Trading DIA ETF 5min Bars Using the nth Order Fixed Memory Polynomial Acceleration Algorithm
Walk Forward in-sample 20 Trading weekdays and out-of-sample 1 Trading weekday
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In previous working papers at https://meyersanalytics.com/papers we showed how the application of a price curve generated by the **Nth Order Fixed Memory Polynomial Acceleration** could be used to develop a strategy to buy and sell futures and stocks intraday. The reasoning behind this type of strategy was to only trade when the price trend acceleration 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 acceleration of that price trend moves above a minimum threshold noise value. Thus, the acceleration strategy would only issue a trade when certain acceleration thresholds above "noise" levels are crossed.

The acceleration strategy that we will use here to trade the Dow Jones ETF (**DIA**) is called the nth Order Polynomial Acceleration Strategy. The nth Order Adaptive Polynomial Acceleration 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 acceleration 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 Acceleration Strategy to trade the DIA ETF on an intraday basis using 5-min bar price data from 12/1/2019 to 7/9/2021.

The n^{th} Order Fixed Memory Acceleration Strategy Defined
The least squares forecast n^{th} order fixed memory polynomial acceleration 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 the n^{th} Order Fixed Memory Polynomial **Acceleration(T+1)** is constructed from the equation shown in the "Math" appendix.

Due to polynomial mathematics, the Acceleration of the 3^{rd} and 4^{th} order degree polynomial curve changes faster than it's corresponding second order degree polynomial acceleration. Whether higher order polynomial accelerations 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 (2nd through 4^{th}) fixed memory polynomial acceleration from the formulas in the "Math" appendix. As will be shown below, walk forward optimization will determine the **degree** for the nth order polynomial acceleration, the number of lookback prices, **N**, needed to compute the polynomial coefficients and the threshold amounts **aup** and **adn**. When the nth order degree acceleration is greater than the threshold amount ***aup*** we will go long. When the acceleration is less than the threshold amount ***-adn*** we will go short.

Buy Rule:
IF Acceleration is greater than or equal to the threshold amount ***aup and* Acceleration*[1] is less than aup*** then buy at the market.

Sell Rule:

IF Acceleration is less than or equal to the threshold amount ***-adn and*** **Acceleration[1] is** ***greater than adn*** then sell at the market.

Where **Acceleration** [1] is the acceleration of the previous bar.

Intraday Bars Exit Rule:

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

Testing The Polynomial Acceleration Strategy Using Walk Forward Optimization

There will be four strategy parameters to determine:

1. **degree**, degree=2 for 2nd order acceleration, degree=3 for 3rd order acceleration, etc.
2. ***N***, is the number of lookback bars of prices to calculate the **acceleration.**
3. ***aup***, the threshold amount that acceleration must be greater than to issue a buy signal
4. ***adn***, the threshold amount that acceleration 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 FixmAn 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 FixmAn Strategy Parameters Using Walk Forward Optimization
There are four strategy parameters to find*, pw, N, aup, adn.*

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 FixmAn 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. **pw=degree from 2 to 4**
2. **N from 6 to 20 in steps of 2.**
3. **aup from 0.25 to 3.5 steps of 0.25**
4. **adn from 0.25 to 3.5 in steps of 0.25**
5. **Mult = 2.9, iNorm=1 (See Appendix 3, the Normalization Multiplier)**

The above pw, n, aup, adn will produce 4704 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≤70 to 90 step 5.** We will also look at the strategy input with no metric-filter. With 4704 different strategy input combinations this will give us 508031 **strategy input|metric-filter** combinations. Each one of these 508031-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 508031combinations 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 FixmAn 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 row 8 of the Figure below. That is,

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3|20|1.25|2.75|0|1555|2.9|pf<2|r2<70. This is constructed as follows. For the strategy inputs **3|20|1.25|2.75|0|1555|2.9|** only those in-sample sections that have a **pf ≤2** and **r2≤70** are used to trade in the following out-of-sample sections. If the in-sample pf > 2 and or r2>70 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	DIA5mFixmA20x1dxo	s12/31/19	e07/09/21	#399	AnyTnp						lSnt2			a(12.2)	s13.1	f508031					c=$4						
2	pw|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	3|20|1.75|2.5|0|1555|2.9|r2<80	15426	14366	132	58.2	2.3	379	0.992	5.59	3.76	1.35	58	68	-671	-696	-1564	12	3	117	19	2231	92	77	104	118	217	5.55E-16
4	3|20|1.75|2.5|0|1555|2.9|pf<6|r2<80	15002	13958	133	57.5	2.3	385	0.973	5.42	3.66	1.35	57	68	-671	-696	-1564	10	3	113	19	2262	92	76	104	125	198	1.67E-16
5	3|20|1.75|2.5|0|1555|2.9|pf<5|r2<80	14871	13855	135	58.5	2.3	388	0.974	5.39	3.66	1.34	58	68	-671	-696	-1282	10	3	110	19	2236	93	76	66	125	311	3.33E-16
6	3|20|1.75|2.5|0|1555|2.9|pf<4|r2<80	14850	13838	136	58.7	2.3	390	0.962	5.34	3.65	1.35	58	68	-671	-696	-1282	10	3	109	19	2233	93	76	66	126	311	3.89E-16
7	3|20|1.75|2.5|0|1555|2.9|pf<3|r2<80	14576	13592	138	59.3	2.3	395	0.941	5.19	3.59	1.38	57	67	-671	-696	-1282	9	3	106	19	2223	92	76	66	130	290	5.55E-17
8	3|20|1.25|2.75|0|1555|2.9|pf<2|r2<70	14385	13417	101	59.4	1.7	284	0.855	4.73	4.25	1.49	58	64	-588	-576	-819	9	3	142	26	1638	95	85	38	93	980	2.78E-16
9	3|20|1.25|2.75|0|1555|2.9|pf<2|r2<75	14340	13276	97	53.9	1.8	300	0.698	4.33	3.92	1.45	57	63	-588	-585	-819	7	3	148	26	1956	93	79	53	109	499	3.11E-15
10	3|20|1.75|2.5|0|1555|2.9|r2<75	14184	13232	133	59.6	2.2	388	0.966	5.47	3.53	1.34	58	67	-671	-696	-1564	8	3	107	19	2170	92	75	104	134	175	5.00E-17
11	3|20|1.75|2.75|0|1555|2.9|pf<5|r2<75	14020	13092	134	60.4	2.2	395	0.721	4.4	3.46	1.36	58	67	-782	-696	-1198	8	3	105	19	2240	91	73	104	140	159	5.00E-17
12	3|20|1.75|2.5|0|1555|2.9|pf<6|r2<75	13975	13027	132	59	2.2	390	0.967	5.43	3.48	1.34	58	67	-671	-696	-1564	7	3	106	19	2171	92	75	104	138	167	1.11E-16
13	3|20|1.75|2.75|0|1555|2.9|pf<4|r2<75	13897	12973	134	60.2	2.2	397	0.717	4.36	3.43	1.36	58	66	-782	-696	-1198	8	3	104	19	2235	91	73	104	143	154	5.00E-17
14	3|20|1.25|2.75|0|1555|2.9|pf<2|r2<80	14077	12969	92	50.8	1.8	302	0.665	4.26	3.77	1.38	57	63	-745	-585	-819	7	3	153	28	1901	93	79	53	118	443	6.20E-14
15	3|20|1.75|2.5|0|1555|2.9|pf<5|r2<75	13844	12924	134	60.2	2.2	393	0.968	5.4	3.47	1.32	59	67	-671	-696	-1282	7	3	103	19	2144	92	75	66	139	263	5.00E-17

