Trading QQQ ETF 5min Bars Using the nth Order Fixed Memory Polynomial Velocity Algorithm
Walk Forward in-sample 10 Trading weekdays and out-of-sample 1 Trading weekday.
1/3/2023 to 10/25/2024 using The Walk Forward Input Explorer
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In previous working papers https://meyersanalytics.com/papers we showed how the application of a price curve generated by the **Nth Order Fixed Memory Polynomial Velocity** could be used to develop a strategy to buy and sell futures and stocks intraday. The reason behind this type of strategy was to only trade when the price trend velocity was above a certain threshold. Many times, prices meander around without any notable trend, and this is considered noise. During these times we do not wish to trade because of the cost of whipsaw losses that would occur from this type of price action. When a price trend finally starts, the velocity of that price trend moves above a minimum threshold noise value. Thus, the velocity strategy would only issue a trade when certain velocity thresholds above "noise" levels are crossed.

The velocity strategy that we will use here to trade the Invesco QQQ Trust Series ETF (**QQQ**) is called the nth Order Polynomial Velocity Strategy. The nth Order Adaptive Polynomial Velocity Strategy has several unknown inputs that we must determine before we can use this strategy to trade. These unknown inputs are the polynomial order or degree, the optimum number of lookback prices we need to determine the coefficients of the polynomial and finally the velocity thresholds. Here we will use Walk Forward Optimization and out-of-sample testing to determine the "best" polynomial inputs as well as how these inputs change over time. We will use the nth Order Fixed Memory Polynomial Velocity Strategy to trade the QQQ ETF on an intraday basis using 5-min bar price data from 1/3/2023 to 10/25/2024.

The n^{th} Order Fixed Memory Velocity Strategy Defined
The least squares forecast n^{th} order fixed memory polynomial velocity is constructed by solving for the coefficients $\beta_0, \beta_1, \beta_2, \beta_3 \ldots \beta_{n\ for}$ the discrete orthogonal Legendre polynomials each day using the last **N bars** of closing prices and the equation for β_j shown in the **"Math"** appendix at the end of this working paper. Then n^{th} Order Fixed Memory Polynomial **Velocity(T+1)** is constructed from the equation shown in the "Math" appendix.

Due to polynomial mathematics, the Velocity of the 2^{nd}, 3^{rd} and 4^{th} order degree polynomial curve changes faster than its corresponding first order degree polynomial velocity. Whether higher order polynomial velocities are an advantage or not, will be determined by the computer when we use a walk forward optimization technique described below.

At each bar we calculate the nth order degree (1^{st} through 3^{rd}) fixed memory polynomial velocity from the formulas in the "Math" appendix. As will be shown below, walk forward optimization will determine the **degree** for the nth order polynomial velocity, the number of lookback prices, **N**, needed to compute the polynomial coefficients and the threshold amounts **vup** and **vdn**. When the nth order degree 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 or equal than the threshold amount ***vup and Velocity [1] is less than vup*** than buy at the market.

Sell Rule:
IF Velocity is less than or equal than the

threshold amount ***-vdn and Velocity [1] is greater than -vdn*** than sell at the market.

Where Velocity [1] is the velocity on the previous bar.

Intraday Bars Exit Rule:

Close the position at ***1555 EST*** (No trades will be carried out overnight).

Testing The Polynomial Velocity Strategy Using Walk Forward Optimization

There will be four strategy parameters to determine:

1. **degree**, degree=1 for straight line velocity, degree=2 for 2nd order velocity, etc.
2. ***N***, is the number of lookback bars of prices to calculate the **velocity.**
3. ***vup***, the threshold amount that velocity must be greater than to issue a buy signal.
4. ***vdn***, the threshold amount that velocity must be less than to issue a sell signal.

As mentioned, to test this Strategy we will use five-minute bar prices of the Invesco QQQ Trust Series ETF traded on the NYSE and known by the symbol QQQ for the 458 trading days from January 3, 2023, to October 25, 2024. However, The Walk Forward Input Explorer will only analyses data from 1/3/2023 to 4/28/2024. 4/30/24 to 10/25/24 will be withheld to see how the filter applied to the 1/3/2023-4/28/2024 data did in the next 126 weekdays days, approximately 6 months of trading days, of 4/30/24 to 10/25/24. Why did we do this? In the WFINP output there is a parameter named BE, Break even(BE) 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. Since most of the BEs in the WFINP are greater than 90, we wanted to see if 98% of returns with a BE< 126 would be positive.

We will test the FixmVn strategy with the above QQQ ETF 5 min bars on a ***walk forward basis***, where the in-sample (***IS***) will be 10 trading weekdays, and the out-of-sample (***OOS***) will be the next trading weekday following as will be described below.

What Is 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 the 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 the 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 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. 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 FixmVn Strategy Parameters Using Walk Forward Optimization
There are four strategy parameters to find*, pw, N, vup, vdn.*

For the test data we will run the TS or MC optimization engine on **QQQ** 5 min price bars from 01/03/2023 to 10/25/24 with the following optimization ranges for the FixmVn strategy inputs. This will create **458, 10 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 when the OOS falls on an exchange holiday or partial days are eliminated. Holidays that fall on a weekday create a 9-day ***IS***. All other ***IS*** periods consist of 10 trading weekdays. The optimization ranges are:

1. **pw=degree from 1 to 3**
2. **N from 5 to 20 in steps of 1.**

3. **vup from 0.25 to 3.5 steps of 0.25**
4. **vdn from 0.25 to 3.5 in steps of 0.25**
5. **Mult = 13.8, iNorm=1 (See Appendix 3, the Normalization Multiplier)**

The above pw, n, vup, vdn will produce 9408 different input combinations or cases of the strategy input parameters for each of the 458 in-sample/out-of-sample files for the 20 months of 5 min bar QQQ 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 http://meyersanalytics.com/Walk-Forward-Optimization.html for a listing of these performance metrics).The question we are attempting to answer statistically, is which performance metric or combination of performance metrics (which we will call a ***filter***) applied to a given set of strategy inputs in the ***in-sample*** section will produce statistically valid profits in the sum of all out-of-sample sections. In other words, we wish to find the best set of strategy inputs ***with a metric filter applied*** in each **in-sample** section that 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 for 10 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 Profit Factor (**PF≤ x**) and/or Losers in a row (**lr ≤ y)**, and/or equity curve straight line correlation coefficient (**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 **metric-filter** combinations of **PF≤2 to 5 step 1, LR≤3,5 step 2 and R2≤50 to 80 step 10.** We will also look at the strategy inputs with no metric-filter. With 9408 different strategy input combinations this will give us 705599 **strategy input|metric-filter** combinations. Each one of these 705599-strategy **input|metric-filter** combinations will be applied to each in-sample section and their out-of-sample performance will be tabulated for 332 PWFO files for 01/03/23-04/29/24. The 126 PWFO files between 04/30/24-10/25/24 are not included because they will be used to see how the strategy input/filter does for BE periods < 127 as discussed above.

Below is a snippet of the output from a run of all 705599 combinations sorted by **tkr/be = t*Ktau*eqR2/BE 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 FixmVn that was run on 100 shares of QQQ ETF 5-minute bars 332 days from 01/03/20232 to 4/29/2024. The in-sample (IS) period is 10 trading weekdays, and the out-of-sample (OOS) period is 1 trading weekday. This strategy was traded between 9:30am to 1555pm Exchange Time (EST). The next section on each input line is how the ***Filter*** did on the next 126 days from 4/30/2024 to 10/25/2024. This section of data was not involved in the Walk Forward Input Explorer filter selection from 1/3/2023 to 4/29/2024.

From this run, we chose the filter on row 8 of the Figure below. That is,

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1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5|r2<60. This is constructed as follows.
For the strategy inputs **1|5|0.5|1.5|0|1555|13.8** only those in-sample sections that have a **pf≤2 and lr≤5 and r2≤60** are used to trade in the following out-of-sample next trading day section. If the in-sample pf>2 or lr > 5 or r2>60, then the next trading day out-of-sample section ***is not*** traded. We chose this row because it had the highest **t** and lowest **BE**,

												lSnt2			a(4.2)	s12.7						c=$4				
1	QQQ5mFixmV10x1dxoa	s01/03/23	e04/29/24	#332	AnyTnp	#126																				
2	pw|N|vup|vdn|xop|xt|mult|<PF<LR<R2	toGP	tONP	aoGP	aoTr	ao#T	#	%P	oW|oL	%Wtr	std	skew	kur	t	LLtr	LLp	eqDD	wpr	lpr	V20	KTau	eqR2	Blw	BE	tkr|be
3	2|13|1|3.5|0|1555|13.8|lr<5r2<50	14383	13635	84	76.9	1.1	172	62	1.35	61	258	0.129	2.7	4.25	-587	-587	-934	10	4	37	95	98	18	77	2844
4	2|13|1|3.5|0|1555|13.8|r2<50	14383	13635	84	76.9	1.1	172	62	1.35	61	258	0.129	2.7	4.25	-587	-587	-934	10	4	37	95	98	18	77	2844
5	2|13|1|3.5|0|1555|13.8|pf<5|lr<5r2<50	14035	13295	83	75.9	1.1	170	62	1.34	61	254	0.108	2.74	4.23	-587	-587	-934	10	4	37	95	98	18	78	2804
6	2|13|1|3.5|0|1555|13.8|pf<5|r2<50	14035	13295	83	75.9	1.1	170	62	1.34	61	254	0.108	2.74	4.23	-587	-587	-934	10	4	37	95	98	18	78	2804
7	1|5|0.5|1.75|0|1555|13.8|pf<2|lr<5r2<50	15244	14028	80	50.1	1.6	190	59	1.63	53	264	0.186	4.53	4.18	-669	-858	-1202	6	5	40	96	99	18	80	2771
8	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<60	15389	14049	81	45.9	1.8	190	61	1.67	52	244	0.184	3.11	4.58	-397	-488	-1377	7	5	35	96	99	27	66	2435
9	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<70	15317	13873	76	42.4	1.8	202	59	1.62	52	243	0.171	3.13	4.44	-397	-488	-1377	7	5	36	96	99	27	71	2213
10	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<60	15635	14091	73	40.5	1.8	214	60	1.57	52	243	0.166	3.18	4.4	-410	-505	-1377	8	5	26	96	99	27	72	2137
11	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<50	14658	13290	77	42.9	1.8	191	62	1.6	52	243	0.181	3.26	4.36	-410	-505	-1377	10	5	15	95	99	27	73	2068
12	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<50	13944	12724	81	45.7	1.8	173	61	1.64	52	245	0.186	3.19	4.33	-397	-488	-1377	9	5	24	96	99	27	74	2033
13	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<50	14550	13178	76	42.4	1.8	192	61	1.6	52	243	0.191	3.26	4.32	-410	-505	-1377	10	5	15	95	99	27	75	2011
14	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<50	14550	13178	76	42.4	1.8	192	61	1.6	52	243	0.191	3.26	4.32	-410	-505	-1377	10	5	15	95	99	27	75	2011
15	1|5|0.5|1.5|0|1555|13.8|lr<5r2<50	14550	13178	76	42.4	1.8	192	61	1.6	52	243	0.191	3.26	4.32	-410	-505	-1377	10	5	15	95	99	27	75	2011
16	1|5|0.5|1.5|0|1555|13.8|lr<5r2<60	15250	13698	71	39.3	1.8	216	60	1.56	52	243	0.179	3.16	4.26	-410	-505	-1377	8	5	26	95	99	27	77	1943
17	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<60	15250	13698	71	39.3	1.8	216	60	1.56	52	243	0.179	3.16	4.26	-410	-505	-1377	8	5	26	95	99	27	77	1943
18	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<60	15250	13698	71	39.3	1.8	216	60	1.56	52	243	0.179	3.16	4.26	-410	-505	-1377	8	5	26	95	99	27	77	1943
19	2|13|1|3.25|0|1555|13.8|r2<50	14162	13418	84	76.1	1.1	169	61	1.39	60	261	0.161	2.67	4.18	-587	-587	-940	10	4	35	94	98	25	80	1933
20	2|13|1|3.25|0|1555|13.8|lr<5r2<50	14162	13418	84	76.1	1.1	169	61	1.39	60	261	0.161	2.67	4.18	-587	-587	-940	10	4	35	94	98	25	80	1933
21	2|13|1|3.25|0|1555|13.8|pf<5|r2<50	13814	13078	83	75.1	1.1	167	61	1.38	60	258	0.143	2.71	4.15	-587	-587	-940	10	4	35	94	98	25	81	1903
22	2|13|1|3.25|0|1555|13.8|pf<5|lr<5r2<50	13814	13078	83	75.1	1.1	167	61	1.38	60	258	0.143	2.71	4.15	-587	-587	-940	10	4	35	94	98	25	81	1903
23	1|5|0.5|1.75|0|1555|13.8|pf<2|r2<50	14359	13015	69	42.7	1.6	207	58	1.51	52	271	0.105	4.23	3.68	-669	-858	-1499	6	5	40	95	99	18	103	1868

