section this filter leaves only one row in the in-sample section with its associated strategy inputs and out-of-sample net profit in the out-of-sample section using the strategy inputs found in the in-sample section. This particular **t10eqR2|p<2|<50-m(p-rd) filter** is then applied to each of the 209 in-sample sections which give 209 sets of strategy inputs that are used to produce the corresponding 209 out-of-sample performance results. The average out-of-sample

performance is calculated from these 209 out-of-sample performance results. In addition many other important out-of-sample performance statistics for this filter are calculated and summarized. **Figure 3** shows such a computer run along with a small sample of other filter combinations that are constructed in a similar manner. Row 3 of the sample output in Figure 3 shows the results of the filter discussed above.

Bootstrap Probability of Filter Results.
Using modern "Bootstrap" techniques, we can calculate the probability of obtaining our filter's total out-of-sample ***net*** profits by chance. Here is how the bootstrap technique is applied. Suppose as an example, we have 100 files of in-sample/out-of-sample data. A mirror random filter is created. Instead of picking an out-of-sample net profit (OSNP) from a filter row as before, the mirror filter picks a ***random*** row's OSNP in each of the 100 files. We repeat this random picking in each of the 100 files 5000 times. Each of the 5000 mirror filters will choose a random row's OSNP of their own in each of the 100 files.. At the end, each of the 5000 mirror filters will have 100 ***random*** OSNP's picked from the rows of the 100 files. The sum of the 100 random OSNP picks for each mirror filter will generate a random total out-of-sample net profit (tOnpNet) or final random equity. The average and standard deviation of the 5000 mirror filter's different random tOnpNets will allow us to calculate the chance probability of our above chosen filter's tOnpNet. Thus given the mirror filter's bootstrap random tOnpNet average and standard deviation, we can calculate the probability of obtaining our chosen filter's tOnpNet by pure chance alone. Figure 3 lists the 5000 mirror filter's bootstrap average for our 209 out-of-sample files of **($24601)** with a bootstrap standard deviation of **$11503**. The probability for obtaining our filters net profit of **$31,639** is **5.06 10^{-7}** which is **4.89** standard deviations from the bootstrap average. For our filter, in row 3 in Figure 3, the expected number of cases that we could obtain by pure chance that would match or exceed the **$31639** is **23064** x **5.06 10^{-7}** = **0.012** where **23064** is the total number of different filters we looked at in this run. This number is much less than 1, so it is improbable that our result was due to pure chance.
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Results

Table 1 below presents a table of the 209 in-sample and out-of-sample windows, the **Filter** selected, strategy inputs and the weekly out-of-sample profit/loss results using the filter described above.

Figure 1 presents a graph of the equity curve generated by using the filter on the 209 weeks ending 10/8/10 – 10/3/14 (note the first month starting 9/2/10 was part of the first 30 day in-sample period). The equity curves is plotted from Equity and Net Equity columns in Table 1. Plotted on the equity curves is the 2nd Order Polynomial curve. 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.

Figure 2 presents the out-of-sample 1 minute bar chart of ES for 8/6/14 to 8/8/14 with the LSQV Indicator and all the buy and sell signals for those dates.

Discussion of Strategy Performance

In Figure 3 Row 3 of the spreadsheet filter output are some statistics that are of interest for our filter. An interesting statistic is **Blw**. Blw is the maximum number of weeks the OSNP equity curve failed to make a new high. Blw is 18 weeks for this filter. This means that 18 weeks was the longest time that the equity for this strategy failed to make a new equity high.

To see the effect of walk forward analysis, take a look at **Table 1**. Notice how the input parameters ***N, vup, vdn*** take sudden jumps from high to low and back . This is the walk forward process quickly adapting to changing volatility conditions in the in-sample sample. In addition, notice how often ***N*** changes from 10 to 70. When the data gets very noisy with a lot of spurious price movements, the lookback period, N, has to be higher. During other times when the noise level is not as much N can be lower to get onboard a trend faster.

In Figure 1, which presents a graph of the equity curve using the filter on the 209 weeks of out-of-sample data, notice how the equity curve follows the 2nd order polynomial trend line with an R^2 of 0.97. This R^2 dropped to 0.96 for the net equity curve.

Using this filter, the strategy was able to generate $31639 net equity after commissions and slippage of $20 trading one ES contract for 209 weeks. This period of time from 10/8/10 to 10/3/14 was a volatile market. Yet the LSQV strategy was able to adapt quite well. From Table 1, the largest losing week was -$1513 on the week ending 11/25/11 a very wild financial time and market week. The largest drawdown was -$1901 from the week ending on 11/11/11 to 11/25/11.. However this drawdown only lasted two weeks and completely recovered and made a new equity high in another Three weeks. The longest time between new equity highs was 18 weeks.

In observing Table 1 we can see that this strategy and filter made trades from a low of 0 or no trades/week to a high of 39 trades/week with an average of 4.0 trades/week. For the no trade weeks, the inputs found by the filter in the in-sample section generated no trades in the out-of-sample section.

Given 23 hour trading of the ES, restricting the strategy to trade only from 830am to 3:00pm CT caused the strategy to miss many profitable trends opportunities when Asia and then Europe opened trading in the early morning. Further research will include the A.M. time zones.

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.

References

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Figure 2 Walk Forward Out-Of-Sample Performance Summary
ES-Mini 1 min bars Robust Regression Velocity Strategy

ES-1 min bars 9/1/2010 - 10/3/2014 using the below filter on each in-sample segment. The input values *N, vup, and vdn* are the values found from applying the filter to the in-sample sample's optimization run.

