Trading DIA ETF 5min Bars Using the Repeated Median Velocity Algorithm
Walk Forward in-sample 20 Trading weekdays and out-of-sample 1 Trading weekday

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 large losses

In previous working papers 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.

Recently much work has been done in what is called robust regression and outlier detection techniques, Ref [1]. Robust regression techniques are now defined by a measure called the "breakdown point". The breakdown point is loosely defined as the smallest amount of bad data points that can cause the regression coefficient solutions to take on values some distance from their true values. Unfortunately, the Least Squares technique has a breakdown point of 1/N. In other words, only one bad data point can significantly change the computation of the velocity or slope of a straight line. The median of a set of numbers has a breakdown point of 50%. This is because when 50% of the numbers are bad then there is no way of telling which are the bad numbers and which are the good numbers. 50% is the highest breakdown point.

The least absolute deviation (LAD) regression estimator from Ref [1] is

$$\text{Minimize}(a,b) \sum_{i=1}^{i=N} \text{absolute value } [\, err(i)]$$

and has a breakdown point of 29.8% . For the LAD this means around ¼ of the price points can be bad before the computations of a and b become erroneous. Siegel Ref [2], in his paper "Robust regression using repeated medians", introduced a technique for finding the slope that has a 50% breakpoint. The repeated median is also described in Ref [1].

While the repeated median technique may sound complicated it is quite easy to compute. Here's how. For demonstration purposes let's suppose we have 15 data points on an x, y graph such that,

X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Y	1	2	10	4	5	6	7	8	9	18	11	12	13	18	15	20

We've added two bad Y points at X positions 3,10, 14 and 16. To calculate the repeated median slope we would take the slope of every pair of y values and then find the median of all the pairs of slopes. For this example, we would take

slope	**1**	**y(2)-y(1)/(2-1) =**	**1.00**
slope	**2**	**y(3)-y(1)/(3-1)=**	**4.50**
slope	**3**	**y(4)-y(1)/4-1)=**	**1.00**
slope	**4**	**y(5)-y(1)/(5-1)=**	**1.00**
slope	**5**	**y6)-y(1)/(6-1)=**	**1.00**
slope	**6**	**y(7)-y(1)/(7-1)=**	**1.00**
slope	**7**	**y(8)-y(1)/(8-1)=**	**1.00**
slope	**8**	**y(9)-y(1)/(9-1)=**	**1.00**
slope	**9**	**y(10)-y(1)/(10-1)=**	**1.89**
slope	**10**	**y(11)-y(1)/(11-1)=**	**1.00**
slope	**11**	**y(12)-y(1)/(12-1)=**	**1.00**
slope	**12**	**y(13)-y(1)/(13-1)=**	**1.00**
slope	**13**	**y(14)-y(1)/(14-1)=**	**1.31**
slope	**14**	**y(15)-y(1)/(15-1)=**	**1.00**
slope	**14**	**y(16)-y(1)/(16-1)=**	**1.27**
		Median =	**1.00**

The median slope of the above is 1. The above process is repeated for:
(y(2)-y(i))/(2-i), i=1 to 15 i≠2,
(y(3)-y(i))/(3-i), i=1 to 15 i≠3,
……..
(y(16)-y(i))/(16-i), i=1 to 16 i≠16.

The final slope is then the **median of all the medians calculated above**. While the repeated median looks redundant because the very first calculation produced the correct slope, price data is not so nicely distributed as our example and the extra calculations are needed to assure that the outliers are eliminated.

The mathematical formula for the above is

$$\text{Slope}(t) = \underset{i=1 \text{ to } N}{\text{median}_i} \{ \underset{j=1 \text{ to } N}{\text{median}_{i \neq j}} [\text{price}(t)-\text{price}(t-i))/(i-j)] \}$$

Figure 1 below shows a plot of the x,y numbers above with the repeated median line and the least squares line on the graph. Notice how the bad points draw the least squares line towards them while the repeated median line is completely unaffected by the outliers. The least Squares line is given by the formula **y=-0.65 + 1.1074*x** . The true line is given by the formula **y=x** . From this simple example we can observe how noise has distorted the least squares estimates of **a** and **b, where y=a+bx**.

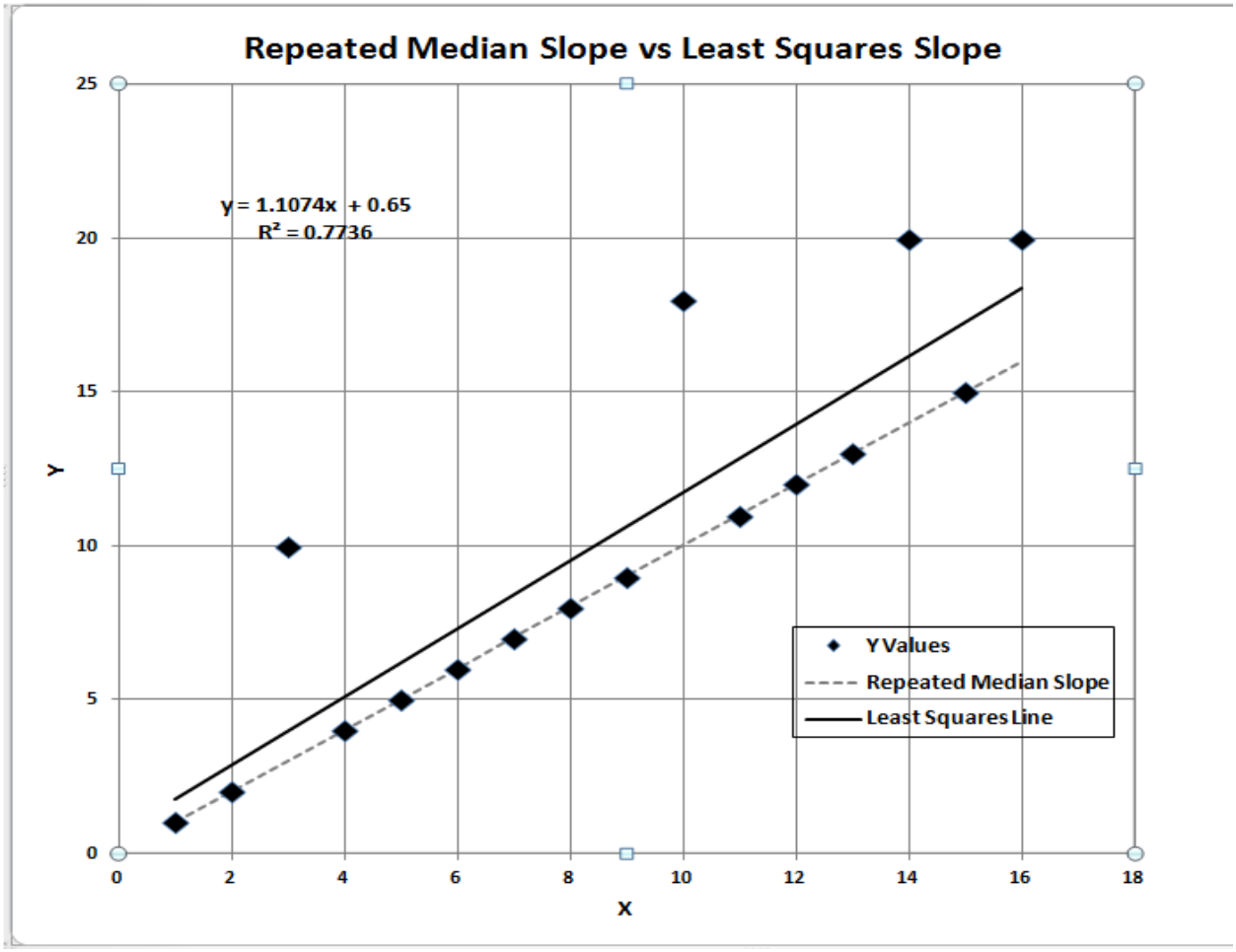

Figure 1 Repeated Median Slope vs Least Squares Slope.

The Repeated Median Velocity (RMedV) System Defined

Here we will use the repeated median slope to create a trading system. For a straight line the velocity is equal to the slope. The repeated median velocity, also called the **robust velocity,** has the advantage that it is a natural random price noise inhibitor. We can create a system such that unless the repeated median velocity using N past price bars is greater than some threshold value we will not buy or sell. A large percentage of price movements are just noise which generates a lot of back-and-forth movements of small magnitudes. This back-and-forth movement creates many false buy and sell signals. However, using the repeated median velocity over N past prices, we will attempt to filter out many of the small price noise movements by requiring that the repeated median velocity to be greater than some threshold before we act.