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 **-$12.2** with a bootstrap standard deviation of **$13.1**. (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 13417/142=94.48). The probability of obtaining our filters average daily net profit **of 94.48** is **$2.78x10^{-16}$** which is **8.1** 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 **$94.48** is $[1-(1-\mathbf{2.78x10^{-16}})^{508031}]$ ~= $\mathbf{508031*2.78x10^{-16}} = 1.41x\ 10^{-10}$ where **508031** is the total number of different filters we looked at in this run. This number is much 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 FixmAn Strategy buy/sells and the FixmAn 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, 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 **38** days for this filter. This means that 38 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=58%**. **%P** is the % winning oos days, **%P=64%**. The average oos winning trade to the average oos losing trade ratio(**oW|oL**) was **1.49**. **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 ($588) and the largest losing day was ($576).

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 $13417 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 FixmAn 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 142 days out of the 399 days or about 35% 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 FixmAn Strategy 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.

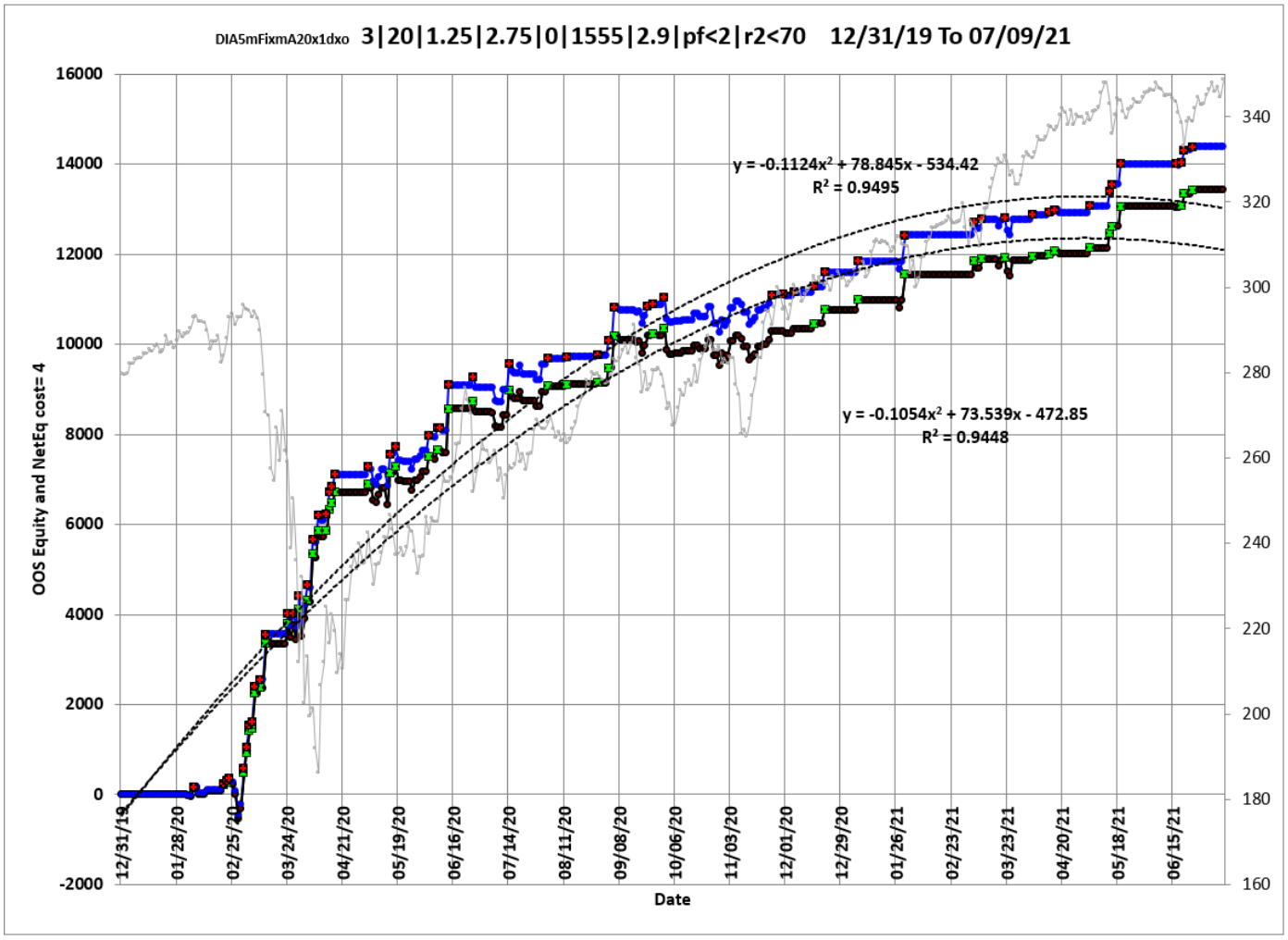

Figure 2 Walk Forward Out-Of-Sample Performance Summary for nth Order Fixed Memory Polynomial Acceleration Strategy DIA 5-minute bar chart from 6/18/21 to 6/24/21