In-sample Section Filter: t10eqR2|p<40<50-m(p-rd)

Where:
osnp = Weekly Out-of-sample net profit from strategy inputs chosen by In-sample Section filter
ollt = out-of-sample largest losing trade for that week from strategy inputs chosen by In-sample Section filter.
odd = Out-of-Sample closing trade drawdown for that week
ont = The number of trades in the out-of-sample week from strategy inputs chosen by In-sample Section filter.
Equity = running sum of the weekly out-of-sample profits(Osnp)
NetEq = running sum of weekly out-of-sample profits minus $20*Ont
Note: Blank rows indicate that no out-of-sample trades were made that week

Week #	In-Sample Dates			Out-Of_Sample Dates			osnp	Equity	osnp -$20/tr	NetEq	ollt	odd	ont	N	vup	vdn
1	09/01/10	to	10/01/10	10/04/10	to	10/08/10	225	225	165	165	-38	-38	3	30	1.6	1.4
2	09/08/10	to	10/08/10	10/11/10	to	10/15/10	(563)	(338)	(663)	(498)	-225	-563	5	20	1.8	1
3	09/15/10	to	10/15/10	10/18/10	to	10/22/10	288	(50)	248	(250)	0	0	2	20	2	1.6
4	09/22/10	to	10/22/10	10/25/10	to	10/29/10	63	13	3	(247)	-38	-38	3	30	1.2	3.4
5	09/29/10	to	10/29/10	11/01/10	to	11/05/10	538	551	498	251	0	0	2	40	2.8	2.6
6	10/06/10	to	11/05/10	11/08/10	to	11/12/10	(300)	251	(320)	(69)	0	0	1	40	3.4	2.6
7	10/13/10	to	11/12/10	11/15/10	to	11/19/10	(75)	176	(95)	(164)	0	0	1	20	2	3.4
8	10/20/10	to	11/19/10	11/22/10	to	11/26/10		176		(164)				20	2.6	3
9	10/27/10	to	11/26/10	11/29/10	to	12/03/10	(538)	(362)	(598)	(762)	-675	-725	3	50	2.6	2.6
10	11/03/10	to	12/03/10	12/06/10	to	12/10/10	(675)	(1037)	(755)	(1517)	-388	-850	4	20	1.4	1.2
11	11/10/10	to	12/10/10	12/13/10	to	12/17/10	100	(937)	80	(1437)	0	0	1	40	1	2.6
12	11/17/10	to	12/17/10	12/20/10	to	12/24/10	300	(637)	260	(1177)	0	0	2	10	0.8	2.4
13	11/24/10	to	12/24/10	12/27/10	to	12/31/10		(637)		(1177)				10	3	2.2
14	12/01/10	to	12/31/10	01/03/11	to	01/07/11	(213)	(850)	(253)	(1430)	-175	-213	2	40	2.2	1.6
15	12/08/10	to	01/07/11	01/10/11	to	01/14/11	825	(25)	685	(745)	-88	-163	7	10	0.4	2.4
16	12/15/10	to	01/14/11	01/17/11	to	01/21/11	(338)	(363)	(418)	(1163)	-288	-613	4	10	1.4	1.6
17	12/22/10	to	01/21/11	01/24/11	to	01/28/11	(38)	(401)	(158)	(1321)	-600	-600	6	30	0.2	2
18	12/29/10	to	01/28/11	01/31/11	to	02/04/11	1225	824	1145	(176)	0	0	4	40	0.8	2.2
19	01/05/11	to	02/04/11	02/07/11	to	02/11/11	(425)	399	(445)	(621)	0	0	1	50	3.4	2.2
20	01/12/11	to	02/11/11	02/14/11	to	02/18/11		399		(621)				40	1.8	2.6
21	01/19/11	to	02/18/11	02/21/11	to	02/25/11	(500)	(101)	(580)	(1201)	-875	-875	4	40	1.8	2.6
22	01/26/11	to	02/25/11	02/28/11	to	03/04/11	0	(101)	(40)	(1241)	-13	-13	2	30	2	2.4
23	02/02/11	to	03/04/11	03/07/11	to	03/11/11	525	424	445	(796)	-163	-163	4	10	2.4	3
24	02/09/11	to	03/11/11	03/14/11	to	03/18/11	(388)	36	(508)	(1304)	-438	-650	6	40	2	3
25	02/16/11	to	03/18/11	03/21/11	to	03/25/11		36		(1304)				30	2	2.6
26	02/23/11	to	03/25/11	03/28/11	to	04/01/11		36		(1304)				30	2	1.8
27	03/02/11	to	04/01/11	04/04/11	to	04/08/11		36		(1304)				30	1.8	3.2
28	03/09/11	to	04/08/11	04/11/11	to	04/15/11	238	274	198	(1106)	0	0	2	30	1.4	2
29	03/16/11	to	04/15/11	04/18/11	to	04/22/11		274		(1106)				30	1.8	3
30	03/23/11	to	04/22/11	04/25/11	to	04/29/11		274		(1106)				10	2.4	2.8
31	03/30/11	to	04/29/11	05/02/11	to	05/06/11	225	499	145	(961)	0	0	4	10	2.4	2.8
32	04/06/11	to	05/06/11	05/09/11	to	05/13/11		499		(961)				20	2.6	3.6