At each price bar we calculate the repeated median velocity (**RMedV**) 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.

The Repeated Median Velocity Trading Strategy

Buy Rule:

IF RMedV is greater than or equal to the threshold amount ***vup and RMedV[1] is less than vup*** then buy at the market.

Sell Rule:
IF RMedV is less or equal to the threshold amount ***-vdn and RMedV[1] is greater than -vdn*** then sell at the market.

Where RMedV[1] is the RMedV on the previous bar.

Intraday Bars Exit Rule:
Close the position at 1555 EST. No trades will be carried overnight.

Testing the Repeated Median Velocity System (RMedV)
Using Walk Forward Optimization
There are three strategy inputs to determine:

1. ***N***, the lookback period to calculate the **RMedV.**
2. ***vup***, the threshold amount that RMedV must be greater than to issue a buy signal
3. ***vdn***, the threshold amount that RMedV must be less than to issue a sell signal

As mentioned, to test this Strategy we will use five-minute bar prices of the Dow Jones ETF traded on the NYSE and known by the symbol DIA for the 399 trading days from December 9, 2019, to July 9, 2021.

We will test the RMedV strategy with the above DIA ETF 5 min bars on a ***walk forward basis***, where the in-sample (***IS***) will be 20 trading weekdays and the out-of-sample (***OOS***) will be the next trading weekday following as will be described below.

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

Whenever we do a TradeStation or Multicharts (TS/MC) 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 inputs. This is called an ***in-sample (IS) 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 cannot 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 strategy 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 or some other performance metric? 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, also called back testing, with no out-of-sample testing cause loses when traded in real time from something that looked great in the in-sample section.

To gain confidence that our input parameter selection method or filter, 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 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 (>50) 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 RMedV Strategy Parameters Using Walk Forward Optimization

There are three strategy parameters to find*, N, vup, vdn.*

For the test data we will run the TS or MC optimization engine on **DIA** 5 min price bars from 12/9/2019 to 7/9/2021 with the following optimization ranges for the RMedV strategy inputs. This will create **399, 20 weekday in-sample periods each followed by a 1 day out-of-sample period** (See Figure 1 for the in-sample/out-of-sample periods). The days are weekdays only. Weekdays where the OOS falls on an exchange holiday or partial days are eliminated. Holidays that fall on a weekday create a 19-day ***IS***. All other ***IS*** periods consist of 20 trading weekdays. The optimization ranges are:

1. **N from 6 to 20 in steps of 1.**
2. **vup from 0.25 to 3.5 steps of 0.25**
3. **vdn from 0.25 to 3.5 in steps of 0.25**

4. **Mult = 2.16, iNorm=1 (See Appendix, the Normalization Multiplier)**

The above pw, n, vup, vdn will produce 2730 different input combinations or cases of the strategy input parameters for each of the 399 in-sample/out-of-sample files for the 19 months of 5 min bar DIA data.

Finding the Best Set of Strategy Inputs to use with an in-sample Metric Filter.

The PWFO generates a number of performance metrics in the in-sample section. (Please see https://meyersanalytics.com/Walk-Forward-Optimization 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 gives 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 using those set of strategy inputs*** in the next out-of-sample section if the in-sample ***metric filter*** satisfied our criteria. ***Else no trades would be made*** in the next out-of-sample section.

The Walk Forward Strategy – 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 section if and only if they satisfy our in-sample ***metric-filter***. Else we will not trade the next out-of-sample section. In this paper the in-sample section is 20 trading days, and the out-of-sample section is the next trading day. After running the PWFO on the in-sample data, we examine the in-sample metric filter that we chose. If the strategy inputs we selected satisfy the in-sample metric filter requirements then we use those strategy inputs to trade the next day. If the strategy inputs do not satisfy the in-sample metric filter we do not trade the next day.

Let us define the in-sample ***metric-filter*** we will use here: in-sample (IS) Profit Factor (**PF≤ x**) and/or IS Losers in a row (**lr ≤ y)**,and/or IS equity curve straight line correlation coefficient t(**r^2(R2) ≤z)**. That is **PF ≤ x and/or lr≤ y and/or R2 ≤ z.**

What 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 lr<y and/or R2 ≤ z**. This will produce seven **strategy input|metric-filter** combinations:

1. **strategy input|PF ≤ x, lr≤y, R2 ≤ z|**
2. **strategy input|PF ≤ x, lr ≤ y|**
3. **strategy input|PF ≤ x, R2 ≤ z|**
4. **strategy input|PF ≤ x |**
5. **strategy input|LR ≤ y, R2 ≤ z|**
6. **strategy input|lr ≤ x|**
7. **strategy input|R2 ≤ z|**
8. **strategy input – we also examine inputs with no filter**

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 **IS metric-filter** combinations of **PF≤2 to 6 step 1, LR≤3,5 step 2 and R2≤30 to 50 step 5.** We will also look at the strategy input with no metric-filter. With 2730 different strategy input combinations this will give us 257039 **strategy input|metric-filter** combinations. Each one of these 257039-strategy **input|metric-filter** combinations will be applied to each in-sample section and their out-of-sample performance will be tabulated for all 399 PWFO files.

Below is a snippet of the output from a run of all 257039combinations sorted by **tONP = total OOS net profit for each strategy input|metric-filter** combination. ***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 RMedV that was run on 100 shares of DIA ETF 5-minute bars 399 days from 12/9/2019 to 7/9/2021. The in-sample (IS) period is 20 trading weekdays, and the out-of-sample (OOS) period is 1 trading weekday. This strategy traded between 9am to 1600pm Exchange Time (EST).

From this run, we chose the filter on Row4 of the Figure below. That is,

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8|0.75|2.5|0|1555|2.16|pf<6|r2<45. This is constructed as follows. For the strategy inputs **8|0.75|2.5|0|1555|2.16|**only those in-sample sections that have a **pf ≤6** and **r2≤45** are used to trade in the following out-of-sample sections. If the in-sample pf > 6 and or r2>45 then the out-of-sample section following the in-sample section ***is not*** traded.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	DIA5mRMedV20x1dxo	s12/31/19	e07/09/21	#399	AnyTnp						lSnt2			a(3.6)	s10.0	f257039					c=$4						
2	N|vup|vdn|xop|xt|mult|<PF<LR<R2	toGP	tONP	aoGP	aoTr	ao#T	std	skew	kur	t	oW|oL	%Wtr	%P	LLtr	LLp	eqDD	wpr	lpr	#	V20	Dev^2	KTau	eqR2	Blw	BE	tkr|bl	Prob
3	8|0.75|2.5|0|1555|2.16|pf<2|r2<45	13720	12492	62	44.7	1.4	261	0.49	6.51	3.52	1.35	56	62	-722	-889	-1021	9	4	223	12	1524	95	86	47	135	450	1.27E-09
4	8|0.75|2.5|0|1555|2.16|pf<6|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
5	8|0.75|2.5|0|1555|2.16|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
6	8|0.75|2.5|0|1555|2.16|pf<3|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
7	8|0.75|2.5|0|1555|2.16|pf<4|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
8	8|0.75|2.5|0|1555|2.16|pf<5|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
9	8|0.75|2.5|0|1555|2.16|pf<2|r2<40	13284	12112	63	45.3	1.4	264	0.514	6.5	3.47	1.37	56	62	-722	-889	-1021	9	4	210	10	1453	95	86	48	139	423	4.54E-10
10	8|0.75|2.5|0|1555|2.16|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
11	8|0.75|2.5|0|1555|2.16|pf<6|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
12	8|0.75|2.5|0|1555|2.16|pf<3|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
13	8|0.75|2.5|0|1555|2.16|pf<4|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
14	8|0.75|2.5|0|1555|2.16|pf<5|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
15	8|0.75|2.5|0|1555|2.16|pf<2|r2<50	12706	11422	54	39.6	1.4	260	0.457	6.53	3.18	1.3	55	61	-722	-889	-1021	9	4	236	11	1440	94	86	47	166	329	1.01E-07

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 500 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 500 files. We repeat this random picking in each of the 500 files 5000 times. Each of the 5000 mirror filters will choose a random row's OSNP of their own in each of the 500 files. At the end, each of the 5000 mirror filters will have 500 ***random*** OSNP's picked from the rows of the 500 files. The sum of the 500 random OSNP picks for each mirror filter will generate a random total out-of-sample net profit (toNP) or final random equity. The average and standard deviation of the 5000-mirror filter's different random toNPs will allow us to calculate the chance probability of our above chosen filter's toNP. Thus, given the mirror filter's bootstrap random toNP average and standard deviation, we can calculate the probability of obtaining our chosen filter's toNP by pure chance alone. Figure 3 lists the 5000-mirror filter's bootstrap average for our 399 out-of-sample files of **-$3.6** with a bootstrap standard deviation of **$10.0**. (Side Note. The average is the average per out-of-sample period. So, the average for the random selection would be the random toNP/399 and the average for the filter would be the filter toNP/# of OOS periods traded or 12418/231=53.75). The probability of obtaining our filters average daily net profit **of 53.75** is **$4.94x10^{-9}$** which is **5.7** standard deviations from the bootstrap average. For our filter, in Row4 above, the expected number of cases that we could obtain by pure chance that would match or exceed **$53.75** is $[1-(1-\mathbf{4.94x10^{-9}})^{257039}]$ ~= **$257039*4.94x10^{-9} = 0.00127$** where **257039** 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.

