Introducing TRI-SIGNAL AI-enabled Predictive Equity Analytics with Dynamic State Space

Introducing a new portfolio predictive analytic strategy that avoids market downturns as well as identifies and captures gains for individual stocks, mutual funds, ETFs, managed portfolios, quantitative research and direct indexing.

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April 15, 2024

Predictive Equity Analytics (PEA) defined

PEA is an analytic framework that predicts the price movement of individual stocks or portfolios of stocks with 90-95%+ accuracy for sufficiently strong price signals over the next 1- 5 trading days. It is based on extracting a set of price signals (i.e., signal_1 and signal_3) that facilitate dynamic state space representation of prices. PEA foundational path dependent aspects were first discussed in Bruno Dupire's 2019 paper Functional Ito Calculus.

PEA = Short range GPS for investment return

Merton type stochastic return model → Signal set extraction → State space representation (path dependence)

Predictive Equity Analytics with Dynamic State Space Definitions: Position, Momentum

$$r_t = \mu_t + f(\sigma_t^2) + I\_jump\_process_t$$

Where return (r_t) is a function of drift (μ_t), volatility (σ_t) and jumps $(I\_jump\_process)$

Important

- Predictive Equity Analytics with Dynamic State Space **position**
  – defined as the ***level of*** μ_t
- Predictive Equity Analytics with Dynamic State Space **momentum**
  – defined as the ***rate of change of*** μ_t

Cf. the **standard momentum** considered in the literature:

- Time series momentum
  – **A security's *own* past return predicts its future return**
- Cross-sectional momentum
  – **A security's *outperformance relative to peers* predicts future *relative outperformance***

Moskowitz, Tobias J., Yao Hua Ooi, and Lasse Heje Pedersen. 2012. "Time Series Momentum." Journal of Financial Economics 104 (2): 228–250. doi:10.1016/j.jfineco.2011.11.003.

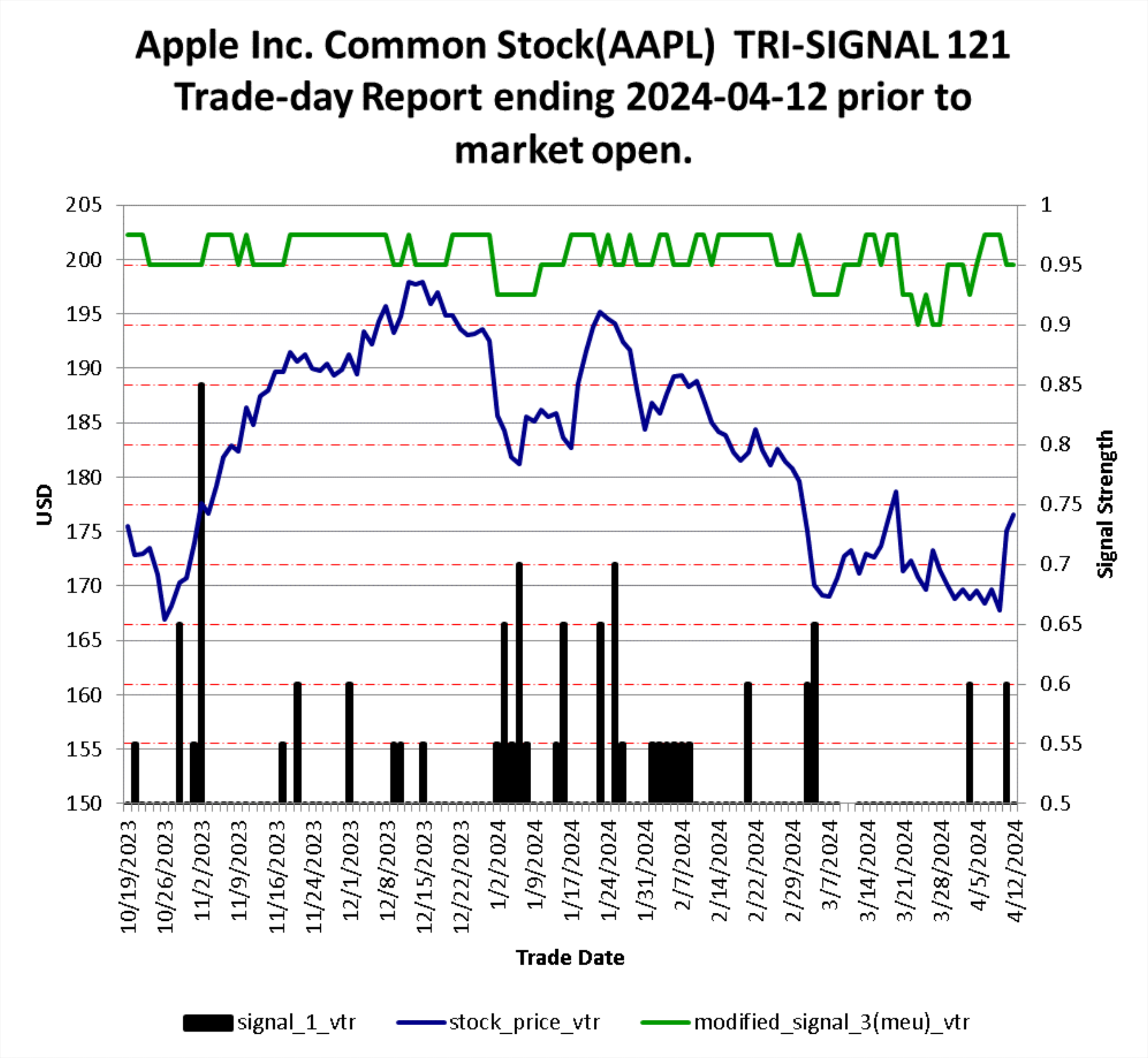
For the **first-time**, the time dependent drift term 'meu' including dynamics has been measured with sufficient accuracy and sensitivity to be distinct from variance components.