Figure 3 Partial output of the Walk Forward Strategy Inputs with Metric Filters (WFINP)
DIA ETF 5 min bars Using The FixmAn 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	DIA5mFixmA20x1dxo	s12/31/19	e07/09/21	#399	AnyTnp						lSnt2			a(12.2)	s13.1	f508031					c=$4						
2	pw|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	3|20|1.75|2.5|0|1555|2.9|r2<80	15426	14366	132	58.2	2.3	379	0.992	5.59	3.76	1.35	58	68	-671	-696	-1564	12	3	117	19	2231	92	77	104	118	217	5.55E-16
4	3|20|1.75|2.5|0|1555|2.9|pf<6|r2<80	15002	13958	133	57.5	2.3	385	0.973	5.42	3.66	1.35	57	68	-671	-696	-1564	10	3	113	19	2262	92	76	104	125	198	1.67E-16
5	3|20|1.75|2.5|0|1555|2.9|pf<5|r2<80	14871	13855	135	58.5	2.3	388	0.974	5.39	3.66	1.34	58	68	-671	-696	-1282	10	3	110	19	2236	93	76	66	125	311	3.33E-16
6	3|20|1.75|2.5|0|1555|2.9|pf<4|r2<80	14850	13838	136	58.7	2.3	390	0.962	5.34	3.65	1.35	58	68	-671	-696	-1282	10	3	109	19	2233	93	76	66	126	311	3.89E-16
7	3|20|1.75|2.5|0|1555|2.9|pf<3|r2<80	14576	13592	138	59.3	2.3	395	0.941	5.19	3.59	1.38	57	67	-671	-696	-1282	9	3	106	19	2223	92	76	66	130	290	5.55E-17
8	3|20|1.25|2.75|0|1555|2.9|pf<2|r2<70	14385	13417	101	59.4	1.7	284	0.855	4.73	4.25	1.49	58	64	-588	-576	-819	9	3	142	26	1638	95	85	38	93	980	2.78E-16
9	3|20|1.25|2.75|0|1555|2.9|pf<2|r2<75	14340	13276	97	53.9	1.8	300	0.698	4.33	3.92	1.45	57	63	-588	-585	-819	7	3	148	26	1956	93	79	53	109	499	3.11E-15
10	3|20|1.75|2.5|0|1555|2.9|r2<75	14184	13232	133	59.6	2.2	388	0.966	5.47	3.53	1.34	58	67	-671	-696	-1564	8	3	107	19	2170	92	75	104	134	175	5.00E-17
11	3|20|1.75|2.75|0|1555|2.9|pf<5|r2<75	14020	13092	134	60.4	2.2	395	0.721	4.4	3.46	1.36	58	67	-782	-696	-1198	8	3	105	19	2240	91	73	104	140	159	5.00E-17
12	3|20|1.75|2.5|0|1555|2.9|pf<6|r2<75	13975	13027	132	59	2.2	390	0.967	5.43	3.48	1.34	58	67	-671	-696	-1564	7	3	106	19	2171	92	75	104	138	167	1.11E-16
13	3|20|1.75|2.75|0|1555|2.9|pf<4|r2<75	13897	12973	134	60.2	2.2	397	0.717	4.36	3.43	1.36	58	66	-782	-696	-1198	8	3	104	19	2235	91	73	104	143	154	5.00E-17
14	3|20|1.25|2.75|0|1555|2.9|pf<2|r2<80	14077	12969	92	50.8	1.8	302	0.665	4.26	3.77	1.38	57	63	-745	-585	-819	7	3	153	28	1901	93	79	53	118	443	6.20E-14
15	3|20|1.75|2.5|0|1555|2.9|pf<5|r2<75	13844	12924	134	60.2	2.2	393	0.968	5.4	3.47	1.32	59	67	-671	-696	-1282	7	3	103	19	2144	92	75	66	139	263	5.00E-17

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

Row 1 DIA5Fixm20x1dxo 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***
  Row 8: **3|20|1.25|2.75|0|1555|2.9|pf<2|r2<70**: The strategy inputs **3|20|1.25|2.75|0|1555|2.9|**for all in-sample files that have **PF≤2 and R2 ≤70**.
  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 random bootstrap average for the 399 out-of-sample files of ($12.2) with a bootstrap standard deviation of $13.1. (Note. The average for the random selection is computed as the Average Random toNP/399) The average net weekly for the filter would be the filter toNP/ (# of OOS) periods traded would be the filter toNP/# of OOS periods traded or 13417/142=94.5). The probability of obtaining our filters average daily net profit **of 94.5** is **$2.78x10^{-16}$** which is **8.1** 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 **$94.5** is $[1-(1-\mathbf{2.78x10^{-16}})^{508031}]$ **~ 508031*2.78x10^{-16} = 1.41x10^{-10}** where **508031** is the total number of different filters we looked at in this run. This number is much 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 FixmAn Strategy

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

Filter: **3|20|1.25|2.75|0|1555|2.9|pf<2|r2<70**: The strategy inputs **3|20|1.25|2.75|0|1555|2.9|** for all in-sample files that have **PF≤2 and R2 ≤70**.
are used to trade in the following out-of-sample sections.
IS tnp = In-sample total net profit
IS nT = In-sample number of trades
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	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/22/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/23/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/24/20	304	3	99	100	0	0	0	0	0	0	0	0	0
01/27/20	304	3	99	100	0	0	0	0	0	0	0	0	0
01/28/20	283	4	14.48	79	0	0	0	0	0	0	0	0	0
01/29/20	283	4	14.48	79	0	0	0	0	0	0	0	0	0
01/30/20	283	4	14.48	79	0	0	0	0	0	0	0	0	0
01/31/20	381	4	19.14	74	0	0	0	0	0	0	0	0	0
02/03/20	72	5	1.22	5	(19)	(23)	1	0	0	-19	-19	(19)	(23)
02/04/20	53	6	1.15	-1	(17)	(29)	3	36	1	-32	-53	(36)	(52)
02/05/20	36	9	1.09	-17	196	192	1	196	1	0	0	160	140
02/06/20	232	10	1.58	-2	0	0	0	0	0	0	0	160	140
02/07/20	232	10	1.58	-2	(133)	(137)	1	0	0	-133	-133	27	3
02/10/20	99	11	1.19	-3	0	0	0	0	0	0	0	27	3