Results

Figure 1 presents a graph of the equity curve generated by using the filter on the 399 days from 12/9/19 to 7/9/21. The equity curves are 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 equity curve with commissions and the green dots are the new highs in net equity. The grey line is the DIA Daily Closing prices superimposed on the Equity Chart.

Figure 2 presents a plot of the RMedV Strategy buy/sells and the RMedV Indicator on the DIA 5min bars for 6/18/2021 - 6/24/2021.

Table 1 below presents a table of the 399 in-sample and out-of-sample windows, the **Filter** selected in-sample strategy inputs and the daily out-of-sample profit/loss results using the filter described above.

Discussion of Strategy Performance

In Figure 3, Row4 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 days the OSNP equity curve failed to make a new high. **Blw** is **32** days for this filter. This means that 32 trading days was the longest time that the equity for this strategy failed to make a new equity high. **%Wtr** is the percentage of all OOS trades that were wins or positive. For this filter, the **%Wtr=55%**. **%P** is the % winning oos days, **%P=61%**. The average oos winning trade to the average oos losing trade ratio(**oW|oL**) was **1.37**. **wpr=9** is the maximum number of consecutive winning oos periods(days) in a row and **lpr=3** is the maximum number of consecutive losing oos periods(days) in a row. The Largest losing trade in the whole period was ($722) and the largest losing day was ($889). The maximum drawdown during this period was ($1021).

In Figure 1, which presents a graph of the equity curve using the filter on the 399 trading days of out-of-sample data, notice how the equity curve follows the 2nd order polynomial trend line with an R^2 of 0.949. The R^2 only dropped to 0.945 for the net equity curve.

Using this filter, the strategy was able to generate $12418 net equity after commissions of $0 (many brokers today 8/1/21 don't charge commissions) and slippage of $4 trading 100 DIA ETF shares for 399 days. The period of time from 2/20/20 to 4/30/20 was a volatile down then up market, yet the RMedV strategy was able to adapt quite well.

In observing Table 1 we can see that this strategy and filter made trades from a low of no trades/day to a high of 7 trades/day with an average of 1.7 trades/day on the days it traded. For the no trade days, the strategy **input|filte**r in the in-sample section didn't satisfy the metric filter and no trades were made the next trading day. The **input|filter** traded 231 days out of the 399 days or about 58% of the time.

References

1. Rousseau, P.J., Leroy, A.M., (1987) "Robust Regression and Outlier Detection", New York, John Wiley & Sons.
2. Siegel, A.F. (1982), "Robust Regression using Repeated Medians." *Biometrika*. 69, pp242-244.
3. Efron, B., Tibshirani, R.J., (1993), "An Introduction to the Bootstrap", New York, Chapman & Hall/CRC.

Figure 1 Graph of RMedV Strategy Out-Of-Sample Equity Applying the Walk Forward Filter Each Day on the in-sample section on DIA 5min Bar Prices 12/9/2019 to 7/9/2020

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 DIA Daily Closing prices superimposed on the Equity Chart.

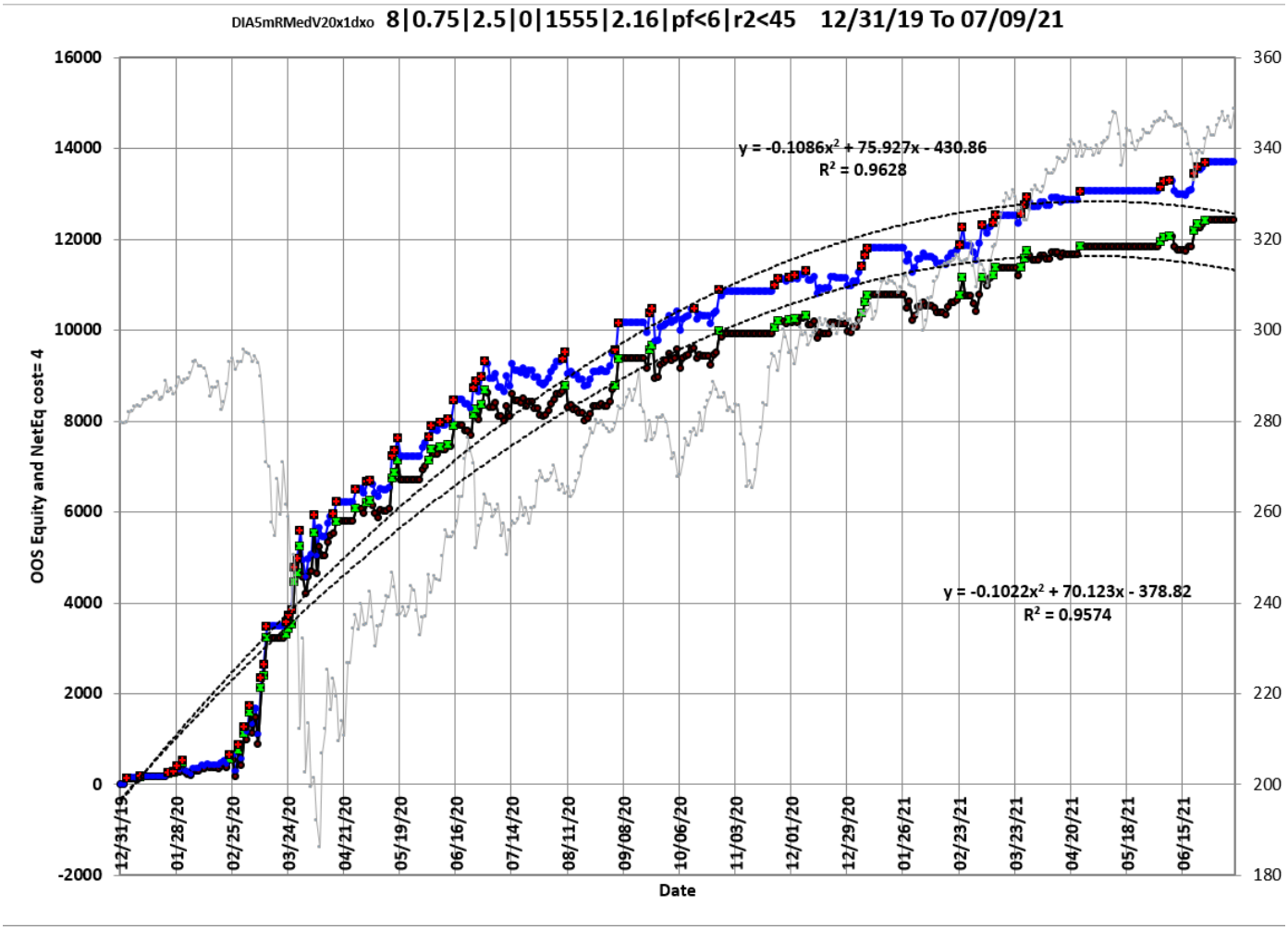

Figure 2 Walk Forward Out-Of-Sample Performance Summary for RMedV Strategy DIA 5-minute bar chart from 6/17/21 to 6/25/21

Figure 3 Partial output of the Walk Forward Strategy Inputs with Metric Filters (WFINP) DIA ETF 5 min bars Using The RMedV Strategy