"The standard assumption of measuring "combined drift and variance produces no bias or error is not valid."

TRI-SIGNAL AI-enabled Predictive Equity Analytics Prospective and Retrospective Analytics

- **Prospectively** TRI-SIGNAL produces 3 signals for each equity symbol prior to market open. Signals {1,3} used together predict in advance of likely coming change point in next 1 to 3 trade-days. Signal 2 is somewhat predictive for changes in “overall variance” but the same information is available within heavy variance matrix “B” and Poisson point-mass matrix “A” below.

- **Retrospectively** TRI-SIGNAL maps the original time-series to a set of 3 x 3 matrices (‘similar in function to ‘Dolby type music filter’)consisting of Signal “C” matrix, Heavy Variance(tail) “B” matrix and Poisson point mass “A” matrix. The eigenvalues and eigenvectors are calculated for a series of 60 trade-day sliding window at time points {-60,…,-20,-10,-5,-1} which enables **earliest retrospective change-point verification signified by uniform change in sign of eigenvector coefficients. This referred to as ‘AI-enabled’.**



Prospectively TRI-SIGNAL produces 3 signals for each equity symbol prior to market open. Signals {1,3} used together predict in advance of likely coming change point in next 1 to 3 trade-days.

Predictive signals available prior to market open:

1) when (Signal_3) meu (green line) drifts up or down, the time-series moves in "similar direction."
2) The level of meu also is predictive by itself, the more time points at levels above 0.95, the move likely the series is NOT moving down. Below 0.95 the series is definitely moving down.
3) Signal_1 at level = 1.0 is associated with prospective change-point detection since it acts much like second derivative of a function in Calculus 1.

Apple(AAPL) Sample Retrospective Matrices

1) Original series ABC (yellow),
2) Signal "C" matrices (light orange) and
3) Combined variance matrices "AB" (light green)

Return is partitioned into drift/meu and variance components over time.

Using combined ABC series, the drop-off of variance contribution is masked as well as drop and then recovery of Signal_3 from t = -40 to to t = 0.

Apple Inc. Common Stock(A		Apple Inc. Common Stock(AAPL) 120 Trade days ending 2024-04-12 prior to market open 2024-04-15 (L: 172.11, C: 176.55, H: 184.19)											
s.													
		Combined & Collapsed Matrices: Al				Combined & Collapsed Matrices: C				Combined & Collapsed Matrices: Al			
(FREQ. / TOTAL COUNT) * AVE.			Signal_3(meu)				Signal_3(meu)				Signal_3(meu)		
		meu < 0.95	meu in [0.9	meu > 0.97		meu < 0.95	meu in [0.9	meu > 0.97		meu < 0.95	meu in [0.9	meu > 0.97	
	Momentum	.0083	.0334	.1253		.0083	.0334	.1253		.	.	.	
120 TD, t= 0	Momentum	.0833	.2499	.334		.0667	.2247	.309		.0166	.0252	.0251	
	Momentum	.0492	.1166	.	1.	.0328	.0831	.	.8833	.0164	.0335	.	.1167
	Momentum	.0166	.0501	.1665		.0166	.0501	.1665		.	.	.	
60 TD, t= 0	Momentum	.0833	.1826	.2676		.0833	.1826	.2508		.	.	.0167	
	Momentum	.0823	.1503	.	.9993	.0495	.0832	.	.8827	.0328	.0671	.	.1166
	Momentum	.	.0336	.1329		.	.0336	.1329		.	.	.	
60 TD, t= -20	Momentum	.1334	.2655	.2839		.1002	.2491	.2671		.0332	.0165	.0167	
	Momentum	.0323	.1161	.	.9977	.0161	.0664	.	.8655	.0162	.0497	.	.1322
	Momentum	.	.0168	.1335		.	.0168	.1335		.	.	.	
60 TD, t= -40	Momentum	.0833	.2495	.3845		.0501	.233	.3511		.0332	.0165	.0334	
	Momentum	.0161	.1162	.	.9998	.0161	.0827	.	.8834	.	.0334	.	.1164
	Momentum	.	.0168	.084		.	.0168	.084		.	.	.	
60 TD, t= -60	Momentum	.0833	.3172	.4005		.0501	.2668	.3671		.0332	.0503	.0334	
	Momentum	.0161	.083	.	1.0008	.0161	.083	.	.8839	.	.	.	.1169

Apple(AAPL) Sample Retrospective Matrices- Eigenvalues, Eigenvectors and Change-point detection

1) Original series ABC (yellow),
2) Signal "C" matrices (light orange) and

Notice the change in sign of coefficients of eigen vectors.