1	QQQ5mFixmV10x1dxoa	s04/30/24	e10/25/24	#126			f705599	
2	pw|N|vup|vdn|xop|xt|mult|<PF<LR<R2	toGPx	toNPx	aoTRx	aoNTx	#x	tOnpNet	Prob
3	2|13|1|3.5|0|1555|13.8|lr<5r2<50	1726	1390	21	1.2	73	15025	2.53E-11
4	2|13|1|3.5|0|1555|13.8|r2<50	1726	1390	21	1.2	73	15025	2.53E-11
5	2|13|1|3.5|0|1555|13.8|pf<5|lr<5r2<50	1489	1157	18	1.2	72	14452	4.44E-11
6	2|13|1|3.5|0|1555|13.8|pf<5|r2<50	1489	1157	18	1.2	72	14452	4.44E-11
7	1|5|0.5|1.75|0|1555|13.8|pf<2|lr<5r2<50	1693	1289	17	2.2	45	15317	4.11E-10
8	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<60	4315	3815	35	2.5	50	17864	3.89E-10
9	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<70	3916	3360	28	2.5	55	17233	4.87E-09
10	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<60	4578	4058	35	2.5	53	18149	1.77E-08
11	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<50	3498	3014	29	2.5	48	16304	3.20E-09
12	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<50	3431	2955	29	2.6	46	15679	4.73E-10
13	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<50	3498	3014	29	2.5	48	16192	4.97E-09
14	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<50	3498	3014	29	2.5	48	16192	4.97E-09
15	1|5|0.5|1.5|0|1555|13.8|lr<5r2<50	3498	3014	29	2.5	48	16192	4.97E-09
16	1|5|0.5|1.5|0|1555|13.8|lr<5r2<60	4578	4058	35	2.5	53	17756	5.16E-08
17	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<60	4578	4058	35	2.5	53	17756	5.16E-08
18	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<60	4578	4058	35	2.5	53	17756	5.16E-08
19	2|13|1|3.25|0|1555|13.8|r2<50	1543	1187	17	1.2	73	14605	2.37E-11
20	2|13|1|3.25|0|1555|13.8|lr<5r2<50	1543	1187	17	1.2	73	14605	2.37E-11
21	2|13|1|3.25|0|1555|13.8|pf<5|r2<50	1306	954	15	1.2	72	14032	4.20E-11
22	2|13|1|3.25|0|1555|13.8|pf<5|lr<5r2<50	1306	954	15	1.2	72	14032	4.20E-11
23	1|5|0.5|1.75|0|1555|13.8|pf<2|r2<50	(909)	(1821)	(4)	2.7	85	11194	6.52E-08

This is the 2nd section from 4/30/2024 to 10/25/2024 which was not included in the Walk Forward Input Explorer(WFINP) run. This is how the filter found by the WFINP on the 1/3/2023-04/29/24 data performed on the next 126 trading days. As one can see, all the filters with BE<127 except #23 performed well on data that they had not been developed on.

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 332 out-of-sample files of **($4.2)** with a bootstrap standard deviation of **$12.7**. (Side Note. The average is the average per out-of-sample period. So, the average for the random selection would be the random toNP/332 and the average for the filter would be the filter toNP/# of OOS periods traded or 14049/190=73.9). The probability of obtaining our filters average daily net profit **of 73.9** is **$3.89x10^{-10}$** which is **6.15** standard deviations from the bootstrap average. For our filter, in row 8 above, the expected number of cases that we could obtain by pure chance that would match or exceed **$73,9** is $[1-(1-\mathbf{3.89x10^{-10}})^{705599}]$ ~ $\mathbf{705599*3.89x10^{-10}}$ = **0.000274** where **705599** 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 458 days from 1/3/23 to 10/25/24. Separated by a red line from the data from 126 trading days from 4/30/24 to 10/17/23 that were not included in the WFINP filter search. 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 QQQ Daily Closing prices superimposed on the Equity Chart.

Figure 2 presents a plot of the FixmVn Strategy buy/sells and the FixmVn Indicator on the QQQ 5min bars for 10/4/2023-10/17/2023.

Table 1 below presents a table of the 458 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. Plus, the 126 trading days from 4/30/24 to 10/27/23 that were not included in the WFINP filter that was run from 1/3/23 – 4/29/24.

Discussion of Strategy Performance

In Figure 3, Row 8 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 **27** days for this filter. This means that 27 trading days were the longest time that the equity for this strategy failed to make a new equity high. However, in the 126 day section 39 trading days was the largest Blw. **%Wtr** is the percentage of all OOS trades that were wins or positive. For this filter, the **%Wtr=52%**. **%P** is the % winning oos days, **%P=61%**. The average oos winning trade to the average oos losing trade ratio(**oW|oL**) was **1.67**. **wpr=7** is the maximum number of consecutive winning oos periods(days) in a row and **lpr=5** is the maximum number of consecutive losing oos periods(days) in a row. The Largest losing trade in the 1/3/23-4/29/24 period was ($397) and the largest losing day was ($488). The largest losing day in the 4/30/24-10/25/24 period was ($888) on 7/18/24. The average trade was $45.9 @ 1.8 average trades on days that it traded for the 1/3/23-4/29/24 period and average trade of $35 2@2.5 average trades on days that it traded for the 4/30/24-10/25/224 period.

In Figure 1, which presents a graph of the equity curve using the filter on the 332 trading days of out-of-sample data, notice how the equity curve follows the 2nd order polynomial trend line with an R^2 of 0.993. The R^2 only dropped to 0.991 for the net equity curve.

Using this filter, the strategy was able to generate $14049 net equity after commissions of $0 (many brokers today, don't charge commissions) and roundtrip slippage of $4 trading 100 QQQ ETF shares for 332 days. The filter

generated an extra $3815 net equity between 4/30/24 to 10/25/24 the data that was not included in the WFINP filter run for a total of $17864 net equity. This period from 1/18/22 to 10/27/23 was a volatile down then up market as can be seen from the QQQ close on the chart. Yet the FixmVn 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 1.8 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 190 days out of the 332 days or 57% of the time. For the 4/30/224-10/25/24 period the **input|filter** traded 50 days out of 126 or 40% of the time.

References

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

Figure 1 Graph of FixmVn Strategy Equity Applying the Walk Forward Filter Each Day on the in-sample section on QQQ 5min Bar Prices 01/03/2023 to 4/29/2024 Not Included in WFINP run 04/30/24-10/25/24

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 QQQ Daily Closing prices superimposed on the Equity Chart.