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	DIA5mRMedV20x1dxo	s12/31/19	e07/09/21	#399	AnyTnp						lSnt2			a(3.6)	s10.0	f257039					c=$4						
2	N|vup|vdn|xop|xt|mult|<PF<LR<R2	toGP	tONP	aoGP	aoTr	ao#T	std	skew	kur	t	oW|oL	%Wtr	%P	LLtr	LLp	eqDD	wpr	lpr	#	V20	Dev^2	KTau	eqR2	Blw	BE	tkr|bl	Prob
3	8|0.75|2.5|0|1555|2.16|pf<2|r2<45	13720	12492	62	44.7	1.4	261	0.49	6.51	3.52	1.35	56	62	-722	-889	-1021	9	4	223	12	1524	95	86	47	135	450	1.27E-09
4	8|0.75|2.5|0|1555|2.16|pf<6|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
5	8|0.75|2.5|0|1555|2.16|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
6	8|0.75|2.5|0|1555|2.16|pf<3|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
7	8|0.75|2.5|0|1555|2.16|pf<4|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
8	8|0.75|2.5|0|1555|2.16|pf<5|r2<45	13686	12418	59	43.2	1.4	258	0.511	6.63	3.5	1.37	55	61	-722	-889	-1021	9	4	231	12	1505	95	86	32	137	650	4.94E-09
9	8|0.75|2.5|0|1555|2.16|pf<2|r2<40	13284	12112	63	45.3	1.4	264	0.514	6.5	3.47	1.37	56	62	-722	-889	-1021	9	4	210	10	1453	95	86	48	139	423	4.54E-10
10	8|0.75|2.5|0|1555|2.16|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
11	8|0.75|2.5|0|1555|2.16|pf<6|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
12	8|0.75|2.5|0|1555|2.16|pf<3|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
13	8|0.75|2.5|0|1555|2.16|pf<4|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
14	8|0.75|2.5|0|1555|2.16|pf<5|r2<40	13147	11943	61	43.7	1.4	261	0.536	6.61	3.42	1.39	55	61	-722	-889	-1021	9	4	216	7	1475	94	86	48	143	401	1.98E-09
15	8|0.75|2.5|0|1555|2.16|pf<2|r2<50	12706	11422	54	39.6	1.4	260	0.457	6.53	3.18	1.3	55	61	-722	-889	-1021	9	4	236	11	1440	94	86	47	166	329	1.01E-07

The WFINP Filter Output Columns are defined as follows: OOS=out-of-sample

Row 1 DIA5RMedV20x1dxo is the PWFO output files abbreviation, First OOS Day End Date (12/09/19), Last OOS Day End Date (07/09/21), **Number of days**(#399) **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=$4).

The WFINP AVE File Output Cols are defined as follows

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

  Col A: ***The Strategy Input/Filter Names***
  Row4: **8|0.75|2.5|0|1555|2.16|pf<6|r2<45**: The strategy inputs **8|0.75|2.5|0|1555|2.16|** for all in-sample files that have **PF≤6 and R2 ≤45**.
  Col B: ***toGP*** Total out-of-sample(oos) gross profit for these 399 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 399 oos periods.
  Col D: ***aoGP*** Average oos gross profit for the # 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 # oos period profits and losses
  Col H: ***skew*** The Skew statistic of the # oos period profits and losses
  Col I: ***kur*** The kurtosis statistic of the # oos period profits and losses
  Col J: ***t*** The student t statistic for the # 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: ***v20 The*** straight-line trend of the oos equity curve for the last 20 bars.
  Col U: ***Dev^2*** A measure of equity curve smoothness. The square root of the average (equity curve minus a straight line)^2)

Col V: ***KTau*** 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 W: ***eqR2*** The correlation coefficient(R^2) of a straight line fit to the equity curve.
Col X: ***Blw*** The maximum number of oos periods the oos equity curve failed to make a new high.
Col Y: ***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 Z: ***tkr/bl*** =100*t*Ktau*eqR2/Blw/BE. This is measure of the best equity curve.

Col AA: ***Prob*** The probability that the filters oos toNP was due to pure chance. Row 1 lists the 5000-mirror filter's bootstrap average for our 399 out-of-sample files of **-$3.6** with a bootstrap standard deviation of **$10.0**. (Side Note. The average is the average per out-of-sample period. So, the average for the random selection would be the random toNP/399 and the average for the filter would be the filter toNP/# of OOS periods traded or 12418/231=53.75). The probability of obtaining our filters average daily net profit **of 53.75** is **$4.94x10^{-9}$** which is **5.7** standard deviations from the bootstrap average. For our filter, in Row4 above, the expected number of cases that we could obtain by pure chance that would match or exceed **$53.75** is $[1-(1-\mathbf{4.94x10^{-9}})^{257039}]$ ~= **$257039*4.94x10^{-9} = 0.00127$** where **257039** 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 the DIA 5-min RMedV Strategy

DIA-5 min bars 12/9/2019 - 7/9/2021.

Filter: **8|0.75|2.5|0|1555|2.16|pf<6|r2<45**: The strategy inputs **8|0.75|2.5|0|1555|2.16|** for all in-sample files that have **PF≤6 and R2 ≤45**.
are used to trade in the following out-of-sample sections.
IS-pf = In-sample pf
IS-r2 = in-sample equity r2
osnp = Daily out-of-sample gross profit in $
NOnp$4 = Daily out-of-sample net profit in $ = **osnp-ont*4**.
ont = The number of trades in the out-of-sample day
ownp = winning profits in the out-of-sample day.
ownt = number of winning trades in the out-of-sample day
ollt = The largest losing trade in the out-of-sample day in $.
odd = The drawdown in the out-of-sample day in $.
EQ=Equity = Running Sum of daily out-of-sample gross profits $
NetEq=Net Equity = running sum of the daily out-of-sample net profits in $
Note1: Blank rows indicate that no out-of-sample trades were made that day
Note2: if IS nT<2 then no trades were made in out-of-sample section

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	0.34	-55	0	0	0	0	0	0	0	0	0
01/01/20	0.51	-61	0	0	0	0	0	0	0	0	0
01/02/20	0.53	-75	135	131	1	135	1	0	0	135	131
01/03/20	0.98	-40	0	0	0	0	0	0	0	135	131
01/06/20	0.79	-27	0	0	0	0	0	0	0	135	131
01/07/20	0.79	-27	0	0	0	0	0	0	0	135	131
01/08/20	1.02	-28	(23)	(27)	1	0	0	-23	-23	112	104
01/09/20	0.93	-13	70	66	1	70	1	0	0	182	170
01/10/20	0.81	27	0	0	0	0	0	0	0	182	170
01/13/20	1.48	64	0	0	0	0	0	0	0	182	170
01/14/20	2.96	70	0	0	0	0	0	0	0	182	170
01/15/20	1.49	49	0	0	0	0	0	0	0	182	170
01/16/20	1.67	48	0	0	0	0	0	0	0	182	170
01/17/20	2.31	64	0	0	0	0	0	0	0	182	170
01/20/20	2.31	64	0	0	0	0	0	0	0	182	170
01/21/20	2.29	57	0	0	0	0	0	0	0	182	170
01/22/20	2.29	57	0	0	0	0	0	0	0	182	170
01/23/20	1.37	39	77	73	1	77	1	0	0	259	243
01/24/20	1.7	49	0	0	0	0	0	0	0	259	243
01/27/20	0.93	-5	27	23	1	27	1	0	0	286	266
01/28/20	0.99	-19	125	121	1	125	1	0	0	411	387
01/29/20	1.28	-14	(103)	(107)	1	0	0	-103	-103	308	280
01/30/20	1.03	-23	214	210	1	214	1	0	0	522	490
01/31/20	1.18	-5	(216)	(220)	1	0	0	-216	-216	306	270
02/03/20	0.84	-11	(46)	(50)	1	0	0	-46	-46	260	220
02/04/20	0.79	-21	(31)	(35)	1	0	0	-31	-31	229	185
02/05/20	0.76	-31	124	120	1	124	1	0	0	353	305
02/06/20	0.94	-31	(9)	(13)	1	0	0	-9	-9	344	292
02/07/20	0.84	-24	0	0	0	0	0	0	0	344	292
02/10/20	0.84	-24	79	75	1	79	1	0	0	423	367
02/11/20	0.94	-15	(32)	(36)	1	0	0	-32	-32	391	331
02/12/20	0.98	-11	61	57	1	61	1	0	0	452	388
02/13/20	1.03	-3	(23)	(27)	1	0	0	-23	-23	429	361