Notice difference in timing of change-point detection of original time series ABC and Signal C.

Apple Inc. Common Stock(AAPL) 120 Trade days ending 2024-04-12 prior to market open 2024-04-15 (L: 172.11, C: 176.55, H: 184.19)

Message Area

Time Index			t = -40	t = -30	t = -20	t = -15	t = -10	t = -5	t = -3	t = -2	t = -1	t = 0
Date			02-14-2024	02-29-2024	03-14-2024	03-21-2024	03-28-2024	04-05-2024	04-09-2024	04-10-2024	04-11-2024	04-12-2024
Stock Price			184.15	180.75	173.	171.37	171.48	169.58	169.67	167.78	175.04	176.55
Combined Signal ABC		t = -60	t = -40	t = -30	t = -20	t = -15	t = -10	t = -5	t = -3	t = -2	t = -1	t = 0
EIGEN_	Momentum(+)	-0.08191	-0.144229	-0.150873	-0.186119	0.233846	0.2665292	0.2889321	0.3086047	0.3159887	0.3234333	-0.337098
	Momentum (0)	-0.97593	-0.944968	-0.933831	-0.935787	0.9046502	0.8788221	0.8777273	0.8696358	0.8642952	0.8588073	-0.83621
	Momentum(-)	-0.2021	-0.293656	-0.324341	-0.299435	0.3562642	0.3957703	0.3822472	0.3853526	0.3913372	0.3972921	-0.432572
	Eigenvalues:	0.407095	0.3816754	0.3902823	0.3828923	0.3585815	0.3501389	0.3673287	0.3657806	0.3599267	0.3542388	0.3546193
	Change-Point detected.					Chg_Pt						Chg_Pt
Combined Signal ABC												
Average TRENDS		1.000785	0.9997947	0.9991215	0.9976648	0.9986268	0.998336	0.9984977	0.9984048	0.9985792	0.998364	0.9992904
Signal C		t = -60	t = -40	t = -30	t = -20	t = -15	t = -10	t = -5	t = -3	t = -2	t = -1	t = 0
EIGEN_	Momentum(+)	0.098836	0.1478821	0.1545314	0.1833217	0.2433206	-0.280361	-0.295333	0.3138355	0.3250977	0.3365796	0.3365796
	Momentum (0)	0.968513	0.9577948	0.9472883	0.9613511	0.9305483	-0.905799	-0.911625	0.9044623	0.8981205	0.891442	0.891442
	Momentum(-)	0.228504	0.2464954	0.2806509	0.2054199	0.2736334	-0.317689	-0.285863	0.2888856	0.2961265	0.3033895	0.3033895
	Eigenvalues:	0.358555	0.3311189	0.3448169	0.3252626	0.2972636	0.2951451	0.316534	0.3143318	0.3067474	0.299447	0.299447
	Change-Point detected.						Chg_Pt		Chg_Pt			
Signal C												
Average TRENDS		1.000652	1.0000539	0.9992786	0.9986052	0.9997151	0.9993796	0.999461	0.9993559	0.9995534	0.9993097	0.9993097

Apple(AAPL) Predictive Report

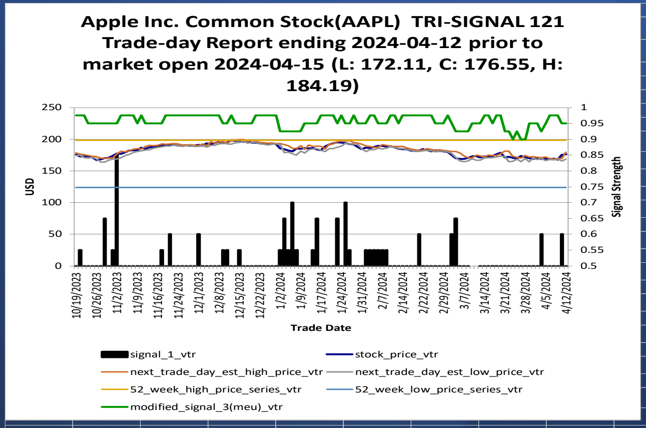
Column V is combined original time-series signal+noise.

