ASTROCYTE RESEARCH

ACTIONABLE REAL-TIME MARKET INTELLIGENCE

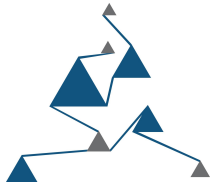
QWAFAFEW - August 2016

Machine Learning-Based Trading Decisions

Or: How I Learned to Stop Worrying and Love when Models Break Down

Presented by Sean Kruzel

Legal Disclaimer



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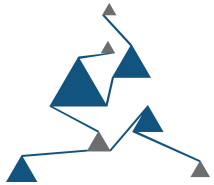
All mentions of specific asset managers, investors or asset classes do not constitute an endorsement for or against a particular entity

ML-Based Trading Decisions

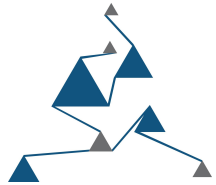


Scientific Process is Hard to Apply to Finance

Markets are Adversarial
Economies are Complex and Evolving

Abstractly specified financial and economic theories
No replication and little testing

Machine Learning vs Investors



Machine Learning Community

Optimization: Custom Functions

Data + Priors = Models

Data Size: Huge
Model Complexity: High

Knowledge Maximization

Investment Community

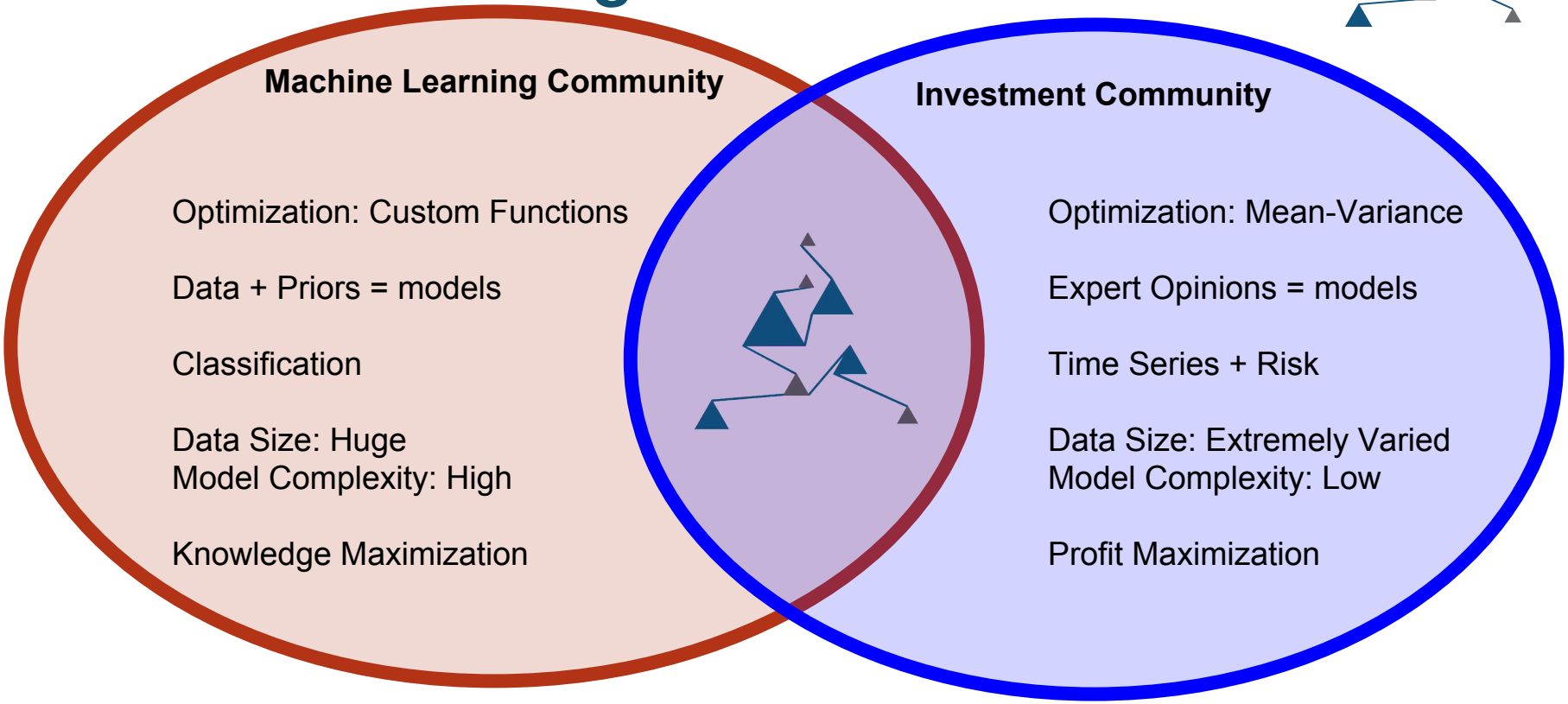
Optimization: Mean-Variance

Expert Opinions = Models