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
02/11/20	99	11	1.19	-3	0	0	0	0	0	0	0	27	3
02/12/20	99	11	1.19	-3	71	67	1	71	1	0	0	98	70
02/13/20	170	12	1.32	-1	0	0	0	0	0	0	0	98	70
02/14/20	81	11	1.15	-4	0	0	0	0	0	0	0	98	70
02/17/20	81	11	1.15	-4	0	0	0	0	0	0	0	98	70
02/18/20	81	11	1.15	-4	0	0	0	0	0	0	0	98	70
02/19/20	81	11	1.15	-4	0	0	0	0	0	0	0	98	70
02/20/20	81	11	1.15	-4	139	135	1	139	1	0	0	237	205
02/21/20	143	11	1.27	1	65	61	1	65	1	0	0	302	266
02/24/20	208	12	1.39	10	56	44	3	176	1	-76	-120	358	310
02/25/20	285	14	1.45	31	(84)	(88)	1	0	0	-84	-84	274	222
02/26/20	201	15	1.28	36	(212)	(216)	1	0	0	-212	-212	62	6
02/27/20	-11	16	0.99	22	(523)	(539)	4	180	2	-588	-703	(461)	(533)
02/29/20	-770	19	0.53	1	240	216	6	735	3	-279	-495	(221)	(317)
03/02/20	-221	24	0.88	-14	809	801	2	974	1	-165	-165	588	484
03/03/20	607	25	1.31	-8	463	447	4	491	3	-28	-28	1051	931
03/04/20	1087	26	1.56	7	482	478	1	482	1	0	0	1533	1409
03/05/20	1373	26	1.71	17	64	48	4	352	3	-288	-288	1597	1457
03/06/20	1437	30	1.64	44	804	788	4	804	4	0	0	2401	2245
03/09/20	2374	33	2.13	61	0	0	0	0	0	0	0	2401	2245
03/10/20	2015	39	1.66	70	145	117	7	1101	2	-255	-760	2546	2362
03/11/20	2160	46	1.54	71	0	0	0	0	0	0	0	2546	2362
03/12/20	1504	49	1.32	70	1007	983	6	1339	5	-332	-332	3553	3345
03/13/20	2511	55	1.5	74	0	0	0	0	0	0	0	3553	3345
03/16/20	3339	60	1.62	77	0	0	0	0	0	0	0	3553	3345
03/17/20	2890	65	1.44	81	0	0	0	0	0	0	0	3553	3345
03/18/20	4062	70	1.62	85	0	0	0	0	0	0	0	3553	3345
03/19/20	3162	77	1.4	88	0	0	0	0	0	0	0	3553	3345
03/20/20	2620	81	1.3	82	0	0	0	0	0	0	0	3553	3345
03/23/20	1200	84	1.12	74	0	0	0	0	0	0	0	3553	3345
03/24/20	1778	89	1.17	52	458	450	2	627	1	-169	-169	4011	3795
03/25/20	2320	90	1.22	49	(289)	(313)	6	482	3	-409	-489	3722	3482
03/26/20	2243	95	1.2	41	291	271	5	581	2	-176	-290	4013	3753
03/27/20	3057	96	1.28	32	(295)	(315)	5	189	1	-251	-484	3718	3438
03/30/20	2522	95	1.23	17	676	672	1	676	1	0	0	4394	4110
03/31/20	2389	94	1.23	13	(576)	(588)	3	0	0	-475	-576	3818	3522
04/01/20	1350	93	1.12	6	384	372	3	444	2	-60	-60	4202	3894
04/02/20	1252	95	1.11	5	438	426	3	438	3	0	0	4640	4320
04/03/20	1626	94	1.15	4	(38)	(42)	1	0	0	-38	-38	4602	4278
04/06/20	784	91	1.07	3	1065	1053	3	1065	3	0	0	5667	5331
04/07/20	2208	88	1.22	3	(74)	(82)	2	278	1	-352	-352	5593	5249
04/08/20	1989	83	1.21	1	600	596	1	600	1	0	0	6193	5845

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
04/09/20	3174	80	1.36	0	(109)	(121)	3	81	1	-121	-190	6084	5724
04/10/20	2058	77	1.24	1	0	0	0	0	0	0	0	6084	5724
04/13/20	1230	72	1.15	1	148	140	2	158	1	-10	-10	6232	5864
04/14/20	1827	69	1.26	5	480	468	3	480	3	0	0	6712	6332
04/15/20	1135	67	1.16	25	136	128	2	136	2	0	0	6848	6460
04/16/20	2171	62	1.39	65	248	244	1	248	1	0	0	7096	6704
04/17/20	2822	58	1.58	78	0	0	0	0	0	0	0	7096	6704
04/20/20	4580	57	2.27	86	0	0	0	0	0	0	0	7096	6704
04/21/20	3669	51	2.1	88	0	0	0	0	0	0	0	7096	6704
04/22/20	3005	52	1.85	90	0	0	0	0	0	0	0	7096	6704
04/23/20	3397	47	2.23	91	0	0	0	0	0	0	0	7096	6704
04/24/20	3010	43	2.18	92	0	0	0	0	0	0	0	7096	6704
04/27/20	3305	38	2.59	90	0	0	0	0	0	0	0	7096	6704
04/28/20	2629	37	2.27	89	0	0	0	0	0	0	0	7096	6704
04/29/20	2863	35	2.55	85	0	0	0	0	0	0	0	7096	6704
04/30/20	2655	33	2.49	79	0	0	0	0	0	0	0	7096	6704
05/01/20	2092	32	2.1	65	0	0	0	0	0	0	0	7096	6704
05/04/20	1814	33	1.83	52	181	177	1	181	1	0	0	7277	6881
05/05/20	930	31	1.43	33	(70)	(74)	1	0	0	-70	-70	7207	6807
05/06/20	934	30	1.49	15	(270)	(274)	1	0	0	-270	-270	6937	6533
05/07/20	64	30	1.03	5	(59)	(63)	1	0	0	-59	-59	6878	6470
05/08/20	114	28	1.06	-2	175	171	1	175	1	0	0	7053	6641
05/11/20	289	29	1.14	-4	172	168	1	172	1	0	0	7225	6809
05/12/20	313	28	1.15	-23	0	0	0	0	0	0	0	7225	6809
05/13/20	-167	25	0.92	-59	(370)	(374)	1	0	0	-370	-370	6855	6435
05/14/20	-673	24	0.72	-79	705	701	1	705	1	0	0	7560	7136
05/15/20	-216	24	0.91	-68	0	0	0	0	0	0	0	7560	7136
05/18/20	-619	21	0.73	-66	154	142	3	215	2	-61	-61	7714	7278
05/19/20	-188	22	0.91	-14	(310)	(314)	1	0	0	-310	-310	7404	6964
05/20/20	-292	20	0.86	-3	2	(2)	1	2	1	0	0	7406	6962
05/21/20	-393	20	0.81	0	(21)	(25)	1	0	0	-21	-21	7385	6937
05/22/20	-318	20	0.84	3	0	0	0	0	0	0	0	7385	6937
05/25/20	-318	20	0.84	3	0	0	0	0	0	0	0	7385	6937
05/26/20	-318	20	0.84	3	(172)	(184)	3	0	0	-97	-172	7213	6753
05/27/20	-148	22	0.92	2	215	211	1	215	1	0	0	7428	6964
05/28/20	-109	22	0.94	8	0	0	0	0	0	0	0	7428	6964
05/29/20	16	20	1.01	17	75	71	1	75	1	0	0	7503	7035
06/01/20	407	19	1.31	24	128	124	1	128	1	0	0	7631	7159
06/02/20	354	19	1.27	33	0	0	0	0	0	0	0	7631	7159
06/03/20	424	18	1.34	34	333	329	1	333	1	0	0	7964	7488
06/04/20	1027	18	2.03	36	0	0	0	0	0	0	0	7964	7488
06/05/20	994	18	1.97	35	(33)	(45)	3	38	1	-54	-71	7931	7443