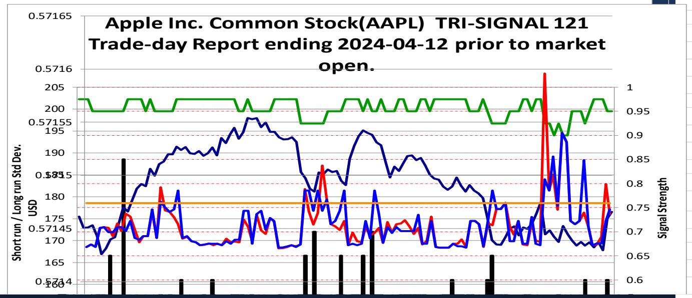
Column W is Signal C contribution.

Columns X is combined variance "AB" matrices.

Change-points detected

Yellow highlighted rows indicate bi-weekly pay-date.





		Apple Inc. Common Stock(AAPL) 120 Trade days ending 2024-04-12 prior to market open 2024-04-15 (L: 172.11, C: 176.55, H: 184.19)										
		URL Information Links :			https://www.barrons.com/quote/stock/AAI		https://finance.yahoo.com/quote/AAPL					
		Instrument	Stock				Short run	Short run	Short run	Long run	Long run	Long run
		Most recent 46 trade dates.					Local Path Dependent(s	Drift(meu	gnal_1 >= 0	20 Trade-day Rolling State Space(Matrices A,B,C)	20 Trade-day Rolling State Space(Matrix C)	ay Rolling State Space(Ma
						As of Close Da	ext Trade-d	ext Trade-d	ext Trade-d	Next Trade-day	Next Trade-day	Next Trade-day
Fokker-Plai	Fokker-Planck Discre	As of Close Date			As of Close Da	etrospectiv	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted
ChgPt in Ti	ChgPt in St	Close Date	ate Behavi	Stock Price	State {0-89}	Action: Bu	Buy/Sell/N	Buy/Sell/N	Buy/Sell/N	Average Return	Average Return	Average Return
	ABC EigenV	4/12/2024	Horizontal	176.55	75	No Action	1.0010, Buy			.9993	.9993	.9991
		4/11/2024	Up	175.04	50	Buy	998, No Act	) chg. -5%, S	IFLECTION F	.9993	.9993	.9991
ABC Medium Signal Ei		4/10/2024	Down	167.78	77	Sell	999, No Action			.9993	.9993	.9991
	ABC,C Eigen	4/9/2024	Up	169.67	77	Buy	999, No Action			.9993	.9993	.9991
		4/8/2024	Down	168.45	71	Sell	999, No Act	chg. +5%, Strong Buy		.9993	.9993	.9991
ABC Medium Signal Ei		4/5/2024	Up	169.58	69	Buy	0.9976, Sell	eu) chg. +2%, Buy		.9993	.9993	.9991
		4/4/2024	Down	168.82	48	Sell	993, No Act	eu) chg. -2	Sell	.9993	.9993	.9991
		4/3/2024	Up	169.65	75	Buy	1.0010, Buy			.9993	.9993	.9991
		4/2/2024	Down	168.84	75	Sell	1.0010, Buy			.9993	.9993	.9991
		4/1/2024	Down	170.03	63	Sell	0.9930, Sell	chg. +5%, Strong Buy		.9993	.9993	.9991
ABC, C Med	ABC,C Eigen	3/28/2024	Down	171.48	72	Sell	996, No Action			.9993	.9993	.9991
		3/27/2024	Up	173.31	78	Buy	0.9913, Sell	) chg. -5%, Strong Sell		.9993	.9993	.9991
		3/26/2024	Down	169.71	67	Sell	1.0212, Buy	chg. +5%, Strong Buy		.9993	.9993	.9991
		3/25/2024	Down	170.85	78	Sell	0.9913, Sell	) chg. -5%, Strong Sell		.9993	.9993	.9991
		3/22/2024	Up	172.28	72	Buy	996, No Action			.9993	.9993	.9991
	ABC EigenV	3/21/2024	Down	171.37	84	Sell	0.9989, Sell	) chg. -5%, Strong Sell		.9993	.9993	.9991
		3/20/2024	Up	178.67	77	Buy	999, No Action			.9993	.9993	.9991
		3/19/2024	Up	176.08	71	Buy	999, No Act	chg. +5%, Strong Buy		.9993	.9993	.9991
		3/18/2024	Up	173.72	81	Buy	000, No Act	) chg. -5%, Strong Sell		.9993	.9993	.9991
		3/15/2024	Down	172.62	77	Sell	999, No Action			.9993	.9993	.9991
		3/14/2024	Up	173.	71	Buy	999, No Act	chg. +5%, Strong Buy		.9993	.9993	.9991
		3/13/2024	Down	171.13	75	Sell	0.9976, Sell			.9977	.9986	.9916
		3/12/2024	Up	173.23	75	Buy	0.9976, Sell			.9977	.9986	.9916
		3/11/2024	Up	172.75	69	Buy	997, No Act	eu) chg. +2%, Buy		.9977	.9986	.9916
		3/8/2024	Up	170.73	72	Buy	1.0050, Buy			.9977	.9986	.9916
		3/7/2024	Horizontal	169.	73	No Action	1.0020, Buy			.9977	.9986	.9916
		3/6/2024	Down	169.12	73	Sell	1.0020, Buy			.9977	.9986	.9916
		3/5/2024	Down	170.12	48	Sell	0.9941, Sell	eu) chg. -2	Sell	.9977	.9986	.9916
		3/4/2024	Down	175.1	51	Sell	0.9841, Sell	) chg. -5%, S	Sell	.9977	.9986	.9916
		3/1/2024	Down	179.66	71	Sell	0.9973, Sell	chg. +5%, Strong Buy		.9977	.9986	.9916
		2/29/2024	Down	180.75	75	Sell	0.9976, Sell			.9977	.9986	.9916
		2/28/2024	Down	181.42	75	Sell	0.9976, Sell			.9977	.9986	.9916
		2/27/2024	Up	182.63	81	Buy	0.9924, Sell	) chg. -5%, Strong Sell		.9977	.9986	.9916
		2/26/2024	Down	181.16	77	Sell	0.9983, Sell			.9977	.9986	.9916
		2/23/2024	Down	182.52	77	Sell	0.9983, Sell			.9977	.9986	.9916
		2/22/2024	Up	184.37	77	Buy	0.9983, Sell			.9977	.9986	.9916
		2/21/2024	Up	182.32	47	Buy	1.0112, Buy	LOCAL INFLECTION F		.9977	.9986	.9916
		2/20/2024	Down	181.56	77	Sell	0.9983, Sell			.9977	.9986	.9916
		2/16/2024	Down	182.31	77	Sell	0.9983, Sell			.9977	.9986	.9916