Data Size: Extremely Varied
Model Complexity: Low

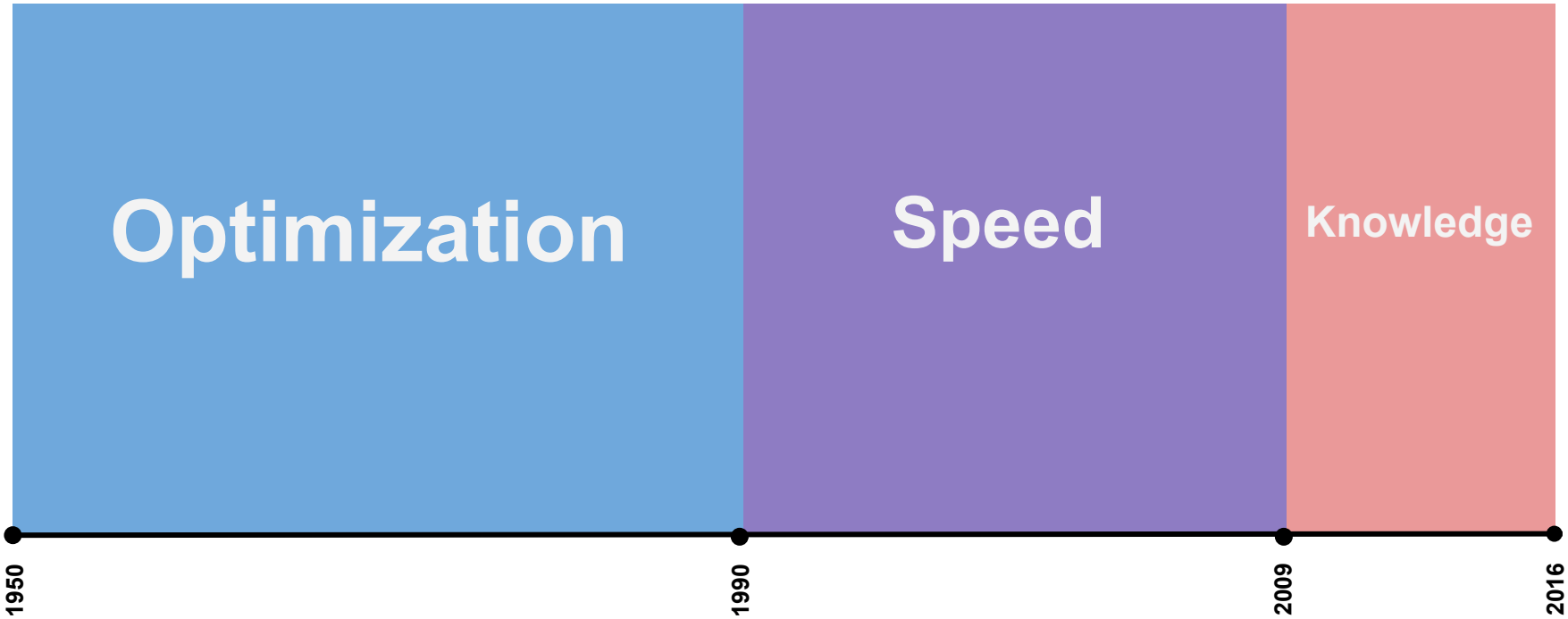
Profit Maximization

Machine Learning vs Investors

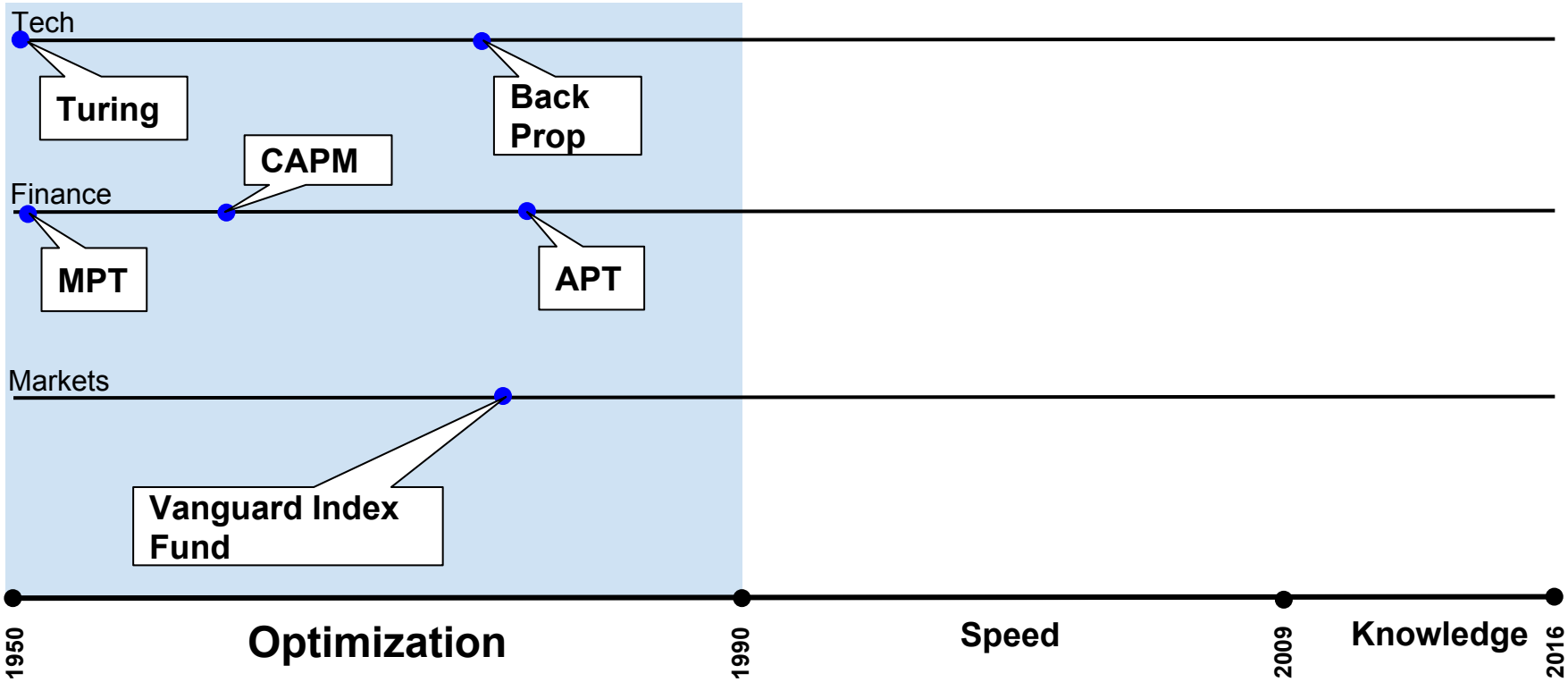


ML and Data Science in Pop Culture

A Stylized History



A Stylized History



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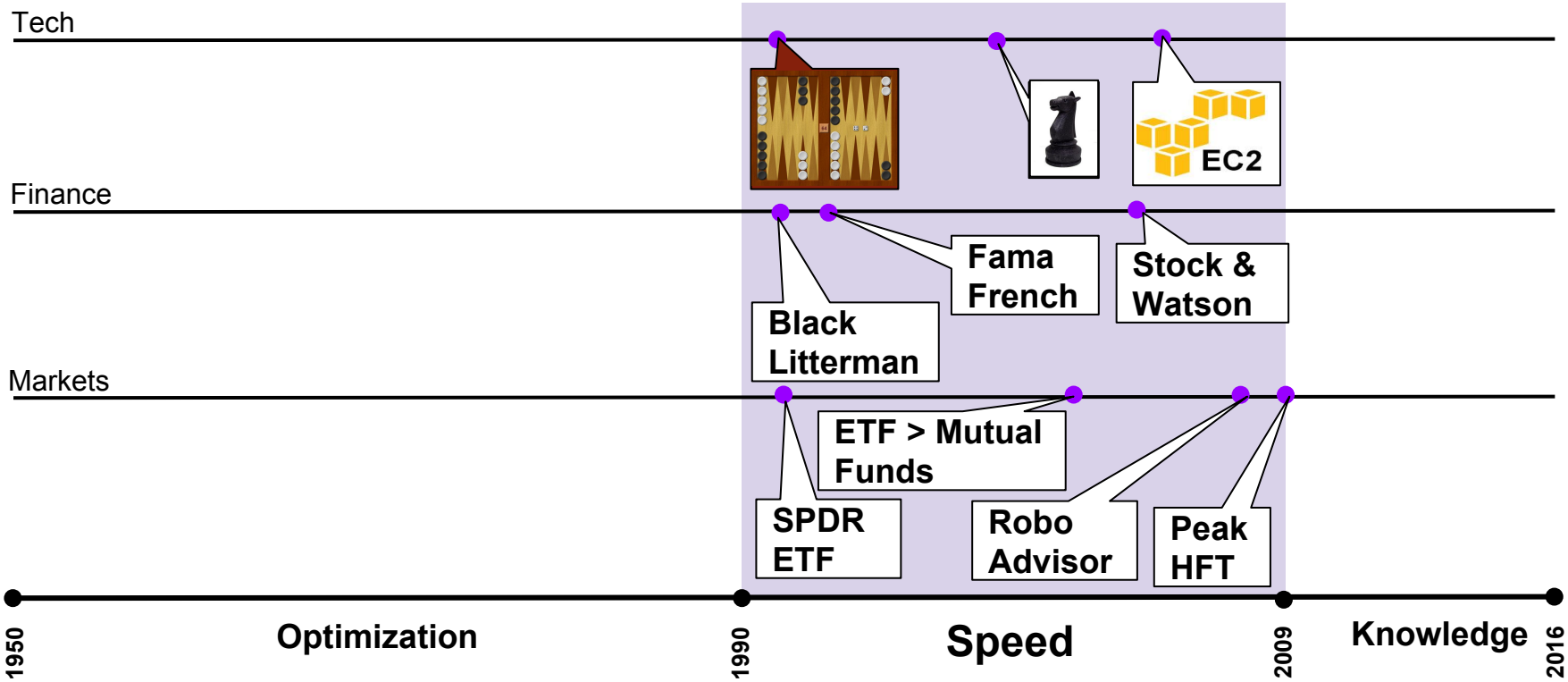