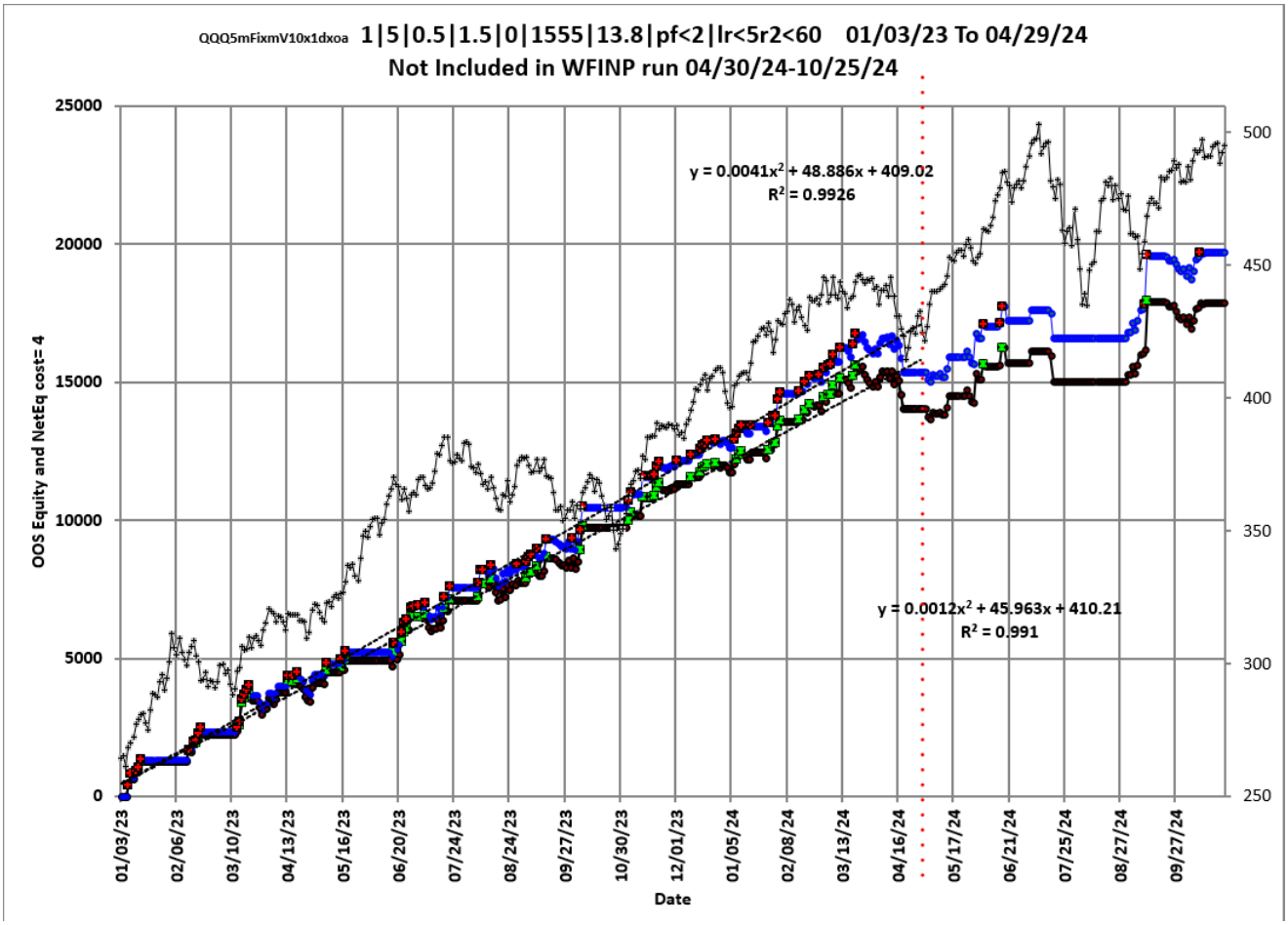

Figure 2 Walk Forward Out-Of-Sample Performance Summary for nth Order Fixed Memory Polynomial Velocity Strategy QQQ 5-minute bar chart from 10/2/24 to 10/15/24

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

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

1	QQQ5mFixmV10x1dxoa	s01/03/23	e04/29/24	#332	AnyTnp	#126					lSnt2			a(4.2)	s12.7					c=$4						
2	pw|N|vup|vdn|xop|xt|mult|<PF<LR<R2	toGP	tONP	aoGP	aoTr	ao#T	#	%P	oW|oL	%Wtr	std	skew	kur	t	LLtr	LLp	eqDD	wpr	lpr	V20	KTau	eqR2	Blw	BE	tkr|be	
3	2|13|1|3.5|0|1555|13.8|lr<5r2<50	14383	13635	84	76.9	1.1	172	62	1.35	61	258	0.129	2.7	4.25	-587	-587	-934	10	4	37	95	98	18	77	2844	
4	2|13|1|3.5|0|1555|13.8|r2<50	14383	13635	84	76.9	1.1	172	62	1.35	61	258	0.129	2.7	4.25	-587	-587	-934	10	4	37	95	98	18	77	2844	
5	2|13|1|3.5|0|1555|13.8|pf<5|lr<5r2<50	14035	13295	83	75.9	1.1	170	62	1.34	61	254	0.108	2.74	4.23	-587	-587	-934	10	4	37	95	98	18	78	2804	
6	2|13|1|3.5|0|1555|13.8|pf<5|r2<50	14035	13295	83	75.9	1.1	170	62	1.34	61	254	0.108	2.74	4.23	-587	-587	-934	10	4	37	95	98	18	78	2804	
7	1|5|0.5|1.75|0|1555|13.8|pf<2|lr<5r2<50	15244	14028	80	50.1	1.6	190	59	1.63	53	264	0.186	4.53	4.18	-669	-858	-1202	6	5	40	96	99	18	80	2771	
8	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<60	15389	14049	81	45.9	1.8	190	61	1.67	52	244	0.184	3.11	4.58	-397	-488	-1377	7	5	35	96	99	27	66	2435	
9	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<70	15317	13873	76	42.4	1.8	202	59	1.62	52	243	0.171	3.13	4.44	-397	-488	-1377	7	5	36	96	99	27	71	2213	
10	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<60	15635	14091	73	40.5	1.8	214	60	1.57	52	243	0.166	3.18	4.4	-410	-505	-1377	8	5	26	96	99	27	72	2137	
11	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<50	14658	13290	77	42.9	1.8	191	62	1.6	52	243	0.181	3.26	4.36	-410	-505	-1377	10	5	15	95	99	27	73	2068	
12	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<50	13944	12724	81	45.7	1.8	173	61	1.64	52	245	0.186	3.19	4.33	-397	-488	-1377	9	5	24	96	99	27	74	2033	
13	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<50	14550	13178	76	42.4	1.8	192	61	1.6	52	243	0.191	3.26	4.32	-410	-505	-1377	10	5	15	95	99	27	75	2011	
14	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<50	14550	13178	76	42.4	1.8	192	61	1.6	52	243	0.191	3.26	4.32	-410	-505	-1377	10	5	15	95	99	27	75	2011	
15	1|5|0.5|1.5|0|1555|13.8|lr<5r2<50	14550	13178	76	42.4	1.8	192	61	1.6	52	243	0.191	3.26	4.32	-410	-505	-1377	10	5	15	95	99	27	75	2011	
16	1|5|0.5|1.5|0|1555|13.8|lr<5r2<60	15250	13698	71	39.3	1.8	216	60	1.56	52	243	0.179	3.16	4.26	-410	-505	-1377	8	5	26	95	99	27	77	1943	
17	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<60	15250	13698	71	39.3	1.8	216	60	1.56	52	243	0.179	3.16	4.26	-410	-505	-1377	8	5	26	95	99	27	77	1943	
18	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<60	15250	13698	71	39.3	1.8	216	60	1.56	52	243	0.179	3.16	4.26	-410	-505	-1377	8	5	26	95	99	27	77	1943	
19	2|13|1|3.25|0|1555|13.8|r2<50	14162	13418	84	76.1	1.1	169	61	1.39	60	261	0.161	2.67	4.18	-587	-587	-940	10	4	35	94	98	25	80	1933	
20	2|13|1|3.25|0|1555|13.8|lr<5r2<50	14162	13418	84	76.1	1.1	169	61	1.39	60	261	0.161	2.67	4.18	-587	-587	-940	10	4	35	94	98	25	80	1933	
21	2|13|1|3.25|0|1555|13.8|pf<5|r2<50	13814	13078	83	75.1	1.1	167	61	1.38	60	258	0.143	2.71	4.15	-587	-587	-940	10	4	35	94	98	25	81	1903	
22	2|13|1|3.25|0|1555|13.8|pf<5|lr<5r2<50	13814	13078	83	75.1	1.1	167	61	1.38	60	258	0.143	2.71	4.15	-587	-587	-940	10	4	35	94	98	25	81	1903	
23	1|5|0.5|1.75|0|1555|13.8|pf<2|r2<50	14359	13015	69	42.7	1.6	207	58	1.51	52	271	0.105	4.23	3.68	-669	-858	-1499	6	5	40	95	99	18	103	1868	

1	QQQ5mFixmV10x1dxoa	s04/30/24	e10/25/24	#126			f705599		
2	pw|N|vup|vdn|xop|xt|mult|<PF<LR<R2	toGPx	toNPx	aoTRx	aoNTx	#x	tOnpNet	Prob	
3	2|13|1|3.5|0|1555|13.8|lr<5r2<50	1726	1390	21	1.2	73	15025	2.53E-11	
4	2|13|1|3.5|0|1555|13.8|r2<50	1726	1390	21	1.2	73	15025	2.53E-11	
5	2|13|1|3.5|0|1555|13.8|pf<5|lr<5r2<50	1489	1157	18	1.2	72	14452	4.44E-11	
6	2|13|1|3.5|0|1555|13.8|pf<5|r2<50	1489	1157	18	1.2	72	14452	4.44E-11	
7	1|5|0.5|1.75|0|1555|13.8|pf<2|lr<5r2<50	1693	1289	17	2.2	45	15317	4.11E-10	
8	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<60	4315	3815	35	2.5	50	17864	3.89E-10	
9	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<70	3916	3360	28	2.5	55	17233	4.87E-09	
10	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<60	4578	4058	35	2.5	53	18149	1.77E-08	
11	1|5|0.5|1.5|0|1555|13.8|pf<3|lr<5r2<50	3498	3014	29	2.5	48	16304	3.20E-09	
12	1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5r2<50	3431	2955	29	2.6	46	15679	4.73E-10	
13	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<50	3498	3014	29	2.5	48	16192	4.97E-09	
14	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<50	3498	3014	29	2.5	48	16192	4.97E-09	
15	1|5|0.5|1.5|0|1555|13.8|lr<5r2<50	3498	3014	29	2.5	48	16192	4.97E-09	
16	1|5|0.5|1.5|0|1555|13.8|lr<5r2<60	4578	4058	35	2.5	53	17756	5.16E-08	
17	1|5|0.5|1.5|0|1555|13.8|pf<5|lr<5r2<60	4578	4058	35	2.5	53	17756	5.16E-08	
18	1|5|0.5|1.5|0|1555|13.8|pf<4|lr<5r2<60	4578	4058	35	2.5	53	17756	5.16E-08	
19	2|13|1|3.25|0|1555|13.8|r2<50	1543	1187	17	1.2	73	14605	2.37E-11	
20	2|13|1|3.25|0|1555|13.8|lr<5r2<50	1543	1187	17	1.2	73	14605	2.37E-11	
21	2|13|1|3.25|0|1555|13.8|pf<5|r2<50	1306	954	15	1.2	72	14032	4.20E-11	
22	2|13|1|3.25|0|1555|13.8|pf<5|lr<5r2<50	1306	954	15	1.2	72	14032	4.20E-11	
23	1|5|0.5|1.75|0|1555|13.8|pf<2|r2<50	(909)	(1821)	(4)	2.7	85	11194	6.52E-08	

The WFINP AVE File Output Cols are defined as follows.

Row 1 QQQ5Fixm10x1dxoa is the PWFO output files abbreviation, First OOS Day End Date (1/18/22), Last OOS Day End Date (8/4/23), **Number of days** (#332) 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).