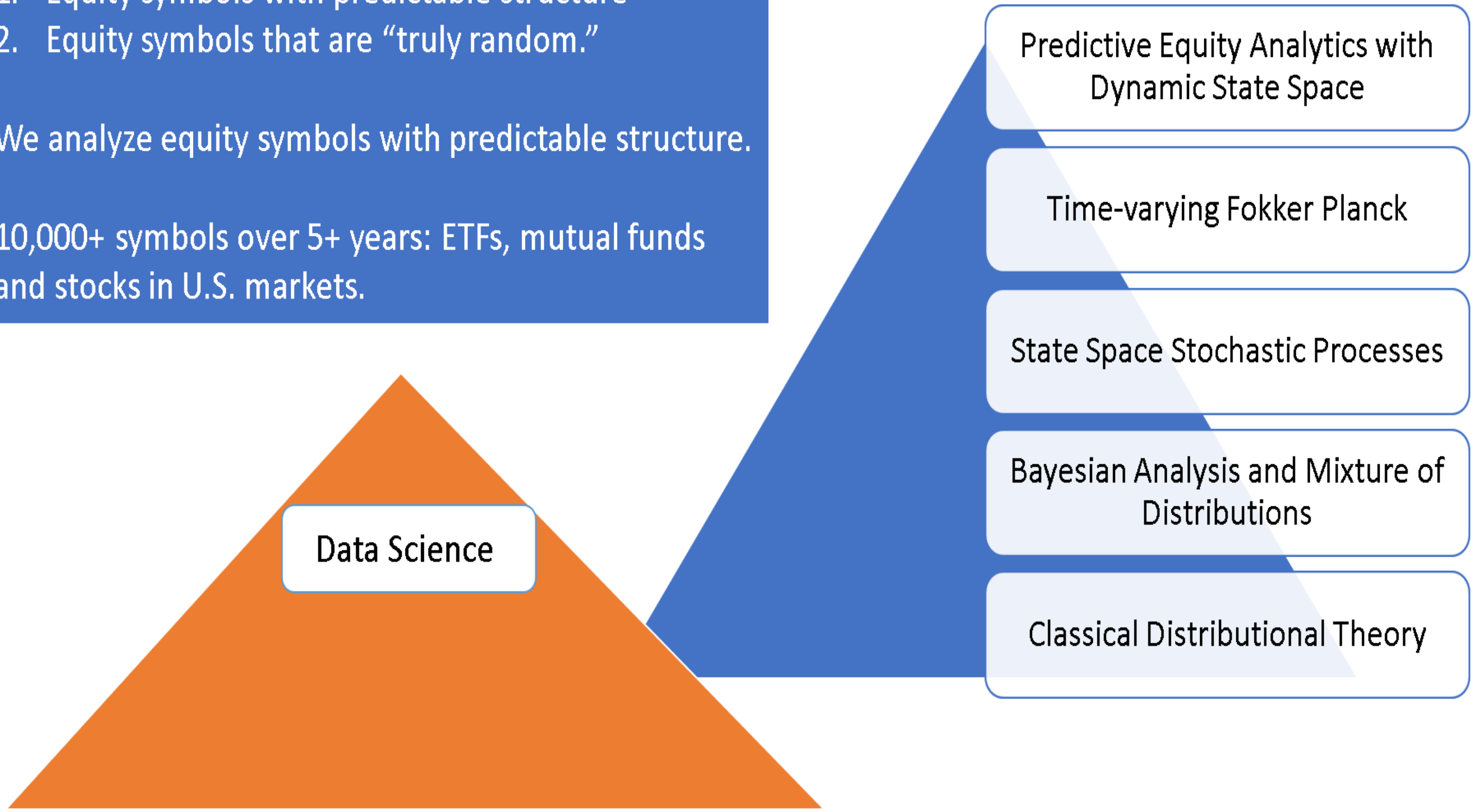
Predictive Equity Analytics with Dynamic State Space