33	04/13/11	to	05/13/11	05/16/11	to	05/20/11		499		(961)				30	2	3.2
Week #	In-Sample Dates			Out-Of_Sample Dates			osnp	Equity	osnp -$20/tr	NetEq	ollt	odd	ont	N	vup	vdn
34	04/20/11	to	05/20/11	05/23/11	to	05/27/11		499		(961)				30	2	3.2
35	04/27/11	to	05/27/11	05/30/11	to	06/03/11	238	737	218	(743)	0	0	1	40	2.4	3.4
36	05/04/11	to	06/03/11	06/06/11	to	06/10/11		737		(743)				40	2.4	3.6
37	05/11/11	to	06/10/11	06/13/11	to	06/17/11	513	1250	453	(290)	-288	-288	3	50	2.2	2.4
38	05/18/11	to	06/17/11	06/20/11	to	06/24/11	(13)	1237	(93)	(383)	-313	-313	4	30	2.6	1.4
39	05/25/11	to	06/24/11	06/27/11	to	07/01/11	550	1787	530	147	0	0	1	30	2.2	2.8
40	06/01/11	to	07/01/11	07/04/11	to	07/08/11		1787		147				30	3.6	1.6
41	06/08/11	to	07/08/11	07/11/11	to	07/15/11	(750)	1037	(950)	(803)	-650	-1313	10	50	1.2	1.2
42	06/15/11	to	07/15/11	07/18/11	to	07/22/11	875	1912	815	12	0	0	3	40	2.6	2
43	06/22/11	to	07/22/11	07/25/11	to	07/29/11	(625)	1287	(745)	(733)	-625	-1188	6	40	3	1.4
44	06/29/11	to	07/29/11	08/01/11	to	08/05/11	3050	4337	2830	2097	-600	-1650	11	50	2.8	1
45	07/06/11	to	08/05/11	08/08/11	to	08/12/11	6225	10562	5445	7542	-513	-1563	39	20	1.8	1.2
46	07/13/11	to	08/12/11	08/15/11	to	08/19/11	(688)	9874	(868)	6674	-688	-1550	9	50	3.6	1.4
47	07/20/11	to	08/19/11	08/22/11	to	08/26/11	863	10737	663	7337	-500	-788	10	40	3	2
48	07/27/11	to	08/26/11	08/29/11	to	09/02/11	613	11350	553	7890	-375	-375	3	50	2.8	2.4
49	08/03/11	to	09/02/11	09/05/11	to	09/09/11	500	11850	460	8350	0	0	2	30	3.2	3
50	08/10/11	to	09/09/11	09/12/11	to	09/16/11	325	12175	285	8635	0	0	2	40	3.2	3.4
51	08/17/11	to	09/16/11	09/19/11	to	09/23/11	(1500)	10675	(1640)	6995	-938	-1563	7	50	1.8	2.6
52	08/24/11	to	09/23/11	09/26/11	to	09/30/11	(350)	10325	(510)	6485	-1050	-1813	8	10	3.4	3.2
53	08/31/11	to	09/30/11	10/03/11	to	10/07/11	2663	12988	2503	8988	-663	-663	8	30	2.6	3
54	09/07/11	to	10/07/11	10/10/11	to	10/14/11	413	13401	333	9321	-13	-13	4	10	2.8	3.2
55	09/14/11	to	10/14/11	10/17/11	to	10/21/11	738	14139	638	9959	-375	-375	5	20	3.2	2
56	09/21/11	to	10/21/11	10/24/11	to	10/28/11	525	14664	445	10404	-475	-475	4	40	3.2	2.2
57	09/28/11	to	10/28/11	10/31/11	to	11/04/11	150	14814	70	10474	-575	-838	4	50	2.8	3.2
58	10/05/11	to	11/04/11	11/07/11	to	11/11/11	1500	16314	1400	11874	-300	-300	5	40	2.2	3
59	10/12/11	to	11/11/11	11/14/11	to	11/18/11	(388)	15926	(468)	11406	-675	-763	4	50	1.6	3.2
60	10/19/11	to	11/18/11	11/21/11	to	11/25/11	(1513)	14413	(1613)	9793	-850	-1513	5	20	0.4	2.6
61	10/26/11	to	11/25/11	11/28/11	to	12/02/11	150	14563	50	9843	-500	-500	5	20	2.8	1
62	11/02/11	to	12/02/11	12/05/11	to	12/09/11	238	14801	138	9981	-575	-1125	5	50	3	2.4
63	11/09/11	to	12/09/11	12/12/11	to	12/16/11	2275	17076	2175	12156	0	0	5	20	3.4	0.2
64	11/16/11	to	12/16/11	12/19/11	to	12/23/11	463	17539	403	12559	-463	-463	3	50	3	1.4
65	11/23/11	to	12/23/11	12/26/11	to	12/30/11	475	18014	395	12954	-313	-313	4	10	2.6	0.2
66	11/30/11	to	12/30/11	01/02/12	to	01/06/12	(838)	17176	(878)	12076	-663	-838	2	50	3	2
67	12/07/11	to	01/06/12	01/09/12	to	01/13/12	113	17289	53	12129	-75	-88	3	50	1.2	1.6
68	12/14/11	to	01/13/12	01/16/12	to	01/20/12	488	17777	468	12597	0	0	1	20	1.8	2.2
69	12/21/11	to	01/20/12	01/23/12	to	01/27/12	38	17815	(62)	12535	-713	-738	5	10	0.4	2.2
70	12/28/11	to	01/27/12	01/30/12	to	02/03/12	900	18715	740	13275	-200	-200	8	40	0.4	1.8
71	01/04/12	to	02/03/12	02/06/12	to	02/10/12	738	19453	618	13893	-25	-25	6	50	0.4	1.6
72	01/11/12	to	02/10/12	02/13/12	to	02/17/12	125	19578	85	13978	0	0	2	30	2	2
73	01/18/12	to	02/17/12	02/20/12	to	02/24/12		19578		13978				40	2.8	3
74	01/25/12	to	02/24/12	02/27/12	to	03/02/12	(25)	19553	(45)	13933	0	0	1	40	2.8	3
75	02/01/12	to	03/02/12	03/05/12	to	03/09/12	(113)	19440	(133)	13800	0	0	1	30	2.8	1.6
76	02/08/12	to	03/09/12	03/12/12	to	03/16/12	163	19603	143	13943	0	0	1	40	3	2.8
77	02/15/12	to	03/16/12	03/19/12	to	03/23/12	(225)	19378	(245)	13698	0	0	1	40	3	2
78	02/22/12	to	03/23/12	03/26/12	to	03/30/12	(200)	19178	(260)	13438	-325	-600	3	40	1.8	1.6
79	02/29/12	to	03/30/12	04/02/12	to	04/06/12	(263)	18915	(283)	13155	0	0	1	10	2.6	2.6
80	03/07/12	to	04/06/12	04/09/12	to	04/13/12	963	19878	803	13958	-275	-500	8	30	0.8	1
81	03/14/12	to	04/13/12	04/16/12	to	04/20/12	0	19878	(40)	13918	-175	-175	2	10	2.8	2.6
82	03/21/12	to	04/20/12	04/23/12	to	04/27/12	(100)	19778	(120)	13798	0	0	1	10	2.8	3.4
83	03/28/12	to	04/27/12	04/30/12	to	05/04/12	125	19903	105	13903	0	0	1	10	3.4	3.4
84	04/04/12	to	05/04/12	05/07/12	to	05/11/12	263	20166	243	14146	0	0	1	20	2.6	3.4
85	04/11/12	to	05/11/12	05/14/12	to	05/18/12	650	20816	610	14756	0	0	2	10	3.4	3
86	04/18/12	to	05/18/12	05/21/12	to	05/25/12	825	21641	765	15521	-100	-100	3	30	2	3