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
06/08/20	786	20	1.72	44	208	204	1	208	1	0	0	8139	7647
06/09/20	822	20	1.75	47	3	(1)	1	3	1	0	0	8142	7646
06/10/20	825	21	1.75	53	(54)	(58)	1	0	0	-54	-54	8088	7588
06/11/20	1141	21	2.46	51	0	0	0	0	0	0	0	8088	7588
06/12/20	357	24	1.27	64	996	976	5	996	5	0	0	9084	8564
06/15/20	1353	29	2.01	76	0	0	0	0	0	0	0	9084	8564
06/16/20	1613	30	2.08	86	0	0	0	0	0	0	0	9084	8564
06/17/20	1944	34	2.28	90	0	0	0	0	0	0	0	9084	8564
06/18/20	1840	34	2.14	90	0	0	0	0	0	0	0	9084	8564
06/19/20	1826	34	2.12	90	0	0	0	0	0	0	0	9084	8564
06/22/20	1401	35	1.68	86	0	0	0	0	0	0	0	9084	8564
06/23/20	1565	36	1.76	84	0	0	0	0	0	0	0	9084	8564
06/24/20	1672	34	1.86	77	0	0	0	0	0	0	0	9084	8564
06/25/20	1134	34	1.5	69	179	167	3	276	1	-55	-97	9263	8731
06/26/20	1313	37	1.55	53	(241)	(245)	1	0	0	-241	-241	9022	8486
06/29/20	997	37	1.38	45	0	0	0	0	0	0	0	9022	8486
06/30/20	869	36	1.33	41	0	0	0	0	0	0	0	9022	8486
07/01/20	869	36	1.33	41	0	0	0	0	0	0	0	9022	8486
07/02/20	536	35	1.21	39	14	2	3	174	1	-88	-88	9036	8488
07/03/20	642	37	1.24	24	0	0	0	0	0	0	0	9036	8488
07/06/20	675	34	1.26	13	(4)	(16)	3	88	1	-50	-92	9032	8472
07/07/20	463	36	1.17	4	(292)	(296)	1	0	0	-292	-292	8740	8176
07/08/20	168	36	1.06	1	(18)	(22)	1	0	0	-18	-18	8722	8154
07/09/20	204	36	1.07	0	0	0	0	0	0	0	0	8722	8154
07/10/20	283	32	1.12	-17	274	270	1	274	1	0	0	8996	8424
07/13/20	-439	28	0.82	-73	0	0	0	0	0	0	0	8996	8424
07/14/20	-853	24	0.61	-82	563	559	1	563	1	0	0	9559	8983
07/15/20	-311	20	0.83	-38	(153)	(157)	1	0	0	-153	-153	9406	8826
07/16/20	-362	20	0.81	-15	(43)	(47)	1	0	0	-43	-43	9363	8779
07/17/20	-370	20	0.81	-2	0	0	0	0	0	0	0	9363	8779
07/20/20	55	19	1.04	0	151	147	1	151	1	0	0	9514	8926
07/21/20	42	19	1.03	6	(175)	(179)	1	0	0	-175	-175	9339	8747
07/22/20	-68	19	0.96	20	0	0	0	0	0	0	0	9339	8747
07/23/20	255	18	1.2	23	0	0	0	0	0	0	0	9339	8747
07/24/20	76	15	1.06	37	0	0	0	0	0	0	0	9339	8747
07/27/20	317	14	1.34	40	0	0	0	0	0	0	0	9339	8747
07/28/20	317	14	1.34	40	(122)	(126)	1	0	0	-122	-122	9217	8621
07/29/20	195	15	1.18	37	0	0	0	0	0	0	0	9217	8621
07/30/20	195	15	1.18	37	322	314	2	322	2	0	0	9539	8935
07/31/20	503	14	1.56	50	0	0	0	0	0	0	0	9539	8935
08/03/20	503	14	1.56	50	139	135	1	139	1	0	0	9678	9070
08/04/20	646	12	1.8	54	0	0	0	0	0	0	0	9678	9070

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
08/05/20	938	11	2.84	41	0	0	0	0	0	0	0	9678	9070
08/06/20	1079	11	3.19	37	0	0	0	0	0	0	0	9678	9070
08/07/20	1079	11	3.19	37	0	0	0	0	0	0	0	9678	9070
08/10/20	805	10	2.63	19	0	0	0	0	0	0	0	9678	9070
08/11/20	805	10	2.63	19	0	0	0	0	0	0	0	9678	9070
08/12/20	-206	10	0.78	18	32	28	1	32	1	0	0	9710	9098
08/13/20	-21	10	0.97	9	0	0	0	0	0	0	0	9710	9098
08/14/20	22	9	1.03	7	0	0	0	0	0	0	0	9710	9098
08/17/20	22	9	1.03	7	0	0	0	0	0	0	0	9710	9098
08/18/20	-129	8	0.83	14	0	0	0	0	0	0	0	9710	9098
08/19/20	46	7	1.08	9	0	0	0	0	0	0	0	9710	9098
08/20/20	46	7	1.08	9	0	0	0	0	0	0	0	9710	9098
08/21/20	46	7	1.08	9	0	0	0	0	0	0	0	9710	9098
08/24/20	46	7	1.08	9	0	0	0	0	0	0	0	9710	9098
08/25/20	46	7	1.08	9	0	0	0	0	0	0	0	9710	9098
08/26/20	168	6	1.38	0	0	0	0	0	0	0	0	9710	9098
08/27/20	168	6	1.38	0	39	35	1	39	1	0	0	9749	9133
08/28/20	-115	5	0.74	-54	0	0	0	0	0	0	0	9749	9133
08/31/20	-115	5	0.74	-54	0	0	0	0	0	0	0	9749	9133
09/01/20	-254	4	0.43	-46	0	0	0	0	0	0	0	9749	9133
09/02/20	-254	4	0.43	-46	335	331	1	335	1	0	0	10084	9464
09/03/20	-42	4	0.91	74	0	0	0	0	0	0	0	10084	9464
09/04/20	-351	7	0.54	21	725	717	2	725	2	0	0	10809	10181
09/07/20	374	9	1.49	60	0	0	0	0	0	0	0	10809	10181
09/08/20	374	9	1.49	60	(68)	(84)	4	150	2	-161	-218	10741	10097
09/09/20	754	12	2.43	76	0	0	0	0	0	0	0	10741	10097
09/10/20	722	11	2.37	72	0	0	0	0	0	0	0	10741	10097
09/11/20	163	12	1.15	33	0	0	0	0	0	0	0	10741	10097
09/14/20	163	12	1.15	33	0	0	0	0	0	0	0	10741	10097
09/15/20	163	12	1.15	33	0	0	0	0	0	0	0	10741	10097
09/16/20	163	12	1.15	33	(49)	(53)	1	0	0	-49	-49	10692	10044
09/17/20	114	13	1.1	12	26	22	1	26	1	0	0	10718	10066
09/18/20	140	14	1.12	4	(259)	(263)	1	0	0	-259	-259	10459	9803
09/21/20	-119	15	0.91	0	177	169	2	177	2	0	0	10636	9972
09/22/20	58	17	1.04	-4	212	208	1	212	1	0	0	10848	10180
09/23/20	270	18	1.19	-4	0	0	0	0	0	0	0	10848	10180
09/24/20	270	18	1.19	-4	39	35	1	39	1	0	0	10887	10215
09/25/20	270	18	1.19	-9	0	0	0	0	0	0	0	10887	10215
09/28/20	270	18	1.19	-9	(18)	(22)	1	0	0	-18	-18	10869	10193
09/29/20	252	19	1.18	-9	0	0	0	0	0	0	0	10869	10193
09/30/20	252	19	1.18	-9	156	152	1	156	1	0	0	11025	10345
10/01/20	73	19	1.05	-7	(466)	(478)	3	0	0	-193	-466	10559	9867