Row 2 to Last Row Columns: A through Z

Col A: ***The Strategy Input/Filter Names***
Row 8: **1|5|0.5|1.5|0|1555|13.8|lr<5|r2<60 :** The inputs **1|5|0.5|1.5|0|1555|13.8|**for all in-sample files that have **lr≤5 and r2≤60**.
Col B: ***toGP*** Total out-of-sample(oos) gross profit for these 332 oos periods (for this run periods = weeks).
Col C: ***toNP*** Total out-of-sample(oos) Net profit (toGP-(# of Trade days)*cost) for the 332 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: ***#*** The number of oos periods this filter produced any profit or loss. Note for some oos periods there are no trades.
Col H: ***std*** the standard deviation of the # oos period profits and losses
Col I: ***skew*** The Skew statistic of the # oos period profits and losses.
Col J: ***kur*** the kurtosis statistic of the # oos period profits and losses
Col K: ***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 L: ***oW|oL*** Ratio of average oos winning trades divided by average oos losing trades.
Col M: ***%Wtr*** The percentage if oos winning trades.
Col N: ***%P*** percent of all oos periods that were profitable.
Col O ***LLtr*** the largest losing oos trade in all oos periods
Col P: ***LLp*** the largest losing oos period
Col Q: ***eqDD*** the oos equity drawdown
Col R: ***wpr*** the largest number of winning oos periods (weeks) in a row.
Col S: ***lpr*** the largest number of losing oos periods in a row.
There can be no strategy inputs that satisfy a given filter 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: ***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 V: ***eqR2*** the correlation coefficient(R^2) of a straight line fit to the equity curve.
Col W: ***Blw*** The maximum number of oos periods the oos equity curve failed to make a new high.
Col X: ***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 Y: ***tkr|bl*** =100*t*Ktau*eqR2/BE. This is a measure of the best equity curve.
Col AA: ***Prob*** The probability that the filters oos toNP was due to pure chance.

The Following columns are the results from 4/30/24-10/25/24 that were not included in the filter scan from 1/3/23 to 4/29/24.

Col AB: ***toGPx*** Total gross profit for the 126 future excluded periods (for this run periods = days).
Col AC: ***toNPx*** Total Net profit for the 126 future excluded periods.
Col AD: ***aoTrx*** Average profit per trade for the 126 future excluded periods
Col AE: ***aoNTx*** Average number of trades per week for the 126 future excluded periods
Col AF: ***#x*** the number of the 120 future excluded periods this strategy/filter traded. Note for some periods there can be no strategy inputs/filter that satisfy the Strategy Inputs/Filter criteria, and no trades will be made during that period.
Col AG: ***tOnpNet -*** toNP+toNPx = Total Net Profits of oos+future periods

Table 1 Walk Forward Out-Of-Sample Performance Summary for the QQQ 5-min FixmVn Strategy

QQQ-5 min bars 01/18/2022 - 10/25/2024.

Filter: **1|5|0.5|1.5|0|1555|13.8|pf<2|lr<5|r2<60;** The inputs **1|5|0.5|1.5|0|1555|13.8**for all in-sample files that have **pf<2 and lr≤5 and r2≤60**.
are used to trade in the following out-of-sample sections.

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 $
Note: Blank rows indicate that no out-of-sample trades were made that day

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
1/3/2023	2.3	3	73	0	0	0	0	0	0	0	18950	0
1/4/2023	3.4	2	69	0	0	0	0	0	0	0	18950	0
1/5/2023	2.2	2	65	0	0	0	0	0	0	0	18950	0
1/6/2023	1.1	2	47	424	412	3	674	1	-232	-250	19374	412
1/9/2023	1.4	4	9	414	406	2	414	2	0	0	19788	818
1/10/2023	1.7	4	25	-161	-173	3	121	1	-148	-282	19627	645
1/11/2023	1.5	4	36	238	234	1	238	1	0	0	19865	879
1/12/2023	2	4	25	134	126	2	258	1	-124	-124	19999	1005
1/13/2023	1.7	4	37	298	290	2	350	1	-52	-52	20297	1295
1/17/2023	1.8	4	49	-17	-21	1	0	0	-17	-17	20280	1274
1/18/2023	1.7	4	71	0	0	0	0	0	0	0	20280	1274
1/19/2023	1.8	4	83	0	0	0	0	0	0	0	20280	1274
1/20/2023	2	3	76	0	0	0	0	0	0	0	20280	1274
1/23/2023	2.5	3	75	0	0	0	0	0	0	0	20280	1274
1/24/2023	2.7	3	72	0	0	0	0	0	0	0	20280	1274
1/25/2023	3.2	3	67	0	0	0	0	0	0	0	20280	1274
1/26/2023	3.7	3	76	0	0	0	0	0	0	0	20280	1274
1/27/2023	2.8	3	82	0	0	0	0	0	0	0	20280	1274
1/30/2023	2.9	3	84	0	0	0	0	0	0	0	20280	1274
1/31/2023	2.1	3	81	0	0	0	0	0	0	0	20280	1274
2/1/2023	2.3	3	80	0	0	0	0	0	0	0	20280	1274
2/2/2023	3.4	3	73	0	0	0	0	0	0	0	20280	1274
2/3/2023	4.4	3	78	0	0	0	0	0	0	0	20280	1274
2/6/2023	2.7	3	83	0	0	0	0	0	0	0	20280	1274
2/7/2023	1.8	4	74	0	0	0	0	0	0	0	20280	1274
2/8/2023	2.7	4	76	0	0	0	0	0	0	0	20280	1274
2/9/2023	1.9	4	79	0	0	0	0	0	0	0	20280	1274
2/10/2023	1.7	4	62	0	0	0	0	0	0	0	20280	1274
2/13/2023	1.5	4	55	361	357	1	361	1	0	0	20641	1631
2/14/2023	2	4	32	0	0	0	0	0	0	0	20641	1631
2/15/2023	1.7	4	25	281	273	2	281	2	0	0	20922	1904
2/16/2023	1.5	4	30	39	27	3	139	1	-67	-100	20961	1931
2/17/2023	1.3	4	51	292	284	2	292	2	0	0	21253	2215
2/21/2023	2	2	40	207	199	2	283	1	-76	-76	21460	2414
2/22/2023	1.4	2	59	-151	-163	3	10	1	-151	-151	21309	2251
2/23/2023	1.5	2	86	0	0	0	0	0	0	0	21309	2251

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
2/24/2023	2.3	2	88	0	0	0	0	0	0	0	21309	2251
2/27/2023	2.9	2	89	0	0	0	0	0	0	0	21309	2251
2/28/2023	2.1	2	91	0	0	0	0	0	0	0	21309	2251
3/1/2023	3	2	83	0	0	0	0	0	0	0	21309	2251
3/2/2023	1.2	6	12	0	0	0	0	0	0	0	21309	2251
3/3/2023	1.4	6	-4	0	0	0	0	0	0	0	21309	2251
3/6/2023	1.6	6	-4	0	0	0	0	0	0	0	21309	2251
3/7/2023	1.4	6	-1	0	0	0	0	0	0	0	21309	2251
3/8/2023	0.9	6	-1	0	0	0	0	0	0	0	21309	2251
3/9/2023	1	6	-10	0	0	0	0	0	0	0	21309	2251
3/10/2023	0.5	6	-22	0	0	0	0	0	0	0	21309	2251
3/13/2023	0.5	6	-49	0	0	0	0	0	0	0	21309	2251
3/14/2023	0.5	5	-63	154	150	1	154	1	0	0	21463	2401
3/15/2023	0.6	4	-61	180	176	1	180	1	0	0	21643	2577
3/16/2023	0.8	4	-68	817	813	1	817	1	0	0	22460	3390
3/17/2023	1.1	4	-40	170	158	3	297	2	-127	-127	22630	3548
3/20/2023	1	4	0	173	165	2	201	1	-28	-28	22803	3713
3/21/2023	1.1	3	10	169	165	1	169	1	0	0	22972	3878
3/22/2023	1.5	2	46	-374	-390	4	234	1	-232	-608	22598	3488
3/23/2023	1.2	3	65	0	0	0	0	0	0	0	22598	3488
3/24/2023	1.6	3	64	0	0	0	0	0	0	0	22598	3488
3/27/2023	1.3	3	34	-246	-250	1	0	0	-246	-246	22352	3238
3/28/2023	1.4	3	0	-228	-244	4	72	1	-167	-300	22124	2994
3/29/2023	1.1	4	-31	153	149	1	153	1	0	0	22277	3143
3/30/2023	1.1	4	-65	45	41	1	45	1	0	0	22322	3184
3/31/2023	0.7	4	-71	380	376	1	380	1	0	0	22702	3560
4/3/2023	0.8	4	-73	-6	-10	1	0	0	-6	-6	22696	3550
4/4/2023	0.7	4	-60	-178	-182	1	0	0	-178	-178	22518	3368
4/5/2023	0.6	4	-49	178	170	2	178	2	0	0	22696	3538
4/6/2023	0.8	4	-11	258	250	2	364	1	-106	-106	22954	3788
4/10/2023	1.4	4	66	0	0	0	0	0	0	0	22954	3788
4/11/2023	2.3	3	82	0	0	0	0	0	0	0	22954	3788
4/12/2023	3.7	2	80	0	0	0	0	0	0	0	22954	3788
4/13/2023	1.8	4	32	351	347	1	351	1	0	0	23305	4135
4/14/2023	2.2	4	31	0	0	0	0	0	0	0	23305	4135
4/17/2023	1.4	4	41	8	4	1	8	1	0	0	23313	4139
4/18/2023	1.4	4	40	-17	-29	3	83	2	-100	-100	23296	4110
4/19/2023	1.6	4	32	152	144	2	159	1	-7	-7	23448	4254
4/20/2023	1.6	4	25	-221	-229	2	0	0	-141	-221	23227	4025
4/21/2023	1	4	15	-89	-97	2	67	1	-156	-156	23138	3928
4/24/2023	1	4	3	-310	-322	3	0	0	-191	-310	22828	3606
4/25/2023	0.6	4	-6	-89	-93	1	0	0	-89	-89	22739	3513
4/26/2023	0.6	4	-9	-77	-81	1	0	0	-77	-77	22662	3432
4/27/2023	0.6	5	-71	524	520	1	524	1	0	0	23186	3952
4/28/2023	0.8	5	-55	209	205	1	209	1	0	0	23395	4157
5/1/2023	1.1	5	-30	-29	-33	1	0	0	-29	-29	23366	4124
5/2/2023	1.1	5	-13	0	0	0	0	0	0	0	23366	4124
5/3/2023	1.1	5	-8	9	1	2	119	1	-110	-110	23375	4125
5/4/2023	0.9	5	4	-21	-25	1	0	0	-21	-21	23354	4100
5/5/2023	1.2	5	36	421	417	1	421	1	0	0	23775	4517
5/8/2023	2	5	70	0	0	0	0	0	0	0	23775	4517
5/9/2023	4.4	2	81	0	0	0	0	0	0	0	23775	4517
5/10/2023	6.2	2	81	0	0	0	0	0	0	0	23775	4517
5/11/2023	4.2	2	73	0	0	0	0	0	0	0	23775	4517
5/12/2023	3.1	2	71	0	0	0	0	0	0	0	23775	4517
5/15/2023	1.6	2	60	136	132	1	136	1	0	0	23911	4649
5/16/2023	2	2	53	-27	-31	1	0	0	-27	-27	23884	4618
5/17/2023	1.9	2	50	311	307	1	311	1	0	0	24195	4925
5/18/2023	2.7	2	35	0	0	0	0	0	0	0	24195	4925