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
02/14/20	0.89	1	0	0	0	0	0	0	0	429	361
02/17/20	0.89	1	0	0	0	0	0	0	0	429	361
02/18/20	0.89	1	(16)	(20)	1	0	0	-16	-16	413	341
02/19/20	0.87	1	46	42	1	46	1	0	0	459	383
02/20/20	1.05	8	54	50	1	54	1	0	0	513	433
02/21/20	1.02	35	(65)	(69)	1	0	0	-65	-65	448	364
02/24/20	1.35	30	194	186	2	203	1	-9	-9	642	550
02/25/20	1.65	46	0	0	0	0	0	0	0	642	550
02/26/20	0.66	7	(358)	(370)	3	0	0	-274	-358	284	180
02/27/20	0.54	-17	585	573	3	585	3	0	0	869	753
02/29/20	0.8	-28	(311)	(327)	4	0	0	-141	-311	558	426
03/02/20	0.75	-33	698	686	3	836	2	-138	-138	1256	1112
03/03/20	1.23	-18	(111)	(131)	5	517	2	-321	-628	1145	981
03/04/20	1.13	-7	597	593	1	597	1	0	0	1742	1574
03/05/20	1.34	0	(428)	(436)	2	0	0	-400	-428	1314	1138
03/06/20	1.13	2	350	342	2	453	1	-103	-103	1664	1480
03/09/20	1.25	7	(566)	(590)	6	272	2	-299	-838	1098	890
03/10/20	1.01	9	1243	1231	3	1332	2	-89	-89	2341	2121
03/11/20	1.36	18	288	272	4	484	2	-103	-103	2629	2393
03/12/20	1.4	39	851	831	5	1073	4	-222	-222	3480	3224
03/13/20	1.6	57	0	0	0	0	0	0	0	3480	3224
03/16/20	1.5	68	0	0	0	0	0	0	0	3480	3224
03/17/20	1.45	77	0	0	0	0	0	0	0	3480	3224
03/18/20	1.55	82	0	0	0	0	0	0	0	3480	3224
03/19/20	1.25	84	0	0	0	0	0	0	0	3480	3224
03/20/20	1.1	65	0	0	0	0	0	0	0	3480	3224
03/23/20	0.96	33	87	67	5	408	3	-291	-291	3567	3291
03/24/20	0.95	15	151	131	5	652	2	-272	-501	3718	3422
03/25/20	1.02	6	116	100	4	808	1	-469	-612	3834	3522
03/26/20	1.07	2	942	938	1	942	1	0	0	4776	4460
03/27/20	1.1	0	197	185	3	218	2	-21	-21	4973	4645
03/30/20	1.15	0	608	604	1	608	1	0	0	5581	5249
03/31/20	1.14	-1	(659)	(679)	5	96	1	-325	-659	4922	4570
04/01/20	1.09	-4	(362)	(370)	2	0	0	-319	-362	4560	4200
04/02/20	1	-5	389	377	3	400	2	-11	-11	4949	4577
04/03/20	1.08	-8	110	102	2	110	2	0	0	5059	4679
04/06/20	1.05	-10	871	867	1	871	1	0	0	5930	5546
04/07/20	1.2	-23	(889)	(905)	4	23	1	-388	-912	5041	4641
04/08/20	0.99	-26	600	596	1	600	1	0	0	5641	5237
04/09/20	1.02	-27	(197)	(201)	1	0	0	-197	-197	5444	5036
04/10/20	0.92	-28	0	0	0	0	0	0	0	5444	5036
04/13/20	0.88	-31	300	292	2	300	2	0	0	5744	5328
04/14/20	0.89	-17	141	137	1	141	1	0	0	5885	5465
04/15/20	0.82	-4	63	55	2	63	2	0	0	5948	5520
04/16/20	1	19	273	269	1	273	1	0	0	6221	5789
04/17/20	1.25	65	0	0	0	0	0	0	0	6221	5789
04/20/20	1.78	83	0	0	0	0	0	0	0	6221	5789
04/21/20	1.62	79	0	0	0	0	0	0	0	6221	5789
04/22/20	1.46	68	0	0	0	0	0	0	0	6221	5789
04/23/20	1.58	57	0	0	0	0	0	0	0	6221	5789
04/24/20	1.24	52	0	0	0	0	0	0	0	6221	5789
04/27/20	1.22	45	280	276	1	280	1	0	0	6501	6065
04/28/20	1.12	53	0	0	0	0	0	0	0	6501	6065
04/29/20	1.26	48	0	0	0	0	0	0	0	6501	6065
04/30/20	1.5	38	(94)	(102)	2	8	1	-102	-102	6407	5963
05/01/20	1.29	14	248	244	1	248	1	0	0	6655	6207
05/04/20	1.35	4	44	36	2	181	1	-137	-137	6699	6243
05/05/20	1.02	7	(92)	(96)	1	0	0	-92	-92	6607	6147
05/06/20	1.45	0	(190)	(194)	1	0	0	-190	-190	6417	5953

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
05/07/20	1.03	0	(90)	(94)	1	0	0	-90	-90	6327	5859
05/08/20	1.09	-6	173	169	1	173	1	0	0	6500	6028
05/11/20	1.18	-6	(14)	(18)	1	0	0	-14	-14	6486	6010
05/12/20	1.02	-16	0	0	0	0	0	0	0	6486	6010
05/13/20	0.95	-17	50	46	1	50	1	0	0	6536	6056
05/14/20	0.94	-16	698	690	2	698	2	0	0	7234	6746
05/15/20	1.15	0	122	118	1	122	1	0	0	7356	6864
05/18/20	1.12	11	276	272	1	276	1	0	0	7632	7136
05/19/20	1.6	42	(423)	(431)	2	0	0	-309	-423	7209	6705
05/20/20	1.67	53	0	0	0	0	0	0	0	7209	6705
05/21/20	1.53	56	0	0	0	0	0	0	0	7209	6705
05/22/20	1.49	53	0	0	0	0	0	0	0	7209	6705
05/25/20	1.39	52	0	0	0	0	0	0	0	7209	6705
05/26/20	1.21	58	0	0	0	0	0	0	0	7209	6705
05/27/20	1.48	53	0	0	0	0	0	0	0	7209	6705
05/28/20	1.53	54	0	0	0	0	0	0	0	7209	6705
05/29/20	1.36	43	213	209	1	213	1	0	0	7422	6914
06/01/20	1.33	43	83	79	1	83	1	0	0	7505	6993
06/02/20	1.4	41	148	144	1	148	1	0	0	7653	7137
06/03/20	1.62	41	235	231	1	235	1	0	0	7888	7368
06/04/20	2.16	41	(92)	(96)	1	0	0	-92	-92	7796	7272
06/05/20	2.16	37	(7)	(11)	1	0	0	-7	-7	7789	7261
06/08/20	1.97	32	178	174	1	178	1	0	0	7967	7435
06/09/20	2.17	29	(54)	(62)	2	0	0	-39	-54	7913	7373
06/10/20	2.06	38	(6)	(10)	1	0	0	-6	-6	7907	7363
06/11/20	2.01	33	130	122	2	553	1	-423	-423	8037	7485
06/12/20	1.34	37	(34)	(46)	3	208	2	-242	-242	8003	7439
06/15/20	1.2	40	462	454	2	581	1	-119	-119	8465	7893
06/16/20	1.29	58	0	0	0	0	0	0	0	8465	7893
06/17/20	1.21	61	0	0	0	0	0	0	0	8465	7893
06/18/20	1.1	50	0	0	0	0	0	0	0	8465	7893
06/19/20	1.19	35	(93)	(101)	2	0	0	-64	-93	8372	7792
06/22/20	1.13	19	(10)	(18)	2	164	1	-174	-174	8362	7774
06/23/20	1.12	7	(90)	(94)	1	0	0	-90	-90	8272	7680
06/24/20	1.1	1	467	459	2	467	2	0	0	8739	8139
06/25/20	1.21	1	124	116	2	325	1	-201	-201	8863	8255
06/26/20	1.39	0	(232)	(236)	1	0	0	-232	-232	8631	8019
06/29/20	1.17	-1	352	348	1	352	1	0	0	8983	8367
06/30/20	1.28	-1	321	317	1	321	1	0	0	9304	8684
07/01/20	1.35	0	(56)	(60)	1	0	0	-56	-56	9248	8624
07/02/20	1.23	1	(319)	(323)	1	0	0	-319	-319	8929	8301
07/03/20	1.13	1	0	0	0	0	0	0	0	8929	8301
07/06/20	1.13	1	108	104	1	108	1	0	0	9037	8405
07/07/20	1.11	2	(292)	(296)	1	0	0	-292	-292	8745	8109
07/08/20	1.02	2	6	2	1	6	1	0	0	8751	8111
07/09/20	1.02	2	(99)	(107)	2	0	0	-91	-99	8652	8004
07/10/20	0.94	6	328	324	1	328	1	0	0	8980	8328
07/13/20	1.08	9	(222)	(226)	1	0	0	-222	-222	8758	8102
07/14/20	0.81	21	494	490	1	494	1	0	0	9252	8592
07/15/20	1.28	43	(135)	(139)	1	0	0	-135	-135	9117	8453
07/16/20	1.33	46	0	0	0	0	0	0	0	9117	8453
07/17/20	1.28	45	(51)	(55)	1	0	0	-51	-51	9066	8398
07/20/20	1.31	36	100	96	1	100	1	0	0	9166	8494
07/21/20	1.4	23	(158)	(162)	1	0	0	-158	-158	9008	8332
07/22/20	1.35	12	90	86	1	90	1	0	0	9098	8418
07/23/20	1.14	7	0	0	0	0	0	0	0	9098	8418
07/24/20	1.09	1	(140)	(144)	1	0	0	-140	-140	8958	8274
07/27/20	1.15	-1	(7)	(11)	1	0	0	-7	-7	8951	8263
07/28/20	0.92	-2	(122)	(126)	1	0	0	-122	-122	8829	8137