Starting with base data and upon application of Predictive Equity Analytics with Dynamic State Space framework, the result is two mutually exclusive sets:

1. Equity symbols with predictable structure
2. Equity symbols that are “truly random.”

We analyze equity symbols with predictable structure.

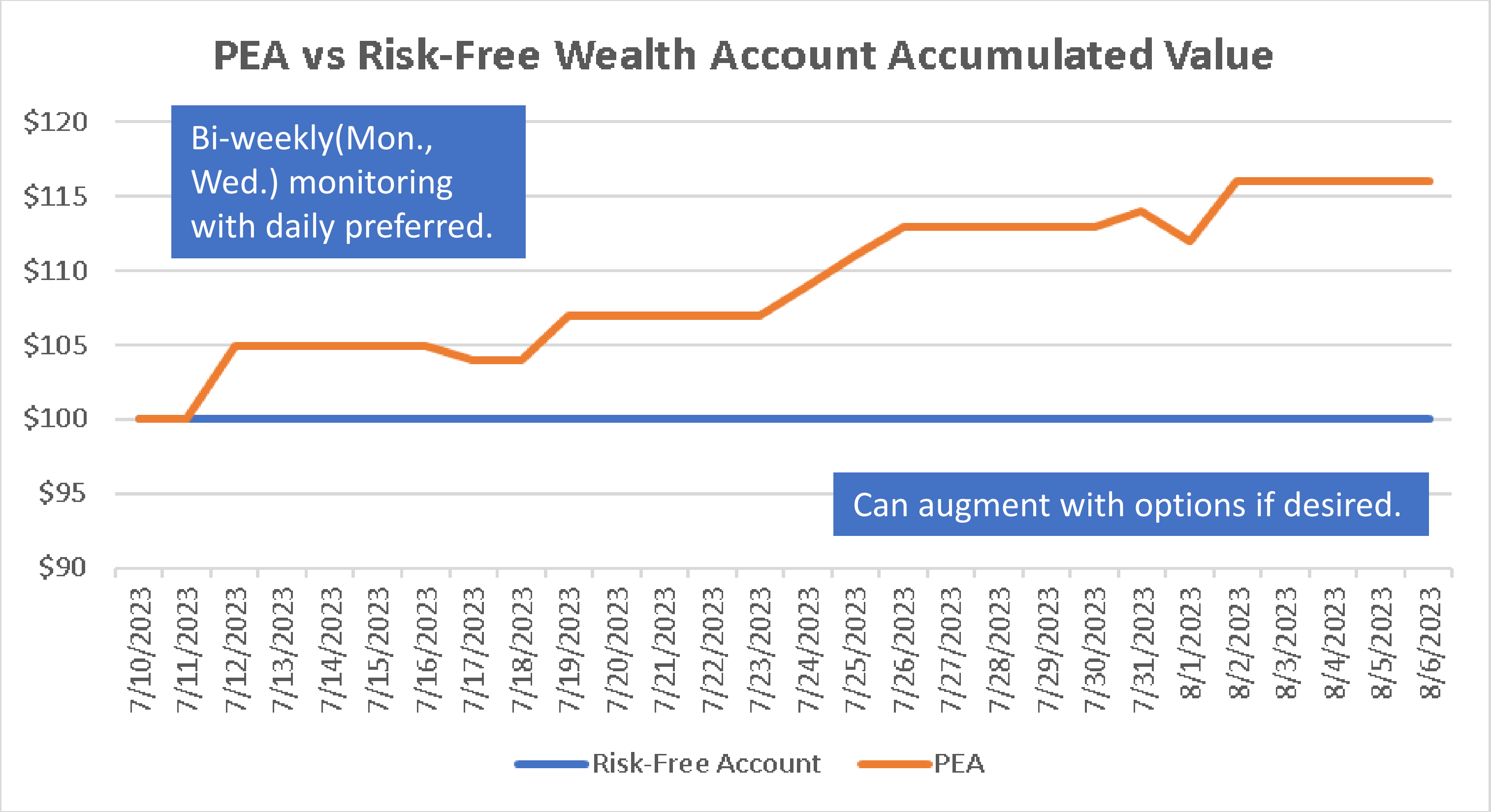
10,000+ symbols over 5+ years: ETFs, mutual funds and stocks in U.S. markets.