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
5/19/2023	4	2	35	0	0	0	0	0	0	0	24195	4925
5/22/2023	2.4	2	46	0	0	0	0	0	0	0	24195	4925
5/23/2023	2.2	2	62	0	0	0	0	0	0	0	24195	4925
5/24/2023	1.6	2	71	0	0	0	0	0	0	0	24195	4925
5/25/2023	2.4	1	69	0	0	0	0	0	0	0	24195	4925
5/26/2023	2.6	1	74	0	0	0	0	0	0	0	24195	4925
5/30/2023	5.9	1	64	0	0	0	0	0	0	0	24195	4925
5/31/2023	2.5	3	64	0	0	0	0	0	0	0	24195	4925
6/1/2023	1.6	6	23	0	0	0	0	0	0	0	24195	4925
6/2/2023	1.3	6	24	0	0	0	0	0	0	0	24195	4925
6/5/2023	1.6	6	22	0	0	0	0	0	0	0	24195	4925
6/6/2023	1.3	6	11	0	0	0	0	0	0	0	24195	4925
6/7/2023	1.6	6	2	0	0	0	0	0	0	0	24195	4925
6/8/2023	0.7	6	-39	0	0	0	0	0	0	0	24195	4925
6/9/2023	0.8	6	-56	0	0	0	0	0	0	0	24195	4925
6/12/2023	0.4	6	-73	0	0	0	0	0	0	0	24195	4925
6/13/2023	0.6	6	-71	0	0	0	0	0	0	0	24195	4925
6/14/2023	0.7	5	-62	-190	-202	3	148	1	-215	-338	24005	4723
6/15/2023	0.8	5	-72	495	491	1	495	1	0	0	24500	5214
6/16/2023	0.9	5	-50	-233	-237	1	0	0	-233	-233	24267	4977
6/20/2023	0.8	5	-10	207	199	2	233	1	-26	-26	24474	5176
6/21/2023	0.9	5	9	431	423	2	431	2	0	0	24905	5599
6/22/2023	1.9	5	45	343	339	1	343	1	0	0	25248	5938
6/23/2023	1.9	5	59	128	120	2	128	2	0	0	25376	6058
6/26/2023	2.9	2	76	0	0	0	0	0	0	0	25376	6058
6/27/2023	1.4	5	59	426	422	1	426	1	0	0	25802	6480
6/28/2023	1.8	5	50	35	23	3	75	2	-40	-40	25837	6503
6/29/2023	2.2	5	33	0	0	0	0	0	0	0	25837	6503
6/30/2023	1.7	5	29	14	10	1	14	1	0	0	25851	6513
7/3/2023	2.3	5	21	0	0	0	0	0	0	0	25851	6513
7/5/2023	1.9	5	2	-39	-43	1	0	0	-39	-39	25812	6470
7/6/2023	1.3	5	0	131	123	2	146	1	-15	-15	25943	6593
7/7/2023	1	5	1	-450	-462	3	0	0	-188	-450	25493	6131
7/10/2023	0.6	5	0	-117	-125	2	8	1	-125	-125	25376	6006
7/11/2023	1	4	-66	89	85	1	89	1	0	0	25465	6091
7/12/2023	0.5	4	-75	4	-4	2	96	1	-92	-92	25469	6087
7/13/2023	0.5	4	-80	322	318	1	322	1	0	0	25791	6405
7/14/2023	0.9	4	-48	-248	-252	1	0	0	-248	-248	25543	6153
7/17/2023	0.7	4	-38	260	256	1	260	1	0	0	25803	6409
7/18/2023	1	4	-12	377	369	2	474	1	-97	-97	26180	6778
7/19/2023	1.3	4	0	-17	-29	3	71	2	-88	-88	26163	6749
7/20/2023	1.3	4	27	382	366	4	532	3	-150	-150	26545	7115
7/21/2023	1.5	4	77	0	0	0	0	0	0	0	26545	7115
7/24/2023	1.3	3	71	0	0	0	0	0	0	0	26545	7115
7/25/2023	1.1	6	10	0	0	0	0	0	0	0	26545	7115
7/26/2023	1.1	6	2	0	0	0	0	0	0	0	26545	7115
7/27/2023	0.9	6	-23	0	0	0	0	0	0	0	26545	7115
7/28/2023	0.7	6	-45	0	0	0	0	0	0	0	26545	7115
7/31/2023	1	6	-58	0	0	0	0	0	0	0	26545	7115
8/1/2023	0.8	6	-66	0	0	0	0	0	0	0	26545	7115
8/2/2023	0.7	6	-75	0	0	0	0	0	0	0	26545	7115
8/3/2023	0.8	6	-55	0	0	0	0	0	0	0	26545	7115
8/4/2023	0.6	6	-17	0	0	0	0	0	0	0	26545	7115
8/7/2023	0.9	3	2	127	123	1	127	1	0	0	26672	7238
8/8/2023	1.3	3	19	460	452	2	460	2	0	0	27132	7690
8/9/2023	1.5	3	49	9	5	1	9	1	0	0	27141	7695
8/10/2023	2	3	66	0	0	0	0	0	0	0	27141	7695
8/11/2023	1.7	3	55	-122	-130	2	0	0	-81	-122	27019	7565
8/14/2023	1.2	5	34	310	306	1	310	1	0	0	27329	7871

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
8/15/2023	1.7	5	29	-110	-114	1	0	0	-110	-110	27219	7757
8/16/2023	1.4	5	22	-358	-366	2	20	1	-378	-378	26861	7391
8/17/2023	0.9	5	6	-273	-277	1	0	0	-273	-273	26588	7114
8/18/2023	0.8	5	0	65	57	2	162	1	-97	-97	26653	7171
8/21/2023	0.8	5	-66	400	388	3	438	2	-38	-38	27053	7559
8/22/2023	1	5	-74	-310	-314	1	0	0	-310	-310	26743	7245
8/23/2023	0.5	5	-72	409	405	1	409	1	0	0	27152	7650
8/24/2023	0.8	5	-52	-127	-139	3	368	1	-277	-277	27025	7511
8/25/2023	0.9	2	0	225	205	5	460	2	-128	-128	27250	7716
8/28/2023	1.1	2	6	-61	-65	1	0	0	-61	-61	27189	7651
8/29/2023	0.9	2	25	172	168	1	172	1	0	0	27361	7819
8/30/2023	1.1	2	55	-42	-54	3	92	1	-94	-134	27319	7765
8/31/2023	1.3	2	72	0	0	0	0	0	0	0	27319	7765
9/1/2023	1.6	2	71	0	0	0	0	0	0	0	27319	7765
9/5/2023	1.1	2	48	132	128	1	132	1	0	0	27451	7893
9/6/2023	1.5	2	41	170	162	2	199	1	-29	-29	27621	8055
9/7/2023	1.3	2	60	88	80	2	166	1	-78	-78	27709	8135
9/8/2023	1.7	2	75	0	0	0	0	0	0	0	27709	8135
9/11/2023	1.3	2	49	202	198	1	202	1	0	0	27911	8333
9/12/2023	1.8	2	51	-334	-338	1	0	0	-334	-334	27577	7995
9/13/2023	0.9	2	34	22	18	1	22	1	0	0	27599	8013
9/14/2023	1	2	7	180	176	1	180	1	0	0	27779	8189
9/15/2023	1.1	2	13	478	470	2	479	1	-1	-1	28257	8659
9/18/2023	2.3	2	32	0	0	0	0	0	0	0	28257	8659
9/19/2023	2.3	2	44	0	0	0	0	0	0	0	28257	8659
9/20/2023	2	3	53	0	0	0	0	0	0	0	28257	8659
9/21/2023	1.1	3	16	-65	-73	2	103	1	-168	-168	28192	8586
9/22/2023	0.9	3	3	-105	-109	1	0	0	-105	-105	28087	8477
9/25/2023	1	3	0	-84	-92	2	71	1	-155	-155	28003	8385
9/26/2023	0.8	3	-10	1	-7	2	171	1	-170	-170	28004	8378
9/27/2023	1	3	-33	-58	-62	1	0	0	-58	-58	27946	8316
9/28/2023	1	3	-64	262	258	1	262	1	0	0	28208	8574
9/29/2023	1	3	-77	-278	-282	1	0	0	-278	-278	27930	8292
10/2/2023	0.6	3	-72	379	367	3	379	3	0	0	28309	8659
10/3/2023	0.8	3	-42	-399	-415	4	192	1	-335	-472	27910	8244
10/4/2023	0.6	3	-32	289	285	1	289	1	0	0	28199	8529
10/5/2023	1	3	-4	395	387	2	395	2	0	0	28594	8916
10/6/2023	1.3	2	19	850	842	2	850	2	0	0	29444	9758
10/9/2023	2.1	2	39	0	0	0	0	0	0	0	29444	9758
10/10/2023	2.2	2	55	0	0	0	0	0	0	0	29444	9758
10/11/2023	2.6	2	72	0	0	0	0	0	0	0	29444	9758
10/12/2023	2.8	2	76	0	0	0	0	0	0	0	29444	9758
10/13/2023	2.7	2	86	0	0	0	0	0	0	0	29444	9758
10/16/2023	3.5	2	89	0	0	0	0	0	0	0	29444	9758
10/17/2023	3.3	2	93	0	0	0	0	0	0	0	29444	9758
10/18/2023	8.5	1	90	0	0	0	0	0	0	0	29444	9758
10/19/2023	2.3	6	58	0	0	0	0	0	0	0	29444	9758
10/20/2023	1.3	11	0	0	0	0	0	0	0	0	29444	9758
10/23/2023	0.7	11	-17	0	0	0	0	0	0	0	29444	9758
10/24/2023	0.7	11	-50	0	0	0	0	0	0	0	29444	9758
10/25/2023	0.6	11	-65	0	0	0	0	0	0	0	29444	9758
10/26/2023	0.5	11	-76	0	0	0	0	0	0	0	29444	9758
10/27/2023	0.5	11	-92	0	0	0	0	0	0	0	29444	9758
10/30/2023	0.4	11	-93	0	0	0	0	0	0	0	29444	9758
10/31/2023	0.4	11	-91	0	0	0	0	0	0	0	29444	9758
11/1/2023	0.4	11	-85	0	0	0	0	0	0	0	29444	9758
11/2/2023	0.8	5	-50	221	217	1	221	1	0	0	29665	9975
11/3/2023	1.1	3	1	298	294	1	298	1	0	0	29963	10269
11/6/2023	1.9	3	12	-86	-90	1	0	0	-86	-86	29877	10179