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
07/29/20	0.66	0	(43)	(47)	1	0	0	-43	-43	8786	8090
07/30/20	0.67	0	43	35	2	106	1	-63	-63	8829	8125
07/31/20	0.86	-3	113	109	1	113	1	0	0	8942	8234
08/03/20	0.94	-3	137	133	1	137	1	0	0	9079	8367
08/04/20	0.96	0	98	94	1	98	1	0	0	9177	8461
08/05/20	1.3	0	123	119	1	123	1	0	0	9300	8580
08/06/20	1.4	1	0	0	0	0	0	0	0	9300	8580
08/07/20	1.54	-3	58	54	1	58	1	0	0	9358	8634
08/10/20	1.28	0	146	142	1	146	1	0	0	9504	8776
08/11/20	1.8	1	(476)	(480)	1	0	0	-476	-476	9028	8296
08/12/20	0.75	5	49	45	1	49	1	0	0	9077	8341
08/13/20	0.88	10	(78)	(82)	1	0	0	-78	-78	8999	8259
08/14/20	0.9	11	0	0	0	0	0	0	0	8999	8259
08/17/20	0.94	13	(83)	(87)	1	0	0	-83	-83	8916	8172
08/18/20	0.79	13	0	0	0	0	0	0	0	8916	8172
08/19/20	0.91	15	(164)	(168)	1	0	0	-164	-164	8752	8004
08/20/20	0.71	8	44	40	1	44	1	0	0	8796	8044
08/21/20	0.74	2	106	102	1	106	1	0	0	8902	8146
08/24/20	0.95	1	187	183	1	187	1	0	0	9089	8329
08/25/20	1.13	1	0	0	0	0	0	0	0	9089	8329
08/26/20	1.29	0	0	0	0	0	0	0	0	9089	8329
08/27/20	1.35	-1	38	34	1	38	1	0	0	9127	8363
08/28/20	1.37	-15	(33)	(37)	1	0	0	-33	-33	9094	8326
08/31/20	1.18	-22	0	0	0	0	0	0	0	9094	8326
09/01/20	1.02	-27	102	98	1	102	1	0	0	9196	8424
09/02/20	1.02	-15	272	268	1	272	1	0	0	9468	8692
09/03/20	1.2	0	100	92	2	337	1	-237	-237	9568	8784
09/04/20	1.25	14	591	583	2	591	2	0	0	10159	9367
09/07/20	1.75	47	0	0	0	0	0	0	0	10159	9367
09/08/20	1.61	69	0	0	0	0	0	0	0	10159	9367
09/09/20	2.24	81	0	0	0	0	0	0	0	10159	9367
09/10/20	2.64	89	0	0	0	0	0	0	0	10159	9367
09/11/20	1.46	71	0	0	0	0	0	0	0	10159	9367
09/14/20	1.44	65	0	0	0	0	0	0	0	10159	9367
09/15/20	1.6	58	0	0	0	0	0	0	0	10159	9367
09/16/20	1.6	58	0	0	0	0	0	0	0	10159	9367
09/17/20	1.85	49	0	0	0	0	0	0	0	10159	9367
09/18/20	1.67	31	(208)	(212)	1	0	0	-208	-208	9951	9155
09/21/20	1.37	15	425	417	2	425	2	0	0	10376	9572
09/22/20	1.53	9	84	80	1	84	1	0	0	10460	9652
09/23/20	1.58	12	(722)	(726)	1	0	0	-722	-722	9738	8926
09/24/20	1.07	4	39	35	1	39	1	0	0	9777	8961
09/25/20	1.07	0	279	275	1	279	1	0	0	10056	9236
09/28/20	1.22	-4	36	32	1	36	1	0	0	10092	9268
09/29/20	1.23	-5	52	48	1	52	1	0	0	10144	9316
09/30/20	1.21	-16	156	152	1	156	1	0	0	10300	9468
10/01/20	1.16	-21	(125)	(129)	1	0	0	-125	-125	10175	9339
10/02/20	1.06	-28	34	30	1	34	1	0	0	10209	9369
10/05/20	0.79	-19	198	194	1	198	1	0	0	10407	9563
10/06/20	0.89	-12	(409)	(417)	2	35	1	-444	-444	9998	9146
10/07/20	0.8	-8	233	229	1	233	1	0	0	10231	9375
10/08/20	0.75	0	53	49	1	53	1	0	0	10284	9424
10/09/20	1.1	1	37	33	1	37	1	0	0	10321	9457
10/12/20	1.13	2	132	128	1	132	1	0	0	10453	9585
10/13/20	1.15	7	16	12	1	16	1	0	0	10469	9597
10/14/20	1.16	13	(225)	(229)	1	0	0	-225	-225	10244	9368
10/15/20	1.01	16	84	76	2	149	1	-65	-65	10328	9444
10/16/20	1.09	17	(19)	(23)	1	0	0	-19	-19	10309	9421
10/19/20	1.22	13	0	0	0	0	0	0	0	10309	9421