Strategic Goal is to Provide "Predictive Data Analytic Tool" that warns of downside and also informs of upside to increase financial wellness security – wealth accumulation rate and protection.

Today, there are no commercially available predictive equity analytic tools available to consumers or policyholders – in insurance or financial services. **What are the implications of first introduction?**

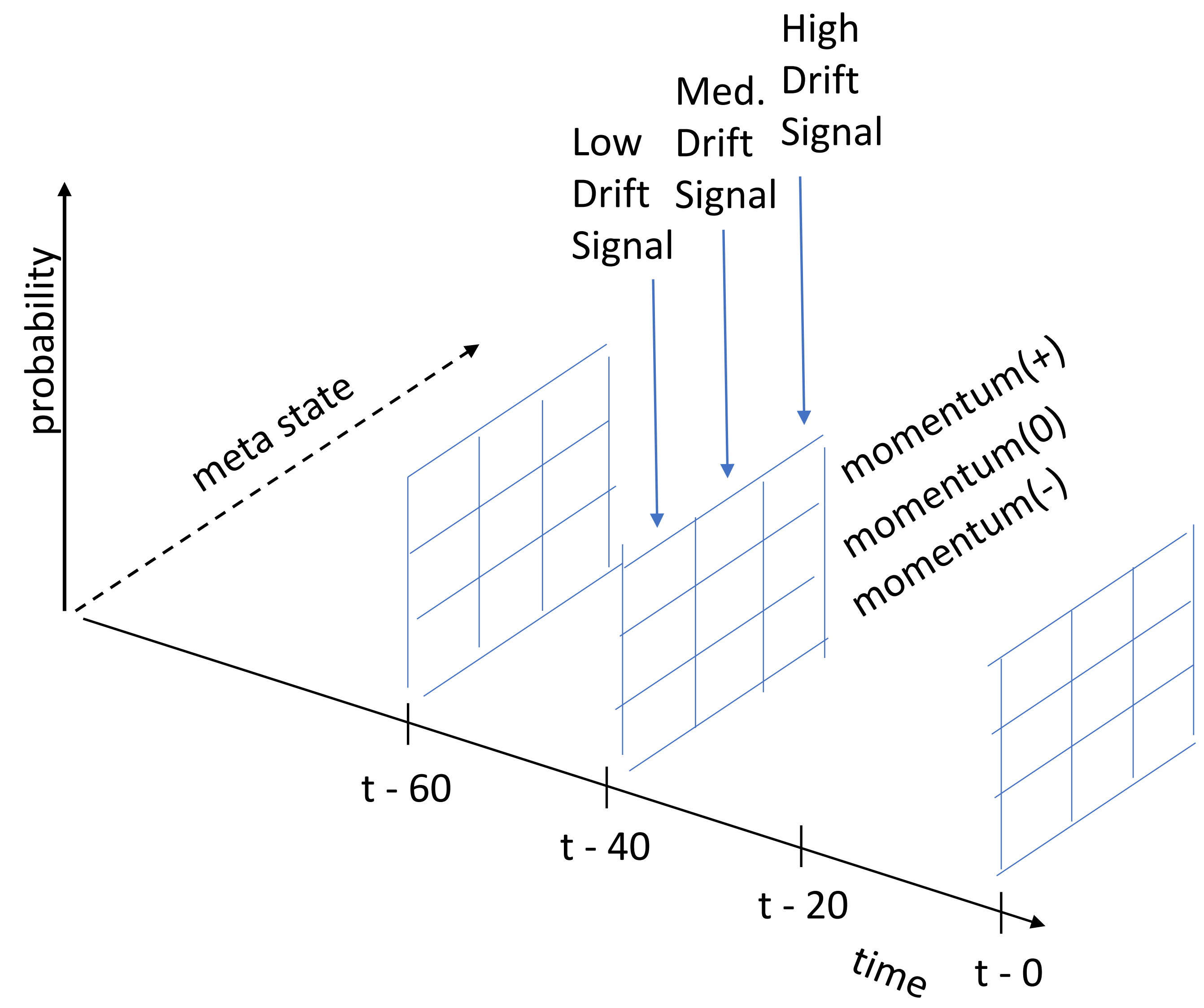
Can we make a "GPS" type tool for equities? Answer: Yes



How?