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
11/7/2023	1.7	3	30	66	62	1	66	1	0	0	29943	10241
11/8/2023	1.7	3	50	-56	-60	1	0	0	-56	-56	29887	10181
11/9/2023	2.7	3	74	0	0	0	0	0	0	0	29887	10181
11/10/2023	1.4	4	50	660	656	1	660	1	0	0	30547	10837
11/13/2023	2.3	4	44	0	0	0	0	0	0	0	30547	10837
11/14/2023	2	4	25	0	0	0	0	0	0	0	30547	10837
11/15/2023	2.1	4	1	0	0	0	0	0	0	0	30547	10837
11/16/2023	1.3	4	0	22	18	1	22	1	0	0	30569	10855
11/17/2023	1.1	4	-1	48	44	1	48	1	0	0	30617	10899
11/20/2023	0.9	4	0	291	287	1	291	1	0	0	30908	11186
11/21/2023	1.2	4	10	167	159	2	167	2	0	0	31075	11345
11/22/2023	1.3	4	47	-202	-214	3	8	1	-173	-202	30873	11131
11/24/2023	2.8	1	55	0	0	0	0	0	0	0	30873	11131
11/27/2023	1.5	1	55	-74	-78	1	0	0	-74	-74	30799	11053
11/28/2023	1.3	2	31	129	125	1	129	1	0	0	30928	11178
11/29/2023	1.3	2	35	12	4	2	130	1	-118	-118	30940	11182
11/30/2023	2	2	27	-10	-14	1	0	0	-10	-10	30930	11168
12/1/2023	1.9	2	9	180	176	1	180	1	0	0	31110	11344
12/4/2023	2.2	2	3	0	0	0	0	0	0	0	31110	11344
12/5/2023	2.7	2	37	0	0	0	0	0	0	0	31110	11344
12/6/2023	2.2	2	80	0	0	0	0	0	0	0	31110	11344
12/7/2023	1.6	2	67	0	0	0	0	0	0	0	31110	11344
12/8/2023	1.9	2	63	0	0	0	0	0	0	0	31110	11344
12/11/2023	1.7	2	52	231	227	1	231	1	0	0	31341	11571
12/12/2023	2.2	2	48	0	0	0	0	0	0	0	31341	11571
12/13/2023	2.3	2	49	0	0	0	0	0	0	0	31341	11571
12/14/2023	2.1	2	51	0	0	0	0	0	0	0	31341	11571
12/15/2023	1.6	3	22	174	170	1	174	1	0	0	31515	11741
12/18/2023	1.6	3	17	146	142	1	146	1	0	0	31661	11883
12/19/2023	1.3	3	22	47	43	1	47	1	0	0	31708	11926
12/20/2023	1.4	3	46	134	122	3	309	1	-160	-160	31842	12048
12/21/2023	2.1	3	54	0	0	0	0	0	0	0	31842	12048
12/22/2023	1.5	3	48	-56	-60	1	0	0	-56	-56	31786	11988
12/26/2023	1.3	3	22	99	95	1	99	1	0	0	31885	12083
12/27/2023	1.2	3	31	-43	-47	1	0	0	-43	-43	31842	12036
12/28/2023	1.3	3	55	-113	-117	1	0	0	-113	-113	31729	11919
12/29/2023	1.4	3	7	110	102	2	110	2	0	0	31839	12021
1/2/2024	1.1	3	1	-4	-12	2	156	1	-160	-160	31835	12009
1/3/2024	1	3	9	-71	-79	2	91	1	-162	-162	31764	11930
1/4/2024	0.8	2	28	-155	-159	1	0	0	-155	-155	31609	11771
1/5/2024	0.7	2	-4	-10	-14	1	0	0	-10	-10	31599	11757
1/8/2024	0.7	3	-25	288	284	1	288	1	0	0	31887	12041
1/9/2024	1.2	3	-11	180	172	2	260	1	-80	-80	32067	12213
1/10/2024	1.3	3	1	176	172	1	176	1	0	0	32243	12385
1/11/2024	1.6	3	15	131	119	3	290	2	-159	-159	32374	12504
1/12/2024	1.9	3	42	-123	-135	3	0	0	-75	-123	32251	12369
1/16/2024	1.5	3	58	-134	-150	4	175	1	-157	-262	32117	12219
1/17/2024	1.3	4	61	0	0	0	0	0	0	0	32117	12219
1/18/2024	1.8	4	56	268	256	3	291	2	-23	-23	32385	12475
1/19/2024	2.6	4	62	0	0	0	0	0	0	0	32385	12475
1/22/2024	3.5	4	54	0	0	0	0	0	0	0	32385	12475
1/23/2024	2.2	4	57	0	0	0	0	0	0	0	32385	12475
1/24/2024	2.2	4	56	0	0	0	0	0	0	0	32385	12475
1/25/2024	1.8	4	63	0	0	0	0	0	0	0	32385	12475
1/26/2024	1.2	4	50	-184	-192	2	0	0	-130	-184	32201	12283
1/29/2024	1.2	3	27	278	274	1	278	1	0	0	32479	12557
1/30/2024	1.4	3	27	-8	-12	1	0	0	-8	-8	32471	12545
1/31/2024	1.6	3	5	237	225	3	331	2	-94	-94	32708	12770
2/1/2024	1.5	3	0	24	12	3	255	1	-143	-231	32732	12782

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
2/2/2024	1.2	3	-9	600	596	1	600	1	0	0	33332	13378
2/5/2024	1.2	3	5	248	244	1	248	1	0	0	33580	13622
2/6/2024	1.7	3	24	-23	-35	3	208	2	-231	-231	33557	13587
2/7/2024	1.5	3	63	0	0	0	0	0	0	0	33557	13587
2/8/2024	1.7	2	79	0	0	0	0	0	0	0	33557	13587
2/9/2024	2.7	2	86	0	0	0	0	0	0	0	33557	13587
2/12/2024	4.1	2	85	0	0	0	0	0	0	0	33557	13587
2/13/2024	3.4	2	90	0	0	0	0	0	0	0	33557	13587
2/14/2024	2.3	4	74	0	0	0	0	0	0	0	33557	13587
2/15/2024	1.9	4	47	82	78	1	82	1	0	0	33639	13665
2/16/2024	2.2	4	20	0	0	0	0	0	0	0	33639	13665
2/20/2024	1.3	4	14	323	315	2	323	2	0	0	33962	13980
2/21/2024	1.9	4	10	-67	-75	2	0	0	-55	-67	33895	13905
2/22/2024	1.7	4	19	298	294	1	298	1	0	0	34193	14199
2/23/2024	2	4	24	0	0	0	0	0	0	0	34193	14199
2/26/2024	1	4	25	-70	-74	1	0	0	-70	-70	34123	14125
2/27/2024	0.9	3	43	44	40	1	44	1	0	0	34167	14165
2/29/2024	1.2	2	30	37	29	2	67	1	-30	-30	34204	14194
2/29/2024	1.2	2	1	-213	-225	3	248	1	-335	-461	33991	13969
3/1/2024	0.9	3	-17	491	487	1	491	1	0	0	34482	14456
3/4/2024	1.3	3	-35	-151	-155	1	0	0	-151	-151	34331	14301
3/5/2024	1.2	3	-25	239	231	2	319	1	-80	-80	34570	14532
3/6/2024	1.1	3	0	30	22	2	78	1	-48	-48	34600	14554
3/7/2024	1.2	3	8	345	341	1	345	1	0	0	34945	14895
3/8/2024	1.2	3	39	-251	-271	5	227	2	-221	-251	34694	14624
3/11/2024	1.4	3	66	0	0	0	0	0	0	0	34694	14624
3/12/2024	1.4	3	60	512	508	1	512	1	0	0	35206	15132
3/13/2024	1.8	3	65	0	0	0	0	0	0	0	35206	15132
3/14/2024	1.7	2	73	0	0	0	0	0	0	0	35206	15132
3/15/2024	1.3	5	3	-119	-127	2	13	1	-132	-132	35087	15005
3/18/2024	0.9	5	-1	-195	-199	1	0	0	-195	-195	34892	14806
3/19/2024	0.9	5	-11	445	437	2	445	2	0	0	35337	15243
3/20/2024	1	5	-23	379	375	1	379	1	0	0	35716	15618
3/21/2024	1.2	5	-24	-197	-201	1	0	0	-197	-197	35519	15417
3/22/2024	0.9	5	-16	90	86	1	90	1	0	0	35609	15503
3/25/2024	1.1	5	-11	73	65	2	91	1	-18	-18	35682	15568
3/26/2024	1.2	5	-5	-262	-266	1	0	0	-262	-262	35420	15302
3/27/2024	0.7	5	-1	-190	-202	3	151	1	-272	-341	35230	15100
3/28/2024	0.6	4	2	-98	-102	1	0	0	-98	-98	35132	14998
4/1/2024	1	3	0	-112	-116	1	0	0	-112	-112	35020	14882
4/2/2024	1.1	3	-15	138	130	2	151	1	-13	-13	35158	15012
4/3/2024	0.8	3	-78	-158	-166	2	34	1	-192	-192	35000	14846
4/4/2024	0.4	3	-77	380	372	2	696	1	-316	-316	35380	15218
4/5/2024	0.9	3	-52	193	181	3	278	2	-85	-85	35573	15399
4/8/2024	1	3	0	-3	-7	1	0	0	-3	-3	35570	15392
4/9/2024	0.9	3	18	36	24	3	303	2	-267	-267	35606	15416
4/10/2024	1.1	3	37	-250	-266	4	99	1	-160	-349	35356	15150
4/11/2024	1.1	3	33	280	268	3	602	1	-185	-322	35636	15418
4/12/2024	1.3	3	18	-465	-473	2	0	0	-397	-465	35171	14945
4/15/2024	1	3	15	317	301	4	570	2	-175	-175	35488	15246
4/16/2024	1.2	3	8	-177	-189	3	31	1	-110	-208	35311	15057
4/17/2024	1.1	3	2	-488	-508	5	114	1	-299	-488	34823	14549
4/18/2024	0.9	3	-17	-484	-500	4	0	0	-169	-484	34339	14049
4/19/2024	0.7	7	-62	0	0	0	0	0	0	0	34339	14049
4/22/2024	0.6	7	-74	0	0	0	0	0	0	0	34339	14049
4/23/2024	0.7	7	-76	0	0	0	0	0	0	0	34339	14049
4/24/2024	0.8	7	-71	0	0	0	0	0	0	0	34339	14049
4/25/2024	0.8	7	-66	0	0	0	0	0	0	0	34339	14049
4/26/2024	0.8	7	-55	0	0	0	0	0	0	0	34339	14049