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
10/02/20	-84	19	0.95	-40	(84)	(88)	1	0	0	-84	-84	10475	9779
10/05/20	-893	18	0.46	-41	0	0	0	0	0	0	0	10475	9779
10/06/20	-893	18	0.46	-41	30	22	2	71	1	-41	-41	10505	9801
10/07/20	-795	16	0.46	-4	0	0	0	0	0	0	0	10505	9801
10/08/20	-795	16	0.46	-4	0	0	0	0	0	0	0	10505	9801
10/09/20	-236	15	0.74	-3	36	32	1	36	1	0	0	10541	9833
10/12/20	-200	16	0.78	-7	0	0	0	0	0	0	0	10541	9833
10/13/20	-200	16	0.78	-7	0	0	0	0	0	0	0	10541	9833
10/14/20	-200	16	0.78	-7	0	0	0	0	0	0	0	10541	9833
10/15/20	-151	15	0.83	-8	145	141	1	145	1	0	0	10686	9974
10/16/20	-32	15	0.96	-6	0	0	0	0	0	0	0	10686	9974
10/19/20	227	14	1.37	-21	(76)	(80)	1	0	0	-76	-76	10610	9894
10/20/20	-26	13	0.96	-55	0	0	0	0	0	0	0	10610	9894
10/21/20	-238	12	0.65	-53	0	0	0	0	0	0	0	10610	9894
10/22/20	-238	12	0.65	-53	210	206	1	210	1	0	0	10820	10100
10/23/20	-67	12	0.9	-21	0	0	0	0	0	0	0	10820	10100
10/26/20	-67	12	0.9	-21	(360)	(364)	1	0	0	-360	-360	10460	9736
10/27/20	-409	12	0.6	-21	0	0	0	0	0	0	0	10460	9736
10/28/20	-409	12	0.6	-21	(192)	(200)	2	92	1	-284	-284	10268	9536
10/29/20	-757	13	0.42	-20	260	256	1	260	1	0	0	10528	9792
10/30/20	-31	11	0.96	-3	(129)	(133)	1	0	0	-129	-129	10399	9659
11/02/20	-76	11	0.91	-16	102	98	1	102	1	0	0	10501	9757
11/03/20	26	12	1.03	-15	308	300	2	347	1	-39	-39	10809	10057
11/04/20	304	12	1.34	1	0	0	0	0	0	0	0	10809	10057
11/05/20	304	12	1.34	1	137	133	1	137	1	0	0	10946	10190
11/06/20	441	13	1.5	10	0	0	0	0	0	0	0	10946	10190
11/09/20	405	12	1.46	9	(69)	(81)	3	242	1	-165	-165	10877	10109
11/10/20	336	15	1.28	30	(164)	(176)	3	118	1	-143	-282	10713	9933
11/11/20	172	18	1.12	17	0	0	0	0	0	0	0	10713	9933
11/12/20	172	18	1.12	17	(284)	(288)	1	0	0	-284	-284	10429	9645
11/13/20	-257	18	0.85	9	85	73	3	183	1	-49	-98	10514	9718
11/16/20	-172	21	0.91	0	58	54	1	58	1	0	0	10572	9772
11/17/20	-38	21	0.98	0	172	168	1	172	1	0	0	10744	9940
11/18/20	134	22	1.07	0	0	0	0	0	0	0	0	10744	9940
11/19/20	134	22	1.07	0	53	49	1	53	1	0	0	10797	9989
11/20/20	-23	22	0.99	1	0	0	0	0	0	0	0	10797	9989
11/23/20	-23	22	0.99	1	98	94	1	98	1	0	0	10895	10083
11/24/20	435	22	1.3	2	199	195	1	199	1	0	0	11094	10278
11/25/20	634	23	1.44	7	0	0	0	0	0	0	0	11094	10278
11/26/20	826	21	1.72	2	0	0	0	0	0	0	0	11094	10278
11/27/20	566	20	1.5	1	0	0	0	0	0	0	0	11094	10278
11/30/20	695	19	1.69	0	8	4	1	8	1	0	0	11102	10282

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
12/01/20	601	19	1.59	0	(41)	(45)	1	0	0	-41	-41	11061	10237
12/02/20	252	18	1.25	4	0	0	0	0	0	0	0	11061	10237
12/03/20	252	18	1.25	4	0	0	0	0	0	0	0	11061	10237
12/04/20	115	17	1.11	10	93	89	1	93	1	0	0	11154	10326
12/07/20	208	18	1.2	17	0	0	0	0	0	0	0	11154	10326
12/08/20	277	15	1.39	58	0	0	0	0	0	0	0	11154	10326
12/09/20	441	12	2.04	93	0	0	0	0	0	0	0	11154	10326
12/10/20	441	12	2.04	93	0	0	0	0	0	0	0	11154	10326
12/11/20	725	11	6.22	95	0	0	0	0	0	0	0	11154	10326
12/14/20	690	9	17.83	90	0	0	0	0	0	0	0	11154	10326
12/15/20	273	9	1.68	32	125	121	1	125	1	0	0	11279	10447
12/16/20	226	9	1.56	7	0	0	0	0	0	0	0	11279	10447
12/17/20	226	9	1.56	7	0	0	0	0	0	0	0	11279	10447
12/18/20	173	8	1.43	-1	0	0	0	0	0	0	0	11279	10447
12/21/20	173	8	1.43	-1	325	321	1	325	1	0	0	11604	10768
12/22/20	400	8	2	0	0	0	0	0	0	0	0	11604	10768
12/23/20	201	7	1.5	0	(20)	(24)	1	0	0	-20	-20	11584	10744
12/24/20	181	8	1.43	8	0	0	0	0	0	0	0	11584	10744
12/25/20	181	8	1.43	8	0	0	0	0	0	0	0	11584	10744
12/28/20	181	8	1.43	8	2	(2)	1	2	1	0	0	11586	10742
12/29/20	175	8	1.42	20	0	0	0	0	0	0	0	11586	10742
12/30/20	216	7	1.57	18	0	0	0	0	0	0	0	11586	10742
12/31/20	216	7	1.57	18	0	0	0	0	0	0	0	11586	10742
01/01/21	216	7	1.57	18	0	0	0	0	0	0	0	11586	10742
01/04/21	123	6	1.32	31	0	0	0	0	0	0	0	11586	10742
01/05/21	123	6	1.32	31	0	0	0	0	0	0	0	11586	10742
01/06/21	123	6	1.32	31	247	243	1	247	1	0	0	11833	10985
01/07/21	370	7	1.98	53	0	0	0	0	0	0	0	11833	10985
01/08/21	370	7	1.98	53	0	0	0	0	0	0	0	11833	10985
01/11/21	320	6	1.84	87	0	0	0	0	0	0	0	11833	10985
01/12/21	714	6	36.7	84	0	0	0	0	0	0	0	11833	10985
01/13/21	589	5	30.45	74	0	0	0	0	0	0	0	11833	10985
01/14/21	589	5	30.45	74	0	0	0	0	0	0	0	11833	10985
01/15/21	589	5	30.45	74	0	0	0	0	0	0	0	11833	10985
01/18/21	589	5	30.45	74	0	0	0	0	0	0	0	11833	10985
01/19/21	264	4	14.2	85	0	0	0	0	0	0	0	11833	10985
01/20/21	200	5	3.38	68	0	0	0	0	0	0	0	11833	10985
01/21/21	220	4	4.44	49	0	0	0	0	0	0	0	11833	10985
01/22/21	220	4	4.44	49	0	0	0	0	0	0	0	11833	10985
01/25/21	261	5	5.08	45	0	0	0	0	0	0	0	11833	10985
01/26/21	276	7	1.9	-18	0	0	0	0	0	0	0	11833	10985
01/27/21	276	7	1.9	-18	(168)	(176)	2	11	1	-179	-179	11665	10809