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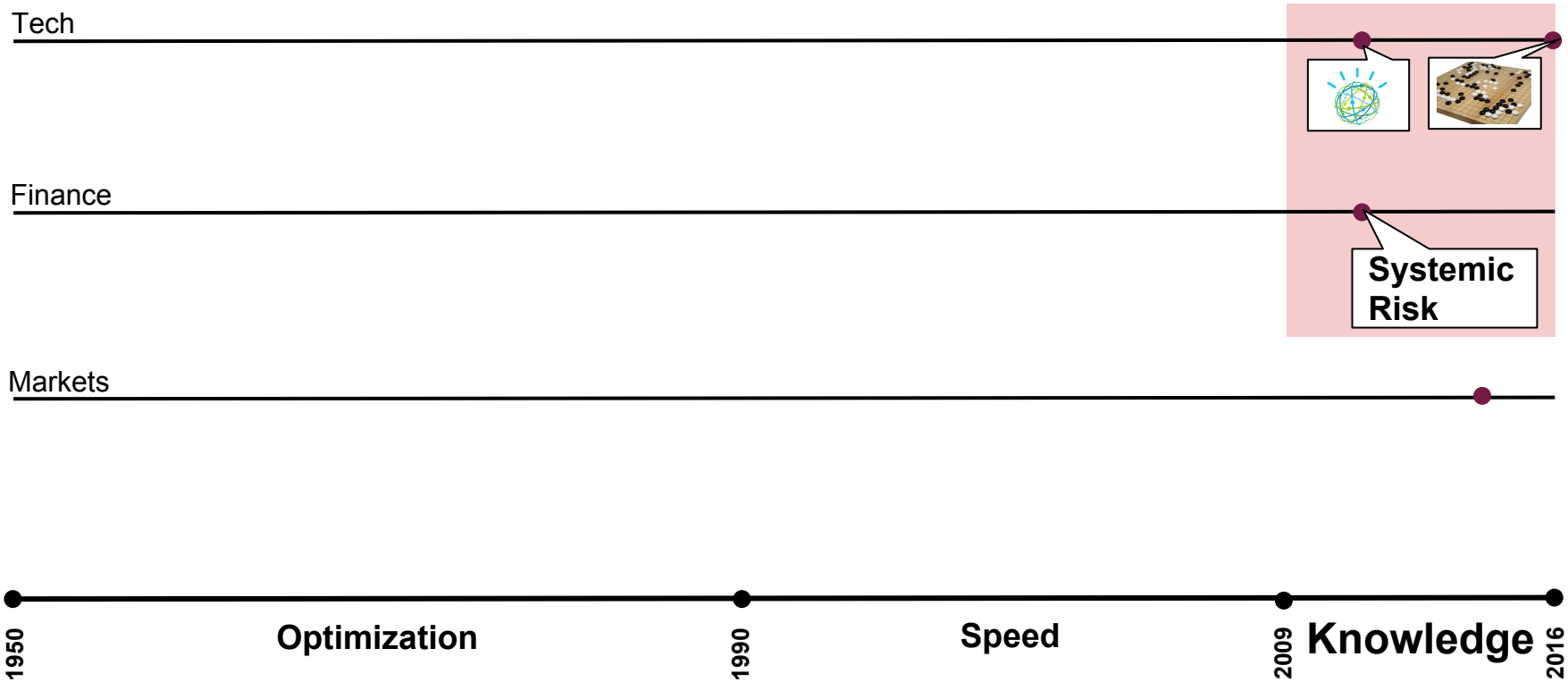