87	04/25/12	to	05/25/12	05/28/12	to	06/01/12	350	21991	290	15811	-388	-388	3	40	3.6	2.8
Week #	In-Sample Dates			Out-Of_Sample Dates			osnp	Equity	osnp -$20/tr	NetEq	ollt	odd	ont	N	vup	vdn
88	05/02/12	to	06/01/12	06/04/12	to	06/08/12	(150)	21841	(350)	15461	-375	-788	10	50	1.2	1
89	05/09/12	to	06/08/12	06/11/12	to	06/15/12	850	22691	790	16251	0	0	3	40	1.6	2
90	05/16/12	to	06/15/12	06/18/12	to	06/22/12	75	22766	15	16266	-188	-188	3	50	1.2	2.4
91	05/23/12	to	06/22/12	06/25/12	to	06/29/12	1300	24066	1180	17446	-163	-163	6	30	0.8	2.8
92	05/30/12	to	06/29/12	07/02/12	to	07/06/12	775	24841	675	18121	-38	-38	5	30	0.6	2
93	06/06/12	to	07/06/12	07/09/12	to	07/13/12	525	25366	425	18546	-75	-75	5	20	1	3.2
94	06/13/12	to	07/13/12	07/16/12	to	07/20/12	163	25529	3	18549	-338	-625	8	10	1.2	2.6
95	06/20/12	to	07/20/12	07/23/12	to	07/27/12	1113	26642	1013	19562	-288	-288	5	30	0.4	3.4
96	06/27/12	to	07/27/12	07/30/12	to	08/03/12	(138)	26504	(218)	19344	-175	-213	4	30	1.6	1.8
97	07/04/12	to	08/03/12	08/06/12	to	08/10/12		26504		19344				20	3.4	2.6
98	07/11/12	to	08/10/12	08/13/12	to	08/17/12		26504		19344				20	3.2	2.6
99	07/18/12	to	08/17/12	08/20/12	to	08/24/12		26504		19344				20	3.6	2.6
100	07/25/12	to	08/24/12	08/27/12	to	08/31/12	(775)	25729	(835)	18509	-450	-775	3	20	3.6	2.6
101	08/01/12	to	08/31/12	09/03/12	to	09/07/12	938	26667	858	19367	-13	-13	4	10	0.8	3.6
102	08/08/12	to	09/07/12	09/10/12	to	09/14/12	525	27192	505	19872	0	0	1	50	2.8	1.6
103	08/15/12	to	09/14/12	09/17/12	to	09/21/12		27192		19872				30	2.8	2.4
104	08/22/12	to	09/21/12	09/24/12	to	09/28/12		27192		19872				30	2.8	2.4
105	08/29/12	to	09/28/12	10/01/12	to	10/05/12	(663)	26529	(683)	19189	0	0	1	30	2.8	2.4
106	09/05/12	to	10/05/12	10/08/12	to	10/12/12	1488	28017	1368	20557	-50	-50	6	50	2	0.4
107	09/12/12	to	10/12/12	10/15/12	to	10/19/12	863	28880	843	21400	0	0	1	40	3	1.6
108	09/19/12	to	10/19/12	10/22/12	to	10/26/12	88	28968	68	21468	0	0	1	40	2.4	3
109	09/26/12	to	10/26/12	10/29/12	to	11/02/12	350	29318	330	21798	0	0	1	40	2.8	2.6
110	10/03/12	to	11/02/12	11/05/12	to	11/09/12	613	29931	553	22351	-138	-138	3	50	2	2
111	10/10/12	to	11/09/12	11/12/12	to	11/16/12	200	30131	120	22471	-600	-600	4	20	2.6	2.2
112	10/17/12	to	11/16/12	11/19/12	to	11/23/12		30131		22471				20	2.8	3
113	10/24/12	to	11/23/12	11/26/12	to	11/30/12	338	30469	318	22789	0	0	1	20	2.8	3
114	10/31/12	to	11/30/12	12/03/12	to	12/07/12		30469		22789				30	2.4	2.6
115	11/07/12	to	12/07/12	12/10/12	to	12/14/12		30469		22789				30	2.4	2.6
116	11/14/12	to	12/14/12	12/17/12	to	12/21/12	1125	31594	1045	23834	-113	-113	4	30	1	2.4
117	11/21/12	to	12/21/12	12/24/12	to	12/28/12	375	31969	315	24149	-213	-213	3	50	2.4	2.8
118	11/28/12	to	12/28/12	12/31/12	to	01/04/13	613	32582	593	24742	0	0	1	30	2.2	3.4
119	12/05/12	to	01/04/13	01/07/13	to	01/11/13		32582		24742				20	3.6	2.4
120	12/12/12	to	01/11/13	01/14/13	to	01/18/13		32582		24742				20	3.6	2.4
121	12/19/12	to	01/18/13	01/21/13	to	01/25/13		32582		24742				20	3.6	2.4
122	12/26/12	to	01/25/13	01/28/13	to	02/01/13		32582		24742				40	3.2	2.6
123	01/02/13	to	02/01/13	02/04/13	to	02/08/13	275	32857	195	24937	-363	-363	4	40	1.6	1.8
124	01/09/13	to	02/08/13	02/11/13	to	02/15/13		32857		24937				40	1.6	2.4
125	01/16/13	to	02/15/13	02/18/13	to	02/22/13	(850)	32007	(890)	24047	-700	-850	2	10	1.4	2.4
126	01/23/13	to	02/22/13	02/25/13	to	03/01/13	1588	33595	1528	25575	-275	-275	3	20	2.4	1.8
127	01/30/13	to	03/01/13	03/04/13	to	03/08/13	(100)	33495	(280)	25295	-225	-413	9	50	0.6	1.4
128	02/06/13	to	03/08/13	03/11/13	to	03/15/13	50	33545	10	25305	-13	-13	2	40	0.8	1.6
129	02/13/13	to	03/15/13	03/18/13	to	03/22/13	(363)	33182	(423)	24882	-188	-363	3	10	2	2.8
130	02/20/13	to	03/22/13	03/25/13	to	03/29/13	388	33570	328	25210	-75	-75	3	30	1	1.8
131	02/27/13	to	03/29/13	04/01/13	to	04/05/13	25	33595	(15)	25195	-63	-63	2	10	3	2.8
132	03/06/13	to	04/05/13	04/08/13	to	04/12/13		33595		25195				10	3.2	3.2
133	03/13/13	to	04/12/13	04/15/13	to	04/19/13	113	33708	73	25268	-300	-300	2	10	3.2	3.2
134	03/20/13	to	04/19/13	04/22/13	to	04/26/13	288	33996	268	25536	0	0	1	40	2.4	3.6
135	03/27/13	to	04/26/13	04/29/13	to	05/03/13	(38)	33958	(58)	25478	0	0	1	40	3.4	3
136	04/03/13	to	05/03/13	05/06/13	to	05/10/13		33958		25478				40	2.2	3
137	04/10/13	to	05/10/13	05/13/13	to	05/17/13	1075	35033	975	26453	-413	-413	5	40	0.4	3
138	04/17/13	to	05/17/13	05/20/13	to	05/24/13	338	35371	218	26671	-513	-575	6	40	1.6	2
139	04/24/13	to	05/24/13	05/27/13	to	05/31/13	(225)	35146	(245)	26426	0	0	1	30	3	3.2
140	05/01/13	to	05/31/13	06/03/13	to	06/07/13	(663)	34483	(743)	25683	-800	-938	4	30	2.8	2.2