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/28/21	108	9	1.22	-8	156	152	1	156	1	0	0	11821	10961
01/29/21	264	10	1.54	-1	591	579	3	591	2	0	0	12412	11540
02/01/21	855	13	2.76	33	0	0	0	0	0	0	0	12412	11540
02/02/21	951	14	2.96	46	0	0	0	0	0	0	0	12412	11540
02/03/21	1135	15	3.34	56	0	0	0	0	0	0	0	12412	11540
02/04/21	888	14	2.83	61	0	0	0	0	0	0	0	12412	11540
02/05/21	888	14	2.83	61	0	0	0	0	0	0	0	12412	11540
02/08/21	784	15	2.33	68	0	0	0	0	0	0	0	12412	11540
02/09/21	749	14	2.27	74	0	0	0	0	0	0	0	12412	11540
02/10/21	749	14	2.27	74	0	0	0	0	0	0	0	12412	11540
02/11/21	758	15	2.29	78	0	0	0	0	0	0	0	12412	11540
02/12/21	634	16	1.89	78	0	0	0	0	0	0	0	12412	11540
02/15/21	634	16	1.89	78	0	0	0	0	0	0	0	12412	11540
02/16/21	634	16	1.89	78	0	0	0	0	0	0	0	12412	11540
02/17/21	698	15	2.08	80	0	0	0	0	0	0	0	12412	11540
02/18/21	698	15	2.08	80	0	0	0	0	0	0	0	12412	11540
02/19/21	698	15	2.08	80	0	0	0	0	0	0	0	12412	11540
02/22/21	657	14	2.01	85	0	0	0	0	0	0	0	12412	11540
02/23/21	771	12	2.89	77	0	0	0	0	0	0	0	12412	11540
02/24/21	1007	13	3.47	81	0	0	0	0	0	0	0	12412	11540
02/25/21	1617	12	8.09	78	0	0	0	0	0	0	0	12412	11540
02/26/21	1272	12	4.05	76	0	0	0	0	0	0	0	12412	11540
03/01/21	633	10	2.36	62	0	0	0	0	0	0	0	12412	11540
03/02/21	639	10	2.37	64	0	0	0	0	0	0	0	12412	11540
03/03/21	455	9	1.98	71	0	0	0	0	0	0	0	12412	11540
03/04/21	455	9	1.98	71	0	0	0	0	0	0	0	12412	11540
03/05/21	-103	11	0.9	13	297	293	1	297	1	0	0	12709	11833
03/08/21	298	11	1.32	7	(140)	(144)	1	0	0	-140	-140	12569	11689
03/09/21	158	12	1.15	3	0	0	0	0	0	0	0	12569	11689
03/10/21	158	12	1.15	3	204	200	1	204	1	0	0	12773	11889
03/11/21	353	12	1.33	1	0	0	0	0	0	0	0	12773	11889
03/12/21	477	11	1.51	-3	0	0	0	0	0	0	0	12773	11889
03/15/21	477	11	1.51	-3	0	0	0	0	0	0	0	12773	11889
03/16/21	477	11	1.51	-3	0	0	0	0	0	0	0	12773	11889
03/17/21	477	11	1.51	-3	0	0	0	0	0	0	0	12773	11889
03/18/21	477	11	1.51	-3	(147)	(151)	1	0	0	-147	-147	12626	11738
03/19/21	330	12	1.3	-4	113	109	1	113	1	0	0	12739	11847
03/22/21	443	13	1.41	-2	75	71	1	75	1	0	0	12814	11918
03/23/21	387	13	1.36	-10	(293)	(297)	1	0	0	-293	-293	12521	11621
03/24/21	-142	13	0.9	-25	(97)	(101)	1	0	0	-97	-97	12424	11520
03/25/21	-681	13	0.54	-21	350	346	1	350	1	0	0	12774	11866
03/26/21	-142	13	0.89	-5	0	0	0	0	0	0	0	12774	11866

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
03/29/21	-94	12	0.92	0	0	0	0	0	0	0	0	12774	11866
03/30/21	-196	11	0.84	8	0	0	0	0	0	0	0	12774	11866
03/31/21	-196	11	0.84	8	0	0	0	0	0	0	0	12774	11866
04/01/21	-196	11	0.84	8	0	0	0	0	0	0	0	12774	11866
04/02/21	362	9	1.53	-3	0	0	0	0	0	0	0	12774	11866
04/05/21	65	8	1.1	-1	91	87	1	91	1	0	0	12865	11953
04/06/21	296	8	1.55	0	0	0	0	0	0	0	0	12865	11953
04/07/21	296	8	1.55	0	0	0	0	0	0	0	0	12865	11953
04/08/21	92	7	1.17	4	0	0	0	0	0	0	0	12865	11953
04/09/21	92	7	1.17	4	0	0	0	0	0	0	0	12865	11953
04/12/21	92	7	1.17	4	0	0	0	0	0	0	0	12865	11953
04/13/21	92	7	1.17	4	51	47	1	51	1	0	0	12916	12000
04/14/21	143	8	1.27	17	0	0	0	0	0	0	0	12916	12000
04/15/21	143	8	1.27	17	69	65	1	69	1	0	0	12985	12065
04/16/21	359	8	1.92	30	0	0	0	0	0	0	0	12985	12065
04/19/21	246	7	1.63	42	(63)	(67)	1	0	0	-63	-63	12922	11998
04/20/21	108	7	1.24	77	0	0	0	0	0	0	0	12922	11998
04/21/21	401	6	3.51	69	0	0	0	0	0	0	0	12922	11998
04/22/21	498	5	8.9	70	0	0	0	0	0	0	0	12922	11998
04/23/21	148	4	3.35	40	0	0	0	0	0	0	0	12922	11998
04/26/21	148	4	3.35	40	0	0	0	0	0	0	0	12922	11998
04/27/21	148	4	3.35	40	0	0	0	0	0	0	0	12922	11998
04/28/21	148	4	3.35	40	0	0	0	0	0	0	0	12922	11998
04/29/21	148	4	3.35	40	0	0	0	0	0	0	0	12922	11998
04/30/21	148	4	3.35	40	0	0	0	0	0	0	0	12922	11998
05/03/21	148	4	3.35	40	0	0	0	0	0	0	0	12922	11998
05/04/21	56	4	1.88	-4	141	137	1	141	1	0	0	13063	12135
05/05/21	197	5	4.08	33	0	0	0	0	0	0	0	13063	12135
05/06/21	197	5	4.08	33	0	0	0	0	0	0	0	13063	12135
05/07/21	197	5	4.08	33	0	0	0	0	0	0	0	13063	12135
05/10/21	197	5	4.08	33	0	0	0	0	0	0	0	13063	12135
05/11/21	197	5	4.08	33	0	0	0	0	0	0	0	13063	12135
05/12/21	-215	6	0.49	-28	0	0	0	0	0	0	0	13063	12135
05/13/21	-215	6	0.49	-28	324	320	1	324	1	0	0	13387	12455
05/14/21	40	6	1.09	-1	158	154	1	158	1	0	0	13545	12609
05/17/21	198	7	1.47	11	0	0	0	0	0	0	0	13545	12609
05/18/21	261	6	1.72	10	0	0	0	0	0	0	0	13545	12609
05/19/21	261	6	1.72	10	448	440	2	448	2	0	0	13993	13049
05/20/21	709	8	2.96	58	0	0	0	0	0	0	0	13993	13049
05/21/21	709	8	2.96	58	0	0	0	0	0	0	0	13993	13049
05/24/21	598	9	2.26	67	0	0	0	0	0	0	0	13993	13049
05/25/21	598	9	2.26	67	0	0	0	0	0	0	0	13993	13049