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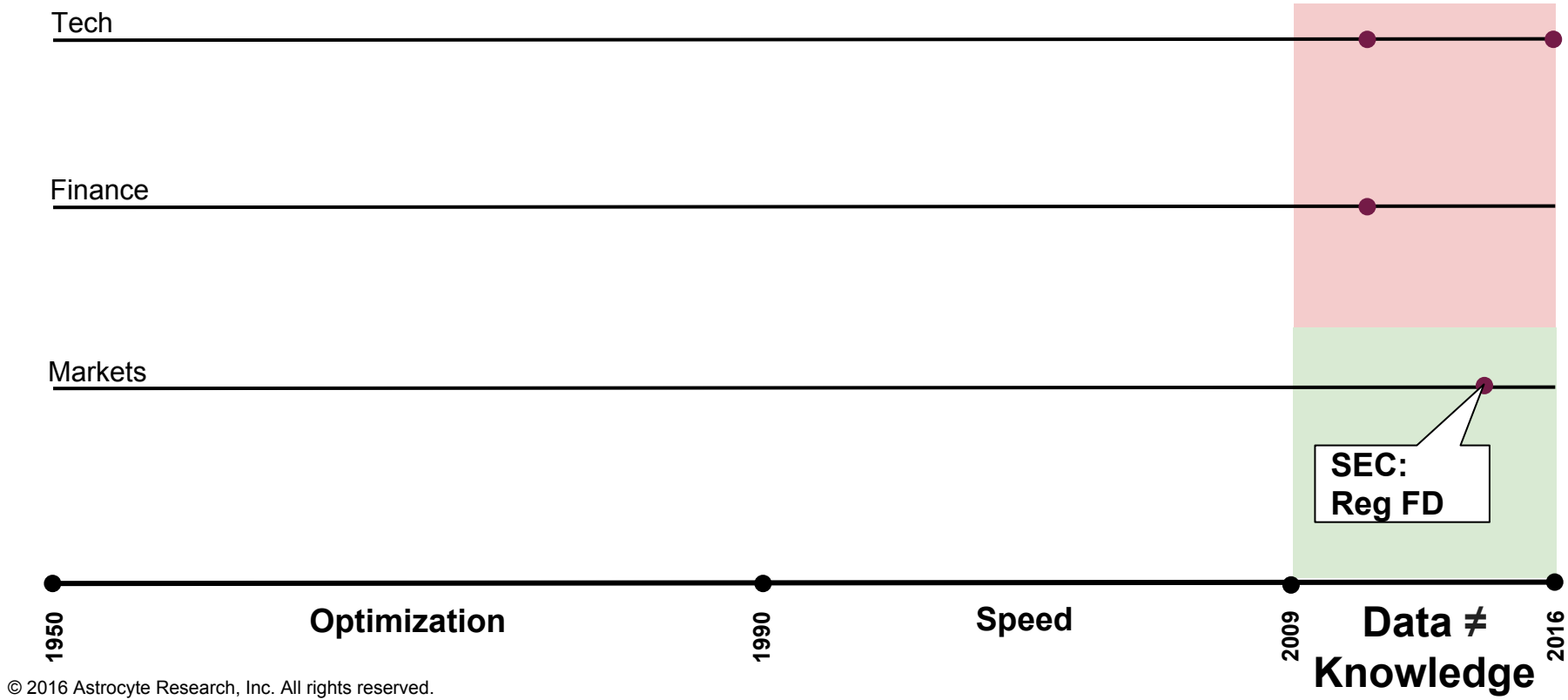


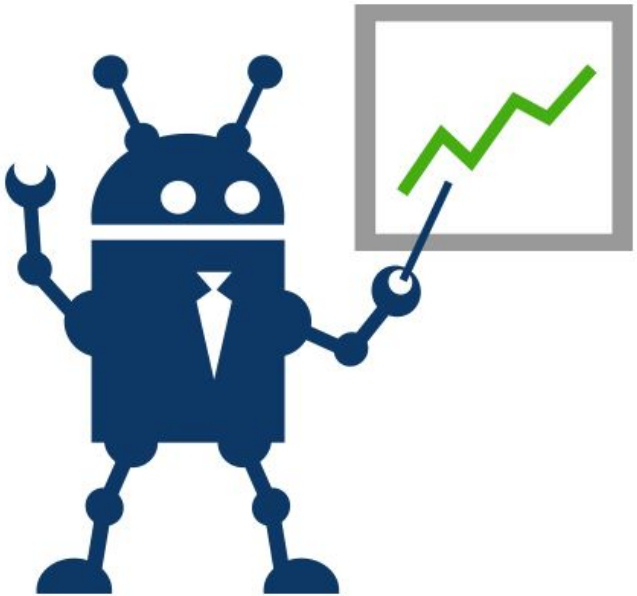
Robo Advisors

Betterment

wealthfront