141	05/08/13	to	06/07/13	06/10/13	to	06/14/13		34483		25683				30	3.4	3.4
Week #	In-Sample Dates			Out-Of_Sample Dates			osnp	Equity	osnp -$20/tr	NetEq	ollt	odd	ont	N	vup	vdn
142	05/15/13	to	06/14/13	06/17/13	to	06/21/13	313	34796	293	25976	0	0	1	30	3.4	3.4
143	05/22/13	to	06/21/13	06/24/13	to	06/28/13		34796		25976				30	3.4	3.2
144	05/29/13	to	06/28/13	07/01/13	to	07/05/13		34796		25976				30	3.4	3.2
145	06/05/13	to	07/05/13	07/08/13	to	07/12/13	(550)	34246	(650)	25326	-300	-688	5	30	2.4	0.2
146	06/12/13	to	07/12/13	07/15/13	to	07/19/13		34246		25326				10	3	3.2
147	06/19/13	to	07/19/13	07/22/13	to	07/26/13		34246		25326				20	2.4	3.4
148	06/26/13	to	07/26/13	07/29/13	to	08/02/13	(200)	34046	(300)	25026	-275	-688	5	10	0.2	3.2
149	07/03/13	to	08/02/13	08/05/13	to	08/09/13		34046		25026				50	3.2	2.4
150	07/10/13	to	08/09/13	08/12/13	to	08/16/13	138	34184	18	25044	-300	-350	6	50	0.2	2.4
151	07/17/13	to	08/16/13	08/19/13	to	08/23/13	(13)	34171	(73)	24971	-413	-413	3	40	1.8	2.2
152	07/24/13	to	08/23/13	08/26/13	to	08/30/13	938	35109	758	25729	-263	-425	9	20	2	0.2
153	07/31/13	to	08/30/13	09/02/13	to	09/06/13	500	35609	420	26149	-200	-200	4	30	2	2.6
154	08/07/13	to	09/06/13	09/09/13	to	09/13/13		35609		26149				20	3.6	3.4
155	08/14/13	to	09/13/13	09/16/13	to	09/20/13	388	35997	368	26517	0	0	1	20	3.6	3.4
156	08/21/13	to	09/20/13	09/23/13	to	09/27/13		35997		26517				30	2.8	3.2
157	08/28/13	to	09/27/13	09/30/13	to	10/04/13		35997		26517				30	2.8	2.8
158	09/04/13	to	10/04/13	10/07/13	to	10/11/13	563	36560	523	27040	0	0	2	30	2.8	2.2
159	09/11/13	to	10/11/13	10/14/13	to	10/18/13	925	37485	805	27845	-475	-475	6	50	1	2.4
160	09/18/13	to	10/18/13	10/21/13	to	10/25/13		37485		27845				10	3	3.2
161	09/25/13	to	10/25/13	10/28/13	to	11/01/13	(350)	37135	(390)	27455	-200	-350	2	10	3	3.2
162	10/02/13	to	11/01/13	11/04/13	to	11/08/13	(88)	37047	(228)	27227	-725	-938	7	50	1	2.4
163	10/09/13	to	11/08/13	11/11/13	to	11/15/13		37047		27227				30	3.4	2.6
164	10/16/13	to	11/15/13	11/18/13	to	11/22/13		37047		27227				20	3	3
165	10/23/13	to	11/22/13	11/25/13	to	11/29/13		37047		27227				20	3	3
166	10/30/13	to	11/29/13	12/02/13	to	12/06/13	(513)	36534	(693)	26534	-350	-900	9	30	0.4	1.8
167	11/06/13	to	12/06/13	12/09/13	to	12/13/13		36534		26534				40	3.2	3
168	11/13/13	to	12/13/13	12/16/13	to	12/20/13	775	37309	715	27249	-238	-238	3	40	2.2	3
169	11/20/13	to	12/20/13	12/23/13	to	12/27/13	(375)	36934	(455)	26794	-213	-463	4	30	2	0.2
170	11/27/13	to	12/27/13	12/30/13	to	01/03/14	50	36984	(30)	26764	-300	-300	4	50	1.2	1
171	12/04/13	to	01/03/14	01/06/14	to	01/10/14	(238)	36746	(358)	26406	-363	-575	6	40	2.6	0.4
172	12/11/13	to	01/10/14	01/13/14	to	01/17/14	1088	37834	948	27354	-188	-375	7	30	1.6	0.6
173	12/18/13	to	01/17/14	01/20/14	to	01/24/14	563	38397	523	27877	-113	-113	2	10	2.6	2.8
174	12/25/13	to	01/24/14	01/27/14	to	01/31/14	(650)	37747	(790)	27087	-475	-963	7	30	1.8	2.4
175	01/01/14	to	01/31/14	02/03/14	to	02/07/14	(75)	37672	(135)	26952	-888	-1525	3	30	3.2	2
176	01/08/14	to	02/07/14	02/10/14	to	02/14/14	(750)	36922	(770)	26182	0	0	1	50	3.2	1.8
177	01/15/14	to	02/14/14	02/17/14	to	02/21/14	400	37322	380	26562	0	0	1	40	2.4	2.2
178	01/22/14	to	02/21/14	02/24/14	to	02/28/14	(525)	36797	(665)	25897	-513	-813	7	40	1	2.8
179	01/29/14	to	02/28/14	03/03/14	to	03/07/14	75	36872	15	25912	-250	-250	3	40	2.6	2.2
180	02/05/14	to	03/07/14	03/10/14	to	03/14/14	1000	37872	820	26732	-288	-488	9	30	1.6	1
181	02/12/14	to	03/14/14	03/17/14	to	03/21/14	(75)	37797	(135)	26597	-325	-363	3	40	3	2.6
182	02/19/14	to	03/21/14	03/24/14	to	03/28/14		37797		26597				20	3.2	3.6
183	02/26/14	to	03/28/14	03/31/14	to	04/04/14		37797		26597				20	3.2	3.6
184	03/05/14	to	04/04/14	04/07/14	to	04/11/14		37797		26597				20	3.2	3.6
185	03/12/14	to	04/11/14	04/14/14	to	04/18/14		37797		26597				20	3.2	3.6
186	03/19/14	to	04/18/14	04/21/14	to	04/25/14	150	37947	50	26647	-188	-188	5	30	2	0.4
187	03/26/14	to	04/25/14	04/28/14	to	05/02/14	525	38472	345	26992	-550	-738	9	30	2	0.4
188	04/02/14	to	05/02/14	05/05/14	to	05/09/14	900	39372	800	27792	-225	-225	5	20	2	2
189	04/09/14	to	05/09/14	05/12/14	to	05/16/14	638	40010	578	28370	0	0	3	40	1.4	1.8
190	04/16/14	to	05/16/14	05/19/14	to	05/23/14	238	40248	218	28588	0	0	1	50	2.4	3.2
191	04/23/14	to	05/23/14	05/26/14	to	05/30/14	213	40461	193	28781	0	0	1	50	2.4	3.4
192	04/30/14	to	05/30/14	06/02/14	to	06/06/14		40461		28781				20	2.4	3.6
193	05/07/14	to	06/06/14	06/09/14	to	06/13/14	(13)	40448	(33)	28748	0	0	1	40	2.2	2.2
194	05/14/14	to	06/13/14	06/16/14	to	06/20/14	1050	41498	910	29658	-250	-250	7	20	0.4	1.8