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
10/20/20	0.96	23	0	(4)	1	0	0	0	0	10309	9417
10/21/20	0.91	44	(171)	(175)	1	0	0	-171	-171	10138	9242
10/22/20	1.38	26	210	206	1	210	1	0	0	10348	9448
10/23/20	1.54	18	63	59	1	63	1	0	0	10411	9507
10/26/20	1.34	17	469	461	2	469	2	0	0	10880	9968
10/27/20	1.75	34	(127)	(131)	1	0	0	-127	-127	10753	9837
10/28/20	1.52	39	86	78	2	279	1	-193	-193	10839	9915
10/29/20	1.39	56	0	0	0	0	0	0	0	10839	9915
10/30/20	1.53	62	0	0	0	0	0	0	0	10839	9915
11/02/20	1.69	70	0	0	0	0	0	0	0	10839	9915
11/03/20	1.46	79	0	0	0	0	0	0	0	10839	9915
11/04/20	2.45	76	0	0	0	0	0	0	0	10839	9915
11/05/20	2.47	77	0	0	0	0	0	0	0	10839	9915
11/06/20	2.57	79	0	0	0	0	0	0	0	10839	9915
11/09/20	2.57	82	0	0	0	0	0	0	0	10839	9915
11/10/20	1.98	86	0	0	0	0	0	0	0	10839	9915
11/11/20	1.96	90	0	0	0	0	0	0	0	10839	9915
11/12/20	2.26	90	0	0	0	0	0	0	0	10839	9915
11/13/20	1.77	84	0	0	0	0	0	0	0	10839	9915
11/16/20	1.94	81	0	0	0	0	0	0	0	10839	9915
11/17/20	1.98	80	0	0	0	0	0	0	0	10839	9915
11/18/20	2.05	76	0	0	0	0	0	0	0	10839	9915
11/19/20	1.72	65	0	0	0	0	0	0	0	10839	9915
11/20/20	1.64	55	0	0	0	0	0	0	0	10839	9915
11/23/20	1.54	43	146	142	1	146	1	0	0	10985	10057
11/24/20	1.34	32	139	135	1	139	1	0	0	11124	10192
11/25/20	1.55	26	0	0	0	0	0	0	0	11124	10192
11/26/20	1.56	15	0	0	0	0	0	0	0	11124	10192
11/27/20	1.57	1	(53)	(57)	1	0	0	-53	-53	11071	10135
11/30/20	1.3	-6	88	80	2	88	2	0	0	11159	10215
12/01/20	1.46	-19	(41)	(45)	1	0	0	-41	-41	11118	10170
12/02/20	1.08	-24	95	91	1	95	1	0	0	11213	10261
12/03/20	0.95	-13	(94)	(98)	1	0	0	-94	-94	11119	10163
12/04/20	0.76	-5	93	89	1	93	1	0	0	11212	10252
12/07/20	0.8	1	0	0	0	0	0	0	0	11212	10252
12/08/20	0.98	4	81	77	1	81	1	0	0	11293	10329
12/09/20	1.06	19	(209)	(213)	1	0	0	-209	-209	11084	10116
12/10/20	0.93	25	7	3	1	7	1	0	0	11091	10119
12/11/20	1.23	16	69	65	1	69	1	0	0	11160	10184
12/14/20	1.1	18	(363)	(367)	1	0	0	-363	-363	10797	9817
12/15/20	0.74	5	125	121	1	125	1	0	0	10922	9938
12/16/20	0.74	7	(14)	(18)	1	0	0	-14	-14	10908	9920
12/17/20	1.11	0	7	3	1	7	1	0	0	10915	9923
12/18/20	1.02	-5	0	0	0	0	0	0	0	10915	9923
12/21/20	1.1	-21	253	249	1	253	1	0	0	11168	10172
12/22/20	1.24	-22	0	0	0	0	0	0	0	11168	10172
12/23/20	1.06	-23	(18)	(22)	1	0	0	-18	-18	11150	10150
12/24/20	1.03	-15	0	0	0	0	0	0	0	11150	10150
12/25/20	1.03	-15	0	0	0	0	0	0	0	11150	10150
12/28/20	1.18	-19	2	(2)	1	2	1	0	0	11152	10148
12/29/20	0.99	-11	(180)	(184)	1	0	0	-180	-180	10972	9964
12/30/20	0.83	-15	(9)	(13)	1	0	0	-9	-9	10963	9951
12/31/20	0.72	-13	111	107	1	111	1	0	0	11074	10058
01/01/21	0.94	-9	0	0	0	0	0	0	0	11074	10058
01/04/21	0.83	-4	185	181	1	185	1	0	0	11259	10239
01/05/21	1.06	0	138	134	1	138	1	0	0	11397	10373
01/06/21	1.13	19	247	243	1	247	1	0	0	11644	10616
01/07/21	1.96	39	154	150	1	154	1	0	0	11798	10766
01/08/21	2.21	57	0	0	0	0	0	0	0	11798	10766

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
01/11/21	2.22	76	0	0	0	0	0	0	0	11798	10766
01/12/21	4.85	78	0	0	0	0	0	0	0	11798	10766
01/13/21	4.72	82	0	0	0	0	0	0	0	11798	10766
01/14/21	4.4	83	0	0	0	0	0	0	0	11798	10766
01/15/21	2.59	76	0	0	0	0	0	0	0	11798	10766
01/18/21	2.08	61	0	0	0	0	0	0	0	11798	10766
01/19/21	1.68	60	0	0	0	0	0	0	0	11798	10766
01/20/21	1.73	56	0	0	0	0	0	0	0	11798	10766
01/21/21	2.08	55	0	0	0	0	0	0	0	11798	10766
01/22/21	1.98	55	0	0	0	0	0	0	0	11798	10766
01/25/21	1.97	54	0	0	0	0	0	0	0	11798	10766
01/26/21	1.14	11	0	0	0	0	0	0	0	11798	10766
01/27/21	1.32	5	(285)	(293)	2	0	0	-186	-285	11513	10473
01/28/21	1.06	-5	156	152	1	156	1	0	0	11669	10625
01/29/21	1.09	-23	(401)	(409)	2	0	0	-273	-401	11268	10216
02/01/21	0.84	-38	96	92	1	96	1	0	0	11364	10308
02/02/21	0.79	-59	202	198	1	202	1	0	0	11566	10506
02/03/21	0.83	-73	0	0	0	0	0	0	0	11566	10506
02/04/21	0.69	-77	113	109	1	113	1	0	0	11679	10615
02/05/21	0.67	-77	(79)	(83)	1	0	0	-79	-79	11600	10532
02/08/21	0.6	-75	14	10	1	14	1	0	0	11614	10542
02/09/21	0.62	-73	0	0	0	0	0	0	0	11614	10542
02/10/21	0.57	-70	(62)	(66)	1	0	0	-62	-62	11552	10476
02/11/21	0.56	-67	(86)	(90)	1	0	0	-86	-86	11466	10386
02/12/21	0.6	-67	0	0	0	0	0	0	0	11466	10386
02/15/21	0.62	-69	0	0	0	0	0	0	0	11466	10386
02/16/21	0.62	-69	(37)	(41)	1	0	0	-37	-37	11429	10345
02/17/21	0.58	-68	154	150	1	154	1	0	0	11583	10495
02/18/21	0.56	-60	109	105	1	109	1	0	0	11692	10600
02/19/21	0.64	-46	0	0	0	0	0	0	0	11692	10600
02/22/21	0.62	-28	57	53	1	57	1	0	0	11749	10653
02/23/21	0.95	4	125	117	2	236	1	-111	-111	11874	10770
02/24/21	1.07	15	397	393	1	397	1	0	0	12271	11163
02/25/21	1.98	38	(408)	(412)	1	0	0	-408	-408	11863	10751
02/26/21	1.16	53	0	0	0	0	0	0	0	11863	10751
03/01/21	1.57	46	0	0	0	0	0	0	0	11863	10751
03/02/21	1.58	41	(160)	(164)	1	0	0	-160	-160	11703	10587
03/03/21	1.14	33	(177)	(181)	1	0	0	-177	-177	11526	10406
03/04/21	0.97	18	376	364	3	520	2	-144	-144	11902	10770
03/05/21	1.17	11	402	398	1	402	1	0	0	12304	11168
03/08/21	1.56	21	(48)	(52)	1	0	0	-48	-48	12256	11116
03/09/21	1.49	29	(139)	(143)	1	0	0	-139	-139	12117	10973
03/10/21	1.35	35	169	165	1	169	1	0	0	12286	11138
03/11/21	1.53	39	65	61	1	65	1	0	0	12351	11199
03/12/21	1.68	41	172	168	1	172	1	0	0	12523	11367
03/15/21	1.81	49	0	0	0	0	0	0	0	12523	11367
03/16/21	1.8	55	0	0	0	0	0	0	0	12523	11367
03/17/21	1.85	50	0	0	0	0	0	0	0	12523	11367
03/18/21	1.79	53	0	0	0	0	0	0	0	12523	11367
03/19/21	1.46	54	0	0	0	0	0	0	0	12523	11367
03/22/21	1.34	51	0	0	0	0	0	0	0	12523	11367
03/23/21	1.3	50	0	0	0	0	0	0	0	12523	11367
03/24/21	1.05	35	(167)	(171)	1	0	0	-167	-167	12356	11196
03/25/21	0.76	32	191	183	2	315	1	-124	-124	12547	11379
03/26/21	1.07	13	208	204	1	208	1	0	0	12755	11583
03/29/21	1.26	11	174	170	1	174	1	0	0	12929	11753
03/30/21	1.3	11	(122)	(126)	1	0	0	-122	-122	12807	11627
03/31/21	1.34	8	(86)	(90)	1	0	0	-86	-86	12721	11537
04/01/21	1.42	2	0	0	0	0	0	0	0	12721	11537