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
4/29/2024	1	7	-35	0	0	0	0	0	0	0	34339	14049
4/30/2024	0.8	7	-7	0	0	0	0	0	0	0	34339	14049
5/1/2024	0.7	7	0	0	0	0	0	0	0	0	34339	14049
5/2/2024	1.2	4	34	-272	-284	3	296	1	-338	-568	34067	13765
5/3/2024	1.3	2	48	-97	-109	3	58	1	-130	-155	33970	13656
5/6/2024	1.4	2	14	264	260	1	264	1	0	0	34234	13916
5/7/2024	1.4	2	3	-18	-22	1	0	0	-18	-18	34216	13894
5/8/2024	1.1	2	7	-19	-27	2	65	1	-84	-84	34197	13867
5/9/2024	1.2	2	9	82	78	1	82	1	0	0	34279	13945
5/10/2024	1.1	2	9	-118	-122	1	0	0	-118	-118	34161	13823
5/13/2024	0.9	2	27	5	1	1	5	1	0	0	34166	13824
5/14/2024	1.1	2	48	284	280	1	284	1	0	0	34450	14104
5/15/2024	2	2	34	413	409	1	413	1	0	0	34863	14513
5/16/2024	1.6	2	62	0	0	0	0	0	0	0	34863	14513
5/17/2024	2.3	2	68	0	0	0	0	0	0	0	34863	14513
5/20/2024	2.6	2	61	0	0	0	0	0	0	0	34863	14513
5/21/2024	2.3	2	72	0	0	0	0	0	0	0	34863	14513
5/22/2024	2.7	2	81	0	0	0	0	0	0	0	34863	14513
5/23/2024	2.2	2	71	0	0	0	0	0	0	0	34863	14513
5/24/2024	1	5	-7	229	225	1	229	1	0	0	35092	14738
5/28/2024	1.3	5	-43	-202	-214	3	86	1	-196	-288	34890	14524
5/29/2024	0.9	5	-62	-219	-227	2	0	0	-124	-219	34671	14297
5/30/2024	0.5	5	-63	-38	-46	2	113	1	-151	-151	34633	14251
5/31/2024	0.6	5	-63	1077	1065	3	1252	2	-175	-175	35710	15316
6/3/2024	1.3	5	-14	-169	-189	5	297	2	-234	-466	35541	15127
6/4/2024	1.1	5	4	12	0	3	103	2	-91	-91	35553	15127
6/5/2024	1	5	27	512	508	1	512	1	0	0	36065	15635
6/6/2024	1.3	4	45	-62	-70	2	13	1	-75	-75	36003	15565
6/7/2024	1.8	3	68	0	0	0	0	0	0	0	36003	15565
6/10/2024	1.4	3	75	0	0	0	0	0	0	0	36003	15565
6/11/2024	1.5	3	76	0	0	0	0	0	0	0	36003	15565
6/12/2024	1.9	3	75	0	0	0	0	0	0	0	36003	15565
6/13/2024	1.9	3	70	0	0	0	0	0	0	0	36003	15565
6/14/2024	1.9	3	59	69	65	1	69	1	0	0	36072	15630
6/17/2024	1.2	3	59	626	622	1	626	1	0	0	36698	16252
6/18/2024	2.3	3	39	0	0	0	0	0	0	0	36698	16252
6/20/2024	1.7	3	34	-515	-535	5	0	0	-272	-515	36183	15717
6/21/2024	1.1	6	40	0	0	0	0	0	0	0	36183	15717
6/24/2024	1.1	7	2	0	0	0	0	0	0	0	36183	15717
6/25/2024	0.6	7	-21	0	0	0	0	0	0	0	36183	15717
6/26/2024	0.7	7	-33	0	0	0	0	0	0	0	36183	15717
6/27/2024	0.8	7	-44	0	0	0	0	0	0	0	36183	15717
6/28/2024	0.7	7	-75	0	0	0	0	0	0	0	36183	15717
7/1/2024	0.7	7	-81	0	0	0	0	0	0	0	36183	15717
7/2/2024	0.6	7	-62	0	0	0	0	0	0	0	36183	15717
7/3/2024	0.9	6	-27	0	0	0	0	0	0	0	36183	15717
7/5/2024	1.5	4	27	416	408	2	416	1	0	0	36599	16125
7/8/2024	2.1	4	47	0	0	0	0	0	0	0	36599	16125
7/9/2024	5.4	1	72	0	0	0	0	0	0	0	36599	16125
7/10/2024	2.8	2	82	0	0	0	0	0	0	0	36599	16125
7/11/2024	3.3	2	87	0	0	0	0	0	0	0	36599	16125
7/12/2024	3.9	3	90	0	0	0	0	0	0	0	36599	16125
7/15/2024	3.3	3	73	0	0	0	0	0	0	0	36599	16125
7/16/2024	2.5	3	61	0	0	0	0	0	0	0	36599	16125
7/17/2024	1.9	3	37	-165	-173	2	161	1	-326	-326	36434	15952
7/18/2024	1.3	3	23	-888	-916	7	137	2	-345	-1025	35546	15036
7/19/2024	0.9	6	-15	0	0	0	0	0	0	0	35546	15036
7/22/2024	0.6	6	-60	0	0	0	0	0	0	0	35546	15036
7/23/2024	0.6	6	-74	0	0	0	0	0	0	0	35546	15036

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
7/24/2024	0.6	6	-90	0	0	0	0	0	0	0	35546	15036
7/25/2024	0.5	6	-90	0	0	0	0	0	0	0	35546	15036
7/26/2024	0.6	6	-85	0	0	0	0	0	0	0	35546	15036
7/29/2024	0.5	6	-80	0	0	0	0	0	0	0	35546	15036
7/30/2024	0.5	6	-72	0	0	0	0	0	0	0	35546	15036
7/31/2024	0.4	7	-77	0	0	0	0	0	0	0	35546	15036
8/1/2024	0.4	7	-82	0	0	0	0	0	0	0	35546	15036
8/2/2024	0.6	7	-74	0	0	0	0	0	0	0	35546	15036
8/5/2024	0.8	7	-61	0	0	0	0	0	0	0	35546	15036
8/6/2024	0.7	7	-65	0	0	0	0	0	0	0	35546	15036
8/7/2024	0.7	7	-71	0	0	0	0	0	0	0	35546	15036
8/8/2024	0.6	7	-79	0	0	0	0	0	0	0	35546	15036
8/9/2024	0.5	7	-79	0	0	0	0	0	0	0	35546	15036
8/12/2024	0.6	7	-77	0	0	0	0	0	0	0	35546	15036
8/13/2024	0.5	7	-79	0	0	0	0	0	0	0	35546	15036
8/14/2024	0.6	7	-81	0	0	0	0	0	0	0	35546	15036
8/15/2024	0.7	7	-92	0	0	0	0	0	0	0	35546	15036
8/16/2024	0.5	7	-95	0	0	0	0	0	0	0	35546	15036
8/19/2024	0.5	7	-90	0	0	0	0	0	0	0	35546	15036
8/20/2024	0.7	7	-72	0	0	0	0	0	0	0	35546	15036
8/21/2024	0.9	7	-24	0	0	0	0	0	0	0	35546	15036
8/22/2024	1.2	7	4	0	0	0	0	0	0	0	35546	15036
8/23/2024	1.4	7	59	0	0	0	0	0	0	0	35546	15036
8/26/2024	2	7	87	0	0	0	0	0	0	0	35546	15036
8/27/2024	5.8	2	94	0	0	0	0	0	0	0	35546	15036
8/28/2024	3.7	2	94	0	0	0	0	0	0	0	35546	15036
8/29/2024	2.6	4	81	0	0	0	0	0	0	0	35546	15036
8/30/2024	1.7	4	58	245	233	3	418	2	-173	-173	35791	15269
9/2/2024	1.6	4	40	0	0	0	0	0	0	0	35791	15269
9/3/2024	1.4	4	36	336	324	3	679	2	-343	-343	36127	15593
9/4/2024	1.5	4	28	-251	-259	2	0	0	-237	-251	35876	15334
9/5/2024	1.5	4	10	313	301	3	313	3	0	0	36189	15635
9/6/2024	1.4	4	-1	377	361	4	644	1	-218	-267	36566	15996
9/9/2024	1.3	4	6	61	49	3	235	2	-174	-174	36627	16045
9/10/2024	1.1	4	22	154	134	5	561	2	-185	-407	36781	16179
9/11/2024	1.2	4	47	1772	1764	2	1772	2	0	0	38553	17943
9/12/2024	2	4	57	0	0	0	0	0	0	0	38553	17943
9/13/2024	2.9	4	66	0	0	0	0	0	0	0	38553	17943
9/16/2024	3	4	64	0	0	0	0	0	0	0	38553	17943
9/17/2024	2.2	4	74	0	0	0	0	0	0	0	38553	17943
9/18/2024	2	4	75	0	0	0	0	0	0	0	38553	17943
9/19/2024	2.1	4	72	0	0	0	0	0	0	0	38553	17943
9/20/2024	1.9	4	63	0	0	0	0	0	0	0	38553	17943
9/23/2024	1.9	3	53	-56	-60	1	0	0	-56	-56	38497	17883
9/24/2024	1.9	3	39	-133	-145	3	237	1	-266	-370	38364	17738
9/25/2024	1.8	3	0	12	8	1	12	1	0	0	38376	17746
9/26/2024	0.9	3	-35	48	36	3	344	2	-296	-296	38424	17782
9/27/2024	0.8	3	-34	-189	-193	1	0	0	-189	-189	38235	17589
9/30/2024	0.7	3	-28	-183	-195	3	252	1	-340	-435	38052	17394
10/1/2024	0.8	3	-39	-71	-95	6	465	2	-238	-536	37981	17299
10/2/2024	0.9	4	-57	89	81	2	278	1	-189	-189	38070	17380
10/3/2024	0.8	4	-51	-253	-277	6	60	2	-109	-305	37817	17103
10/4/2024	0.8	4	-62	296	288	2	314	1	-18	-18	38113	17391
10/7/2024	0.8	4	-51	-418	-434	4	30	1	-367	-448	37695	16957
10/8/2024	0.7	4	-54	295	291	1	295	1	0	0	37990	17248
10/9/2024	0.9	4	-44	411	407	1	411	1	0	0	38401	17655
10/10/2024	1	4	-19	75	67	2	116	1	-41	-41	38476	17722
10/11/2024	1	4	0	188	180	2	276	1	-88	-88	38664	17902
10/14/2024	1.2	4	8	-45	-57	3	116	1	-86	-161	38619	17845

Date	pf	lr	r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
10/15/2024	1.3	4	22	35	19	4	404	1	-145	-369	38654	17864
10/16/2024	1.4	3	70	0	0	0	0	0	0	0	38654	17864
10/17/2024	1.2	6	64	0	0	0	0	0	0	0	38654	17864
10/18/2024	1	6	5	0	0	0	0	0	0	0	38654	17864
10/21/2024	0.9	6	0	0	0	0	0	0	0	0	38654	17864
10/22/2024	1.3	6	-33	0	0	0	0	0	0	0	38654	17864
10/23/2024	1.2	6	-44	0	0	0	0	0	0	0	38654	17864
10/24/2024	0.8	6	-54	0	0	0	0	0	0	0	38654	17864
10/25/2024	0.8	6	-58	0	0	0	0	0	0	0	38654	17864

Appendix I: n^{th} Order Polynomial Next Bar's Forecast Math

What is the n^{th} Order Polynomial?