195	05/21/14	to	06/20/14	06/23/14	to	06/27/14	125	41623	105	29763	0	0	1	10	2.4	2.6
Week #	**In-Sample Dates**			**Out-Of_Sample Dates**			**osnp**	**Equity**	**osnp -$20/tr**	**NetEq**	**ollt**	**odd**	**ont**	**N**	**vup**	**vdn**
196	05/28/14	to	06/27/14	06/30/14	to	07/04/14		41623		29763				10	2.6	2.6
197	06/04/14	to	07/04/14	07/07/14	to	07/11/14	400	42023	300	30063	-238	-238	5	40	1.4	1.4
198	06/11/14	to	07/11/14	07/14/14	to	07/18/14	(400)	41623	(500)	29563	-1050	-1050	5	40	0.8	2.8
199	06/18/14	to	07/18/14	07/21/14	to	07/25/14	(50)	41573	(150)	29413	-188	-238	5	30	0.2	2.6
200	06/25/14	to	07/25/14	07/28/14	to	08/01/14	1038	42611	898	30311	-300	-563	7	10	2.6	2
201	07/02/14	to	08/01/14	08/04/14	to	08/08/14	713	43324	653	30964	0	0	3	20	3.4	2.8
202	07/09/14	to	08/08/14	08/11/14	to	08/15/14	(13)	43311	(33)	30931	0	0	1	20	3.4	3.4
203	07/16/14	to	08/15/14	08/18/14	to	08/22/14	88	43399	28	30959	-163	-163	3	20	1.2	1.8
204	07/23/14	to	08/22/14	08/25/14	to	08/29/14	(325)	43074	(345)	30614	0	0	1	10	2.6	1.6
205	07/30/14	to	08/29/14	09/01/14	to	09/05/14		43074		30614				30	2.4	2.4
206	08/06/14	to	09/05/14	09/08/14	to	09/12/14		43074		30614				50	3	2.8
207	08/13/14	to	09/12/14	09/15/14	to	09/19/14	(75)	42999	(95)	30519	0	0	1	50	3.4	2
208	08/20/14	to	09/19/14	09/22/14	to	09/26/14	750	43749	650	31169	-600	-600	5	20	1.4	2.2
209	08/27/14	to	09/26/14	09/29/14	to	10/03/14	550	44299	470	31639	-488	-488	4	50	2.2	2.8

Where:
osnp = Weekly Out-of-sample net profit from strategy inputs chosen by In-sample Section filter
ollt = out-of-sample largest losing trade for that week from strategy inputs chosen by In-sample Section filter.
odd = Out-of-Sample closing trade drawdown for that week
ont = The number of trades in the out-of-sample week from strategy inputs chosen by In-sample Section filter.
Equity = running sum of the weekly out-of-sample profits(Osnp)
NetEq = running sum of weekly out-of-sample profits minus $20*Ont
Note: Blank rows indicate that no out-of-sample trades were made that week

Figure 1 Graph of Least Squares Velocity Strategy Net Equity Applying the Walk Forward Filter Each Week
On ES 1min Bar Prices 10/8/2010 to 10/3/2014

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.