Date	IS tnp	IS nT	IS pf	IS r2	osnp	NOnp$4	ont	ownp	ownt	ollt	odd	EQ	NetEq
12/31/19	244	2	99	100	0	0	0	0	0	0	0	0	0
01/01/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/02/20	91	1	99	0	0	0	0	0	0	0	0	0	0
01/03/20	229	2	99	100	0	0	0	0	0	0	0	0	0
01/06/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/07/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/08/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/09/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/10/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/13/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/14/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/15/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/16/20	138	1	99	0	0	0	0	0	0	0	0	0	0
01/17/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/20/20	227	2	99	100	0	0	0	0	0	0	0	0	0
01/21/20	227	2	99	100	0	0	0	0	0	0	0	0	0
05/26/21	598	9	2.26	67	0	0	0	0	0	0	0	13993	13049
05/27/21	598	9	2.26	67	0	0	0	0	0	0	0	13993	13049
05/28/21	516	10	1.93	68	0	0	0	0	0	0	0	13993	13049
05/31/21	516	10	1.93	68	0	0	0	0	0	0	0	13993	13049
06/01/21	517	9	1.93	67	0	0	0	0	0	0	0	13993	13049
06/02/21	376	8	1.68	76	0	0	0	0	0	0	0	13993	13049
06/03/21	376	8	1.68	76	0	0	0	0	0	0	0	13993	13049
06/04/21	475	9	1.86	76	0	0	0	0	0	0	0	13993	13049
06/07/21	475	9	1.86	76	0	0	0	0	0	0	0	13993	13049
06/08/21	475	9	1.86	76	0	0	0	0	0	0	0	13993	13049
06/09/21	843	8	5.37	61	0	0	0	0	0	0	0	13993	13049
06/10/21	843	8	5.37	61	0	0	0	0	0	0	0	13993	13049
06/11/21	262	8	1.58	6	0	0	0	0	0	0	0	13993	13049
06/14/21	104	7	1.23	-6	0	0	0	0	0	0	0	13993	13049
06/15/21	104	7	1.23	-6	0	0	0	0	0	0	0	13993	13049
06/16/21	104	7	1.23	-6	2	(2)	1	2	1	0	0	13995	13047
06/17/21	-342	6	0.24	-50	(17)	(21)	1	0	0	-17	-17	13978	13026
06/18/21	-359	7	0.23	-62	52	44	2	54	1	-2	-2	14030	13070
06/21/21	-196	8	0.45	-47	273	269	1	273	1	0	0	14303	13339
06/22/21	77	9	1.22	-3	0	0	0	0	0	0	0	14303	13339
06/23/21	77	9	1.22	-3	0	0	0	0	0	0	0	14303	13339
06/24/21	77	9	1.22	-3	82	78	1	82	1	0	0	14385	13417
06/25/21	241	9	1.87	6	0	0	0	0	0	0	0	14385	13417
06/28/21	241	9	1.87	6	0	0	0	0	0	0	0	14385	13417
06/29/21	241	9	1.87	6	0	0	0	0	0	0	0	14385	13417
06/30/21	241	9	1.87	6	0	0	0	0	0	0	0	14385	13417
07/01/21	241	9	1.87	6	0	0	0	0	0	0	0	14385	13417
07/02/21	142	8	1.51	22	0	0	0	0	0	0	0	14385	13417
07/05/21	142	8	1.51	22	0	0	0	0	0	0	0	14385	13417
07/06/21	142	8	1.51	22	0	0	0	0	0	0	0	14385	13417
07/07/21	135	7	1.49	72	0	0	0	0	0	0	0	14385	13417
07/08/21	135	7	1.49	72	0	0	0	0	0	0	0	14385	13417
07/09/21	337	8	3.86	77	0	0	0	0	0	0	0	14385	13417

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 is 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.

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

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 ***acceleration*** and ***acceleration*** by the equations:

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

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

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

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 are 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, acceleration and acceleration which are given by the equations

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

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

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

The n^{th} Order Fixed Memory Forecast Next Bar's Acceleration 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 **Acceleration** = $d^2P_F(T+1)/d^2t$ is constructed from the acceleration equation above and plotted under the price chart. In general, what we will be doing is following the plotted curve of **Acceleration** which is calculated at each bar from the previous T bars. When the acceleration is greater than a threshold amount ***aup*** we will go long. When the acceleration is less than a threshold amount ***-adn*** we will go short.

Buy Rule:

IF Acceleration is greater than the threshold amount ***aup*** then buy at the market.

Sell Rule:

IF Acceleration is less than the threshold amount ***-adn*** 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 is 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 acceleration and acceleration can be easily found by the equations below.

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

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

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 acceleration or acceleration, we notice that the amplitude, and the maximum and minimum values of the acceleration or acceleration vary quite significantly with different degree and N inputs.

Below is a table of the standard deviation (SD) of the 56340 calculated Acceleration 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 acceleration 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 aup/adn and aup/adn during optimization.

@ES.D 5 min bars Date Range 1140801 to 1150220
Total Number of Bars=56340 Norm=0
FixmAn Multiplier= 1/SD to Scale Acceleration 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	9.3990
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 Acceleration 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 Acceleration and Acceleration strategy and indicator. If each tradable's Acceleration is multiplied by a number such that the standard deviation of that tradable's Acceleration is around one, then the search space for aup and adn 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.