The n^{th} Order Polynomial, also called the n^{th} Order Fixed Memory Polynomial, is simply the least square fit of a polynomial of the form $\mathbf{b_0+b_1*t+b_2*t^2+b_3*t^3+\ldots b_n*t^n}$ to a ***fixed*** number of past data points. Where **t** is discrete time bars. Time could be daily bars or 5-minute bars. We use the term "Fixed Memory" to designate that only a fixed number of data points are used to calculate the polynomial coefficients. It is assumed that the time bars occur at fixed intervals of time so tic bars would not be appropriate for this analysis. Least squares are a mathematical technique where the squared vertical distance between the data and the curve that is being fit to the data is minimized. When the net squared distance (also called the sum of the squared errors) is minimized, a unique set of coefficients $\mathbf{b_0,b_1,b_2,\ldots,b_n}$ for the polynomial is determined. This type of error minimization is mathematically solvable and is widely used in science and mathematics.

For a 4^{th} order polynomial equation, the least squares coefficients are obtained from the solution of the following matrix equation.

$$\begin{bmatrix} T & \sum t & \sum t^2 & \sum t^3 & \sum t^4 \\ \sum t & \sum t^2 & \sum t^3 & \sum t^4 & \sum t^5 \\ \sum t^2 & \sum t^3 & \sum t^4 & \sum t^5 & \sum t^6 \\ \sum t^3 & \sum t^4 & \sum t^5 & \sum t^6 & \sum t^7 \\ \sum t^4 & \sum t^5 & \sum t^6 & \sum t^7 & \sum t^8 \end{bmatrix} \begin{bmatrix} a_0 \\ b_0 \\ c_0 \\ d_0 \\ e_0 \end{bmatrix} = \begin{bmatrix} \sum p(t) \\ \sum (p(t)*t) \\ \sum (p(t)*t^2) \\ \sum (p(t)*t^3) \\ \sum (p(t)*t^4) \end{bmatrix}$$

where

p(T) is the current bar's price, **p(T-1)** is the previous bar's price and **p(1)** is the price **T** bars ago.
T is the number of Bars in the Least Squares estimation
$\sum$**p(t)** is the summation of prices from **t=1 to T** bars
$\sum$**p(t)*t** is the summation of prices times t from **t=1 to T** bars
$\sum$**t** is the summation of the integer **t** from **t=1 to T** bars
$\sum t^2$ is the summation of the integer **t** squared from **t=1 to T** bars
etc.

Once the coefficients to the polynomial have been solved for, we generate the forecast for the next bar's price which is given for the equation by:

$$\mathbf{P_f = a_0 + b_0*(T+1) + c_0*(T+1)^2 + d_0*(T+1)^3 + e_0*(T+1)^4}$$

Where $\mathbf{P_f}$ stands for price forecast.

With these coefficients, we can also generate the forecast for the next bar's ***velocity*** and ***velocity*** by the equations:

$$\mathbf{Velocity(T+1) = dP_f/dt = b_0 + 2c_0*(T+1) + 3d_0*(T+1)^2 + 4e_0*(T+1)^3}$$

$$\mathbf{Acceleration(t+1) = d^2P_f/d^2t = 2c_0 + 6d_0*(T+1) + 12e_0*(T+1)^2}$$

We use the next bar forecast because changes in the trend are more quickly reflected in the forecast price, velocity and velocity than in the end point price, velocity and velocity.

Programs that solve for the solution to matrix equations can be found in the book "Numerical Recipes" by W. Press, et. al. However this type of matrix equation solvers is very slow and for these types of problems are unstable. They cause numerical errors and floating-point overflows due to matrix inversion ill conditioning which produces false results.

Appendix I: n^{th} Order Polynomial Next Bar's Forecast Math

Fortunately, these types of problems can be solved by a fast, efficient and accurate algorithm using Discrete Orthogona1 Legendre Polynomials. This method is explained in detail in Norman Morrison' book entitled "Introduction to Sequential Smoothing and Prediction", Chapter 7 page 223., referenced at the end of this section.

Without going into detail here (see Morrison reference), the polynomial filter can now be represented by:

$$P_e(t) = \sum_{j=0}^{n} \beta_j * \phi_j(t) \quad j=0 \text{ to } n$$

Where **n** is the polynomial order, **T** is the total number of Bars of data used in the Least Squares fit and

$$\beta_j = \sum_{k=0}^{T-1} p(t-T+k) * \phi_j(k)$$

$\phi_j(t)$ = the *normalized* discrete Legendre polynomial. t = an integer from 0 to T

The coefficients, $\beta_0, \beta_1, \beta_2, \beta_3, , , , \beta_n$ for a n^{th} order polynomial can now be solved for by the equation above and we can generate the forecast for the next bar's close, velocity and velocity which are given by the equations

$$P_F(T+1) = \beta_0*\phi_0(T+1) + \beta_1*\phi_1(T+1) + \beta_2*\phi_2(T+1) + \beta_3*\phi_3(T+1) + \ldots + \beta_n*\phi_n(T+1)$$

$$\text{Velocity} = (dP_F/dt)_{(T+1)} = \beta_1*(d\phi_1/dt)_{(T+1)} + \beta_2*(d\phi_2/dt)_{(T+1)} + \beta_3*(d\phi_3/dt)_{(T+1)} + + \beta_n*(d\phi_n/dt)_{(T+1)}$$

$$\text{Acceleration} = (d^2P_F/d^2t)_{(T+1)} = \beta_2*(d^2\phi_2/d^2t)_{(T+1)} + \beta_3*(d^2\phi_3/d^2t)_{(T+1)} + \ldots + \beta_n*(d^2\phi_n/d^2t)_{(T+1)}$$

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

The least squares forecast is constructed by solving for the least squares coefficients $\beta_1, \beta_2, , , \beta_n$ at each bar using the last **T** bars of closing prices and the Discrete Orthogonal Legendre Polynomial equations for β_j above. Then **Velocity** = $d^2P_F(T+1)/d^2t$ is constructed from the velocity equation above and plotted under the price chart. In general, what we will be doing is following the plotted curve of **Velocity** which is calculated at each bar from the previous T bars. When the velocity is greater than a threshold amount ***vup*** we will go long. When the velocity is less than a threshold amount ***-vdn*** we will go short.

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

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

References

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

The *Normalization Multiplier*

What is the Multiplier?

The n^{th} Order Fixed Memory Polynomial, also called an n^{th} Order Polynomial, is the least square fit of a polynomial of the form $\mathbf{b_0+b_1*t+b_2*t^2+b_3*t^3+\ldots+b_n*t^n}$ to a ***fixed*** number of past data points. Where **t** is discrete time bars. Time could be daily bars or 5-minute bars. We use the term "Fixed Memory" to designate that only a fixed number of data points are used to calculate the polynomial coefficients. It is assumed that the time bars occur at fixed intervals of time so tic bars would not be appropriate for this analysis. Least squares are a mathematical technique where the squared vertical distance between the data and the curve that is being fit to the data is minimized. When the net squared distance (also called the sum of the squared errors) is minimized, a unique set of coefficients $\mathbf{b_0,b_1,b_2,\ldots,b_n}$ for the polynomial is determined. This type of error minimization is mathematically solvable and is widely used in science and mathematics. Once the $\mathbf{b_n}$ coefficients are found using a lookback period of **T** bars to calculate the $\mathbf{b_n}$ coefficients, then the next bar's estimate **(T+1)** of the n^{th} order polynomial velocity and acceleration can be easily found by the equations below.

$$\mathbf{Velocity(T+1) = dP_f/dt = b_0 + 2c_0*(T+1) + 3d_0*(T+1)^2 + 4e_0*(T+1)^3 +\ldots.+n*b_n*(T+1)^{n-1}}$$

$$\mathbf{Acceleration(t+1) = d^2P_f/d^2t = 2\,c_0 + 9d_0*(T+1) + 12e_0*(T+1)^3+\ldots\ldots.+ n*(n-1)*b_n*(T+1)^{n-2}}$$

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

For any tradable, the inputs to the polynomial are the **polynomial degree (Order)** and the number or lookback bars **N** (denoted by T in equations above). When we plot the velocity or acceleration, we notice that the amplitude, and the maximum and minimum values of the velocity or acceleration vary quite significantly with different degree and N inputs.

Below is a table of the standard deviation (SD) of the 56340 calculated Velocity values for different **degree** and **N** inputs. We used 1min bars of the E-Mini from 8/1/2014 to 2/20/2015 to generate this table. As one can see the standard deviation of the velocity for each degree and N vary greatly. For instance, for degree=4, N=20 the SD is 6.8 times the SD for degree=1, N=20. This creates problems when trying to determine the correct ranges for vup/vdn and aup/adn during optimization.

@ES.D 5 min bars Date Range 1140801 to 1150220
Total Number of Bars=56340 Norm=0
FixmVn Multiplier= 1/SD to Scale Velocity pw and N Range to One SD

Degree	N	SD	1/SD
1	20	0.1902	5.2565
1	30	0.1540	6.4916
1	40	0.1328	7.5279
1	50	0.1183	8.4502
1	60	0.1077	9.3320
1	70	0.0996	10.0440
avg		0.1338	7.8430
2	20	0.4351	2.2982
2	30	0.3443	2.9046
2	40	0.2936	3.4060
2	50	0.1583	3.8275
2	60	0.2371	4.2180
2	70	0.2173	4.6010

avg		**0.2981**	**3.5425**
3	**20**	**0.7854**	**1.2732**
3	**30**	**0.5933**	**1.6855**
3	**40**	**0.4973**	**2.0111**
3	**50**	**0.4347**	**2.3005**
3	**60**	**0.3949**	**2.5324**
3	**70**	**0.3656**	**2.7352**
avg		**0.5119**	**2.0897**
4	**20**	**1.2924**	**0.7738**
4	**30**	**0.9279**	**1.0777**
4	**40**	**0.7582**	**1.3189**
4	**5**	**0.6542**	**1.5285**
4	**60**	**0.5804**	**1.7228**
4	**70**	**0.5314**	**1.8818**
avg		**0.7908**	**1.3839**

The problem may get worse when we want to find good inputs for other tradables. Other tradables, because of their scales and tick size have much different Velocity ranges then the E-Mini for the same degree and N. Thus, the NS search ranges have to be different for each different tradable.

To solve this problem and to have a standard search space for each tradable, I created a **Mult** input for each FixmXVA Velocity and Acceleration strategy and indicator. If each tradable's Velocity is multiplied by a number such that the standard deviation of that tradable's Velocity is around one, then the search space for vup and vdn for each tradable would be 0 to 3.5 SDs and we wouldn't have to change the TS search space every time we wanted to examine a new stock or future. The complicated equations that I use to normalize the ranges to one standard deviation were derived using the software TableCurve 3D, automated surface and equation discovery.