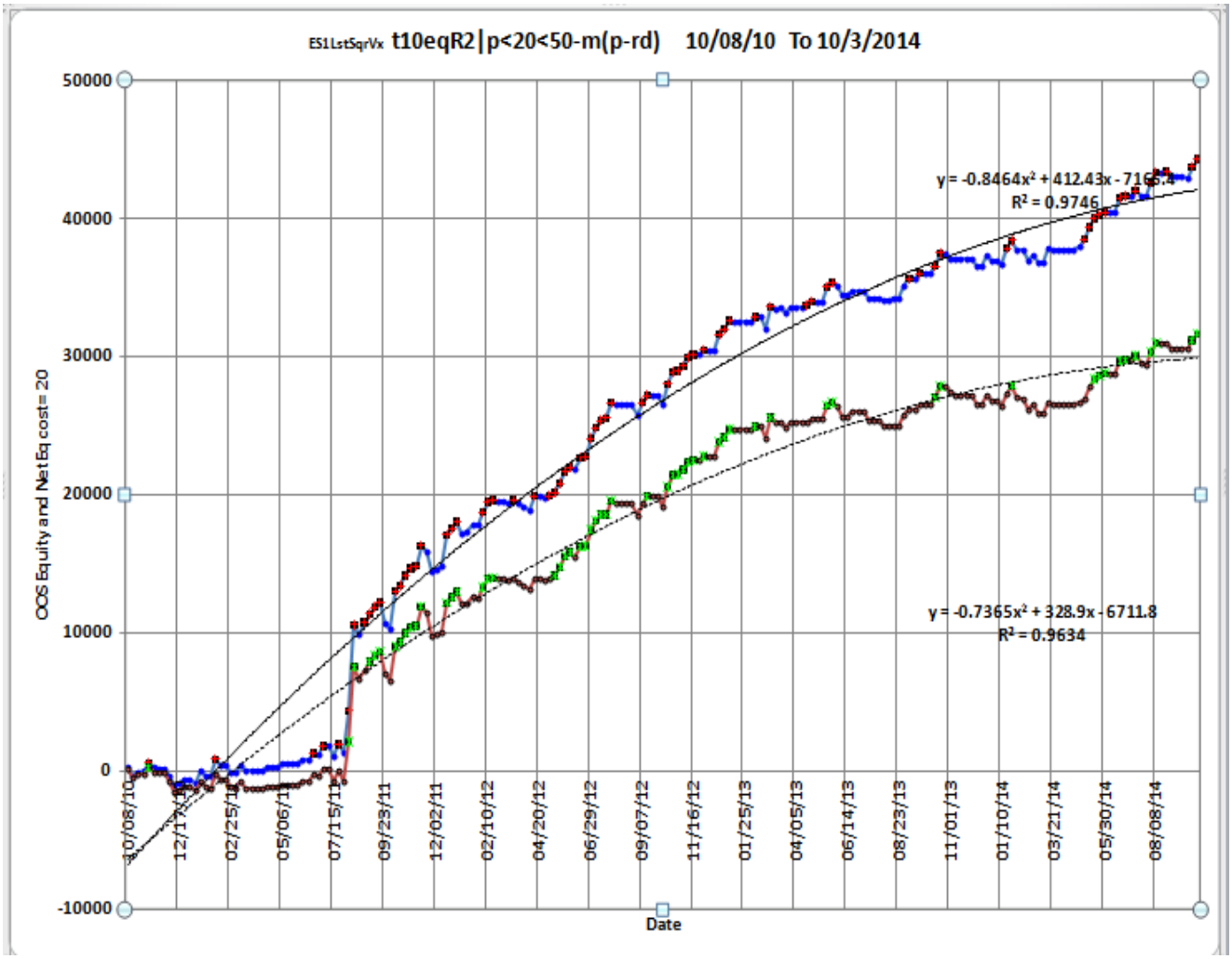

Figure 2 Walk Forward Out-Of-Sample Performance Summary for ES1 Least Squares Velocity Strategy 1 minute bar chart from 9/29/14-10/3/2014

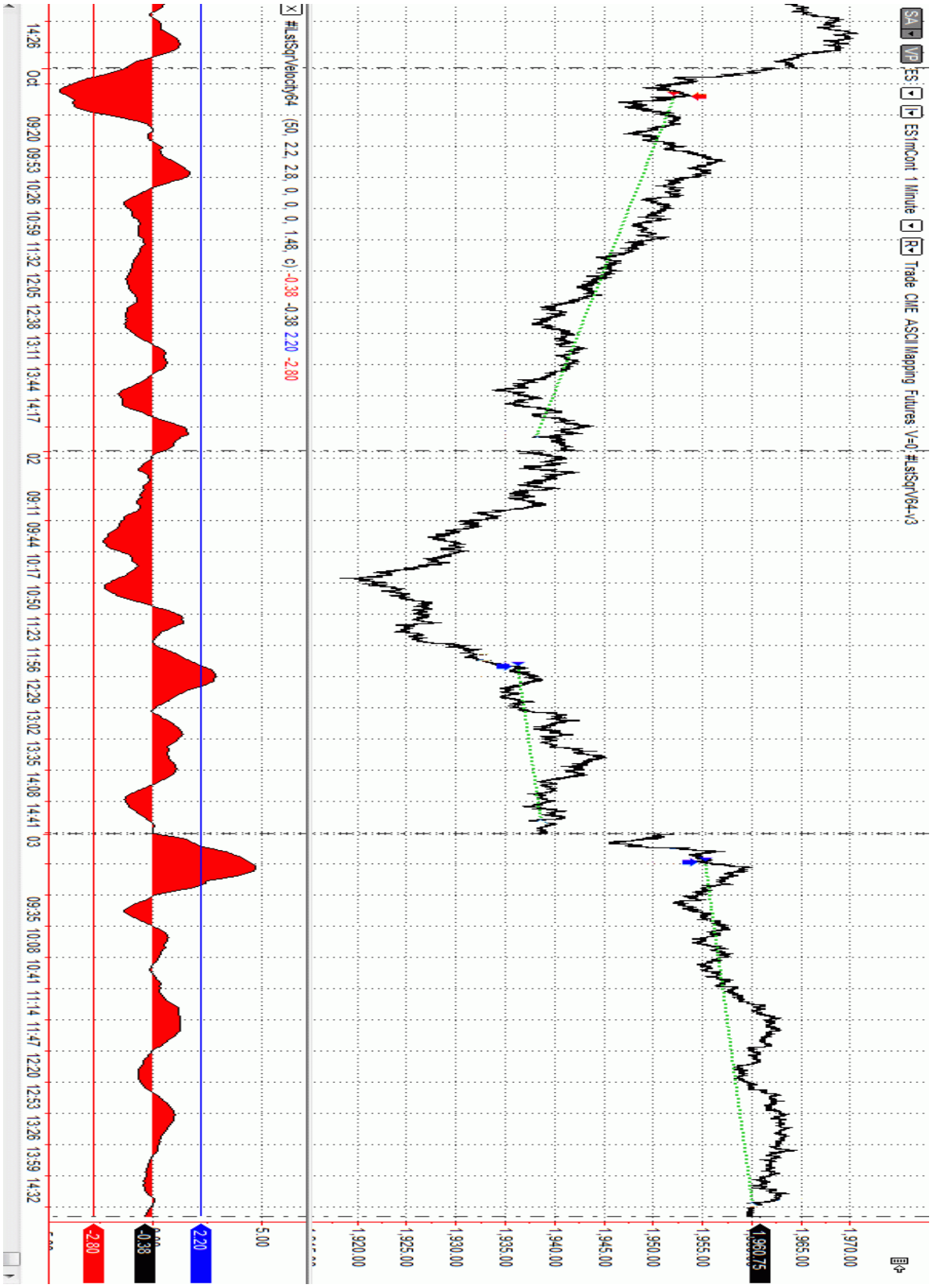

Figure 3 Partial output of the Walk Forward Metric Performance Explorer (WFME)
ES-Mini 1 min bars Least Squares Velocity System