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
04/02/21	1.18	-15	0	0	0	0	0	0	0	12721	11537
04/05/21	0.89	-14	91	87	1	91	1	0	0	12812	11624
04/06/21	0.99	-12	0	0	0	0	0	0	0	12812	11624
04/07/21	1.11	-18	(66)	(70)	1	0	0	-66	-66	12746	11554
04/08/21	0.91	-17	0	0	0	0	0	0	0	12746	11554
04/09/21	0.86	-15	158	154	1	158	1	0	0	12904	11708
04/12/21	0.85	-4	0	0	0	0	0	0	0	12904	11708
04/13/21	0.86	0	0	0	0	0	0	0	0	12904	11708
04/14/21	0.86	0	(90)	(94)	1	0	0	-90	-90	12814	11614
04/15/21	0.74	6	69	65	1	69	1	0	0	12883	11679
04/16/21	0.94	24	(25)	(29)	1	0	0	-25	-25	12858	11650
04/19/21	1.04	57	0	0	0	0	0	0	0	12858	11650
04/20/21	1.04	57	0	0	0	0	0	0	0	12858	11650
04/21/21	1.49	55	0	0	0	0	0	0	0	12858	11650
04/22/21	2.38	53	0	0	0	0	0	0	0	12858	11650
04/23/21	2.25	43	195	191	1	195	1	0	0	13053	11841
04/26/21	2.22	52	0	0	0	0	0	0	0	13053	11841
04/27/21	1.79	72	0	0	0	0	0	0	0	13053	11841
04/28/21	2.57	79	0	0	0	0	0	0	0	13053	11841
04/29/21	3.72	75	0	0	0	0	0	0	0	13053	11841
04/30/21	4.21	81	0	0	0	0	0	0	0	13053	11841
05/03/21	4.21	81	0	0	0	0	0	0	0	13053	11841
05/04/21	3.72	88	0	0	0	0	0	0	0	13053	11841
05/05/21	4.72	91	0	0	0	0	0	0	0	13053	11841
05/06/21	7.75	92	0	0	0	0	0	0	0	13053	11841
05/07/21	8.7	94	0	0	0	0	0	0	0	13053	11841
05/10/21	7.47	97	0	0	0	0	0	0	0	13053	11841
05/11/21	2.86	93	0	0	0	0	0	0	0	13053	11841
05/12/21	2.72	90	0	0	0	0	0	0	0	13053	11841
05/13/21	3.5	88	0	0	0	0	0	0	0	13053	11841
05/14/21	4.08	87	0	0	0	0	0	0	0	13053	11841
05/17/21	4.99	88	0	0	0	0	0	0	0	13053	11841
05/18/21	5.18	90	0	0	0	0	0	0	0	13053	11841
05/19/21	5.18	90	0	0	0	0	0	0	0	13053	11841
05/20/21	5.81	91	0	0	0	0	0	0	0	13053	11841
05/21/21	6.88	88	0	0	0	0	0	0	0	13053	11841
05/24/21	4.11	89	0	0	0	0	0	0	0	13053	11841
05/25/21	4.28	91	0	0	0	0	0	0	0	13053	11841
05/26/21	3.09	90	0	0	0	0	0	0	0	13053	11841
05/27/21	2.75	88	0	0	0	0	0	0	0	13053	11841
05/28/21	2.22	81	0	0	0	0	0	0	0	13053	11841
05/31/21	2.19	76	0	0	0	0	0	0	0	13053	11841
06/01/21	2.19	72	0	0	0	0	0	0	0	13053	11841
06/02/21	1.72	59	0	0	0	0	0	0	0	13053	11841
06/03/21	1.51	44	99	95	1	99	1	0	0	13152	11936
06/04/21	1.48	33	110	106	1	110	1	0	0	13262	12042
06/07/21	1.6	32	0	0	0	0	0	0	0	13262	12042
06/08/21	2.06	22	22	18	1	22	1	0	0	13284	12060
06/09/21	2.09	2	0	0	0	0	0	0	0	13284	12060
06/10/21	2.09	2	(222)	(226)	1	0	0	-222	-222	13062	11834
06/11/21	1.28	-3	(77)	(81)	1	0	0	-77	-77	12985	11753
06/14/21	1.01	-22	0	0	0	0	0	0	0	12985	11753
06/15/21	0.96	-48	0	0	0	0	0	0	0	12985	11753
06/16/21	0.96	-48	(21)	(25)	1	0	0	-21	-21	12964	11728
06/17/21	0.54	-77	106	102	1	106	1	0	0	13070	11830
06/18/21	0.42	-71	15	7	2	42	1	-27	-27	13085	11837
06/21/21	0.52	-58	362	358	1	362	1	0	0	13447	12195
06/22/21	0.86	-12	141	137	1	141	1	0	0	13588	12332
06/23/21	1.25	2	(71)	(75)	1	0	0	-71	-71	13517	12257

Date	pf	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
06/24/21	1.25	16	62	58	1	62	1	0	0	13579	12315
06/25/21	1.59	32	107	103	1	107	1	0	0	13686	12418
06/28/21	1.79	49	0	0	0	0	0	0	0	13686	12418
06/29/21	1.79	49	0	0	0	0	0	0	0	13686	12418
06/30/21	1.82	57	0	0	0	0	0	0	0	13686	12418
07/01/21	2.41	62	0	0	0	0	0	0	0	13686	12418
07/02/21	2.27	70	0	0	0	0	0	0	0	13686	12418
07/05/21	2.05	78	0	0	0	0	0	0	0	13686	12418
07/06/21	2.05	78	0	0	0	0	0	0	0	13686	12418
07/07/21	2.2	91	0	0	0	0	0	0	0	13686	12418
07/08/21	2.24	92	0	0	0	0	0	0	0	13686	12418
07/09/21	3.04	89	0	0	0	0	0	0	0	13686	12418

Repeated Median Velocity Normalization Multiplier

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

Below is a table, generated by the #iRMedVtMULTSTD indicator of the standard deviation(SD) of the 108333 calculated RMedV values for different **N**. We used 5 min bars of the CL from 3/8/2014 to 2/12/2016 to generate this table.

@CL 5 min bars Date Range 1140803 to 1160212
Total Number of Bars=108333 Sqrt(n) Norm=0
Trading Times Constraint Start Time=800 EndTime=1430
RMedVx Multiplier to Scale RMedVx N Range to One Std

4 Std=0.0734077 1/std=13.6226
6 Std=0.056242 1/std=17.7803
8 Std=0.0470003 1/std=21.2765
10 Std=0.0414414 1/std=24.1304
12 Std=0.0375377 1/std=26.6399
14 Std=0.0346289 1/std=28.8776
16 Std=0.0322738 1/std=30.9849
18 Std=0.0302399 1/std=33.0689
20 Std=0.0285976 1/std=34.968
22 Std=0.0272164 1/std=36.7426
24 Std=0.0259991 1/std=38.4629
26 Std=0.0249334 1/std=40.1069
28 Std=0.0239323 1/std=41.7845
30 Std=0.0230171 1/std=43.446
1/Std Mult Average=30.8494

As one can see the RMedV Standard Deviation for N=4 is over 3 times the SD for N=30. This makes it difficult to find a range for vup and vdn that satisfy all N. We would like to find a multiplier of the RMedV that normalizes all the RMedV standard deviations for any given N to the same SDs.

Fortunately, the SDs for the different Ns for The RMedV are proportional to **√N**. So, if we multiply the RMedV by the √N, the RMedV for different N should have the same SDs and ranges. Below are the results for multiplying the RMedV by √N and computing it's standard deviation.

@CL 5 min bars Date Range 1140803 to 1160212
Total Number of Bars=108333 Sqrt(n) Norm=1
Trading Times Constraint Start Time=800 EndTime=1430
RMedVx Multiplier to Scale RMedVx N Range to One Std
4 Std=0.146815 1/std=6.81128
6 Std=0.137764 1/std=7.25878
8 Std=0.132937 1/std=7.52237
10 Std=0.131049 1/std=7.63072
12 Std=0.130034 1/std=7.69028
14 Std=0.12957 1/std=7.71786

16 Std=0.129095 1/std=7.74622
18 Std=0.128297 1/std=7.79441
20 Std=0.127892 1/std=7.81907
22 Std=0.127656 1/std=7.83354
24 Std=0.127369 1/std=7.8512
26 Std=0.127136 1/std=7.86561
28 Std=0.126638 1/std=7.89652
30 Std=0.12607 1/std=7.93212
1/Std Mult Average=7.66928

As we can see the SDs are now very close. If we multiply all RMedVs by 7.669*√N then the SDs of the velocities for all will be normalized to 1. For this case 7.669 would be the multiplier ***xmult***, in the strategy and indicator. This allows us to do an optimization search for ranges of vup and vdn from 0.2 to 3.4 standard deviations for all N.

Please note that different futures and different time bars give different multipliers.