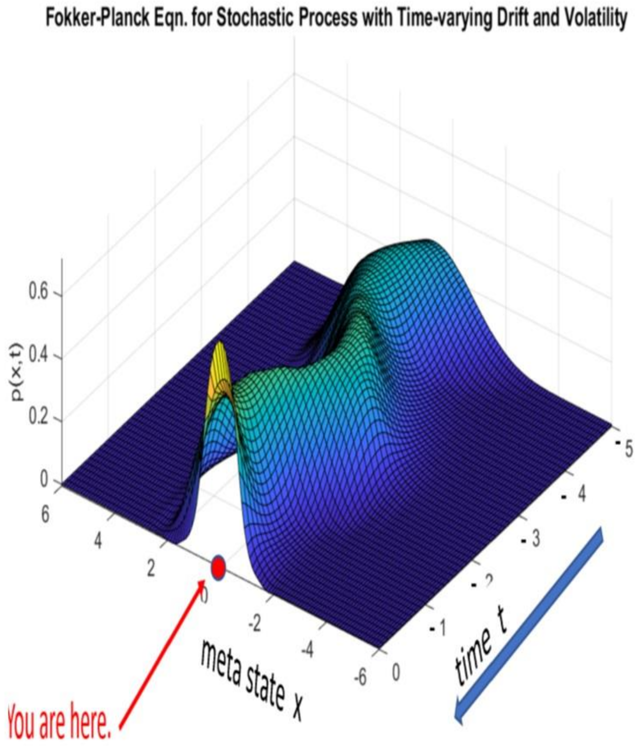
Predictive Equity Analytics with Dynamic State Space can estimate current eigenvalues and eigenvectors for discrete approximation to time-varying Fokker-Planck probability distribution transformation in two modes 1) (signal + nose) and 2.) core signal. At points in time where dominant eigenvalue changes in excess of a threshold a "change-point" has occurred and with analysis future behavior of {up, horizontal, down} can be determined. PES w DSS can also filter Poisson Outliers.

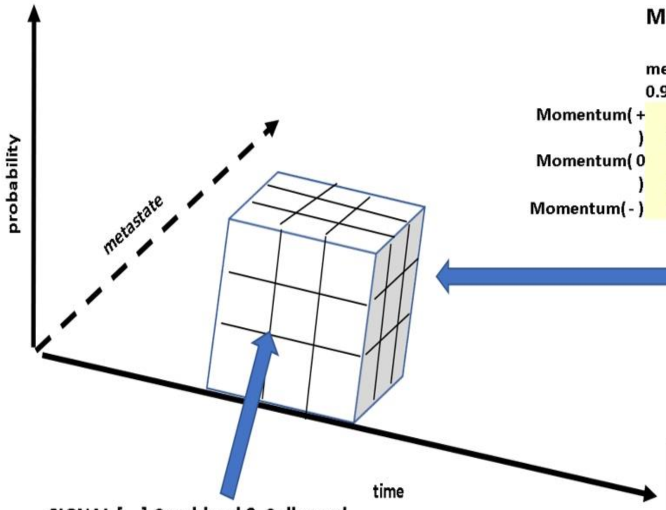
Matrix Theory Representation as Alternative Measurement Framework: Earliest possible Change-point Detection in meta state dimension as as well as time dimension.



PREVIEW:

Predictive Equity Analytics with Dynamic State Encapsulates enables Approximation of Time-varying Fokker-Planck Equation using Eigenvalues and Eigenvectors in Meta-state(spatial) and Time dimensions for NEXT Trade-day including Change-point.





Combined & Collapsed Matrices: ABC

	Signal_3(meu)		
	meu < 0.95	meu in [0.95,0.97]	meu > 0.97
Momentum(+)	0.14987	0.13310	0.19986
Momentum(0)	0.30065	0.33360	0.30041
Momentum(-)	0.00000	0.03316	0.03316

SIGNAL [ ] Combined & Collapsed Matrices: ABC

	time		
	60_m40	60_m20	60_m0
Momentum(+)	0.14987	0.13310	0.14987
Momentum(0)	0.30065	0.33360	0.30065
Momentum(-)	0.00000	0.03316	0.00340

The average probability under the curve is estimated using **vector cross-product** of dominant signal w.r.t. time and dominant signal w.r.t metastate. (right hand rule).

Integration bounaries are estimated by taking max and min of observed data points.

The average probability under the curve eigenvalue can also be calculated.

APPENDIX

Theoretical Foundations: TRI-SIGNAL Predictive Equity Analytics with Dynamic State Space

What is at the heart of Predictive Equity Analytics with Dynamic State Space that "makes it work?"

Answer: "The core solution is a sufficiently accurate discrete approximation to the time-varying Fokker-Planck probability distribution transformation using eigenvalues and eigenvectors (i.e., linear algebra)."

Viewers are more familiar with Black-Scholes equation which is non-time varying Fokker-Planck equation.

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Drift as predictor

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Poisson outlier process and option pricing

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Existence and uniqueness of discrete spectral solution (eigenvalue and eigenfunction) to time-varying Fokker-Planck probability transformation equation (Chapters 4 – 9 with chapters 1 -3 as foundation). [Spectral solution is theoretically valid (existence and uniqueness). Estimation of eigenvalues and eigenfunctions remained "a problem for applied research." From calculus, we approximate eigenfunctions with eigenvectors/lines for small domain neighborhoods.]

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