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	ES1LstSqrVx	s10/08/10	e10/03/14	#209	AnyTnp				a(24601)	s11503	f23064										c=$ 20	
2	Filter-Metric	tOnp	aOnp	aOTrd	aO#T	B0	%P	t	std	LLp	eqDD	lr	#	eqTrn	eqV^3	eqR2	Dev^2	Blw	BE	eff	tOnpNet	Prob
3	t10eqR2|p<20<50-m(p-rd)	44299	280	70	4	(0.4)	64	4.37	806	-1513	-1901	4	158	235	-27	94	3609	18	33	0.95	31639	5.06E-07
4	t10eqR2|p<20-m(p-rd)	45712	287	51.3	5.6	(0.8)	64	4.26	851	-1500	-2776	4	159	250	-91	93	4197	20	35.1	0.84	27892	2.52E-06
5	b20std|p<40<50-eq2V	45137	313	49.3	6.4	(0.8)	67	4.71	798	-1913	-2589	3	144	226	201	98	2087	13	25.9	3.16	26837	3.88E-06
6	b10std|p<30<50-eq2A	42598	288	51.2	5.6	(1.3)	60	4.83	725	-1225	-2075	4	148	199	263	93	3382	14	25.4	0	25958	5.53E-06
7	t10mLb|p<40-eq2A	36227	212	64.2	3.3	(1.1)	60	3.49	795	-1838	-3089	5	171	181	114	91	3392	23	56.3	2.9	24947	8.26E-06
8	t10mLb|p<40<50-eq2A	36227	212	64.2	3.3	(1.1)	60	3.49	795	-1838	-3089	5	171	181	114	91	3392	23	56.3	2.9	24947	8.26E-06
9	t10eqR2|p<20-eqTrn	40268	272	51	5.3	(1.4)	60	3.89	850	-1138	-2538	6	148	211	0	93	3542	30	39	0.8	24468	9.96E-06
10	t10eqR2|p<20<50-nT	33370	238	73.5	3.2	(0.3)	61	4.04	697	-1400	-2250	6	140	168	108	96	1968	16	34.2	1.03	24290	1.07E-05
11	t50eqR2|p<20<50-eqTrn	34062	227	68.8	3.3	(0.8)	60	3.9	713	-1450	-2326	4	150	165	101	88	3708	36	39.4	0.93	24162	1.12E-05

The WFME Filter Output Columns are defined as follows:

Row 1 ES1LSqVx is the strategy abbreviation, First OOS Week End Date(10/8/110), Last OOS Week End Date(10/3/14), **Number of weeks**(#209) **a**=average of bootstrap random picks. **s=** standard deviation of bootstrap random picks. **f**=number of different filters examined. **c=** slippage and round trip trade cost(c=$20).

Filter = The filter that was run. Row 3 filter **t10eqR2|p<40<50-m(p-rd)**

The **t10eqR2|p<40<50-m(p-rd**) filter produced the following average 209 week statistics on row 3.

tOnp = Total out-of-sample(oos) net profit for these 209 weeks.

aOsp = Average oos net profit for the 209 weeks

aOTrd = Average oos profit per trade

aO#T = Average number of oos trades per week

B0 = The 209 week trend of the out-of-sample weekly profits

%P = The percentage of oos weeks that were profitable

t = The student t statistic for the 209 weekly oos profits. The higher the t statistic the higher the probability that this result was not due to pure chance

std = The standard deviation of the 209 weekly oos profits

llp = The largest losing oos period(week)

eqDD = The oos equity drawdown

lr = The largest number of losing oos weeks in a row

= The number of weeks this filter produced a weekly result. Note for some weeks there can be no strategy inputs that satisfy a given filter's criteria.

eqTrn = The straight line trend of the oos gross profit equity curve in $/week.

eqV^3 = The ending velocity of 3rd order polynomial that is fit to the equity curve

EqR2 = The correlation coefficient(r^2) of a straight line fit to the equity curve

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

Blw = The maximum number of weeks the oos equity curve failed to make a new high.

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

eff = Efficency. The average daily out-of-sample profit divided by the average daily in-sample profit.

tOnpNet = Total out-of-sample net profit(tOnpNet) minus the total trade cost.
tOnpNet=tOnp **–** (Number of trade weeks)*aOnT*Cost.

Prob = the probability that the filter's tOnpNet was due to pure chance.

Appendix: The *Normalization Multiplier*

What is the Multiplier ?

The Least Square Velocity, is the least square fit of a of a straight to a set of prices

If you are fitting the straight line to N prices then the "Best Fit" coefficients **a** and **b** can be solved for easily and are given by

a = [2(2N+1)/N(N-1)] $\sum_1^N p(t)$ **– [6/(N(N-1)]** $\sum_1^N t * p(t)$

b = Velocity = [12/N(N^2 –1)] $\sum_1^N t * p(t)$ **– [6/N(N-1)]** $\sum_1^N p(t)$

Where **p(t)** is the price at point time point **t** and **N** is the number of prices we are using to calculate the coefficients. Here **p(1)** is the first price in the series and **p(N)** is the last price in the series.

One of the inputs to the calculation of Velocity is the **N** the number of lookback bars. When we plot the velocity we notice that the amplitude, and the maximum and minimum values of the velocity vary quite significantly with different **N** inputs.

Below is a table of the standard deviation of the 416339 calculated Velocity values for different **N**. We used 1 min bars of the E-Mini from 9/2/2010 to 10/3/2014 to generate this table.

ES 1 min bars Date Range
8/30/2010 to 10/3/2014
Total Number of Bars=416339

LSqVelocity Multiplier to Scale Velocity N Range to One SD. SD=Standard Deviation

N	SD	1/SD
10	0.218868	4.56897
20	0.151289	6.60986
30	0.122786	8.14427
40	0.106348	9.40308
50	0.095134	10.5115
60	0.086852	11.5138
70	0.08042	12.4347

As one can see the Velocity Standard Deviation for N=10 is approximately 3 times the SD for N=70. This makes it difficult to find a set of vup and vdn that satisfy all N. We would like to find a multiplier of the Velocity that normalizes all the N SDs and ranges to the same SDs.

Fortunately the SDs for the different Ns for a Least Squares Velocity are proportional to √N. So if we multiply the Velocity by the √N, the Velocities for different N should have the same SDs and ranges. Below are the results for multiplying the Velocity by √N.

ES 1 min bars Date Range8/30/2010 to10/3/2014 Total Number of Bars=416339 sqrt(N)

LSqVelocity Multiplier to Scale Velocity N Range to One SD

N	SD	1/SD
10	0.69212	1.44484
20	0.676585	1.47801
30	0.672525	1.48693
40	0.672605	1.48676
50	0.672697	1.48655
60	0.672753	1.48643
70	0.672846	1.48622
AVE	0.67602	1.47939

As we can see the SDs are now very close. If we multiply all velocities by 1.47939*√N then the SDs of the velocities for all will be normalized to 1. This allows us to do an optimization search for ranges of vup and vdn from 0.2 to 3.6 standard deviations for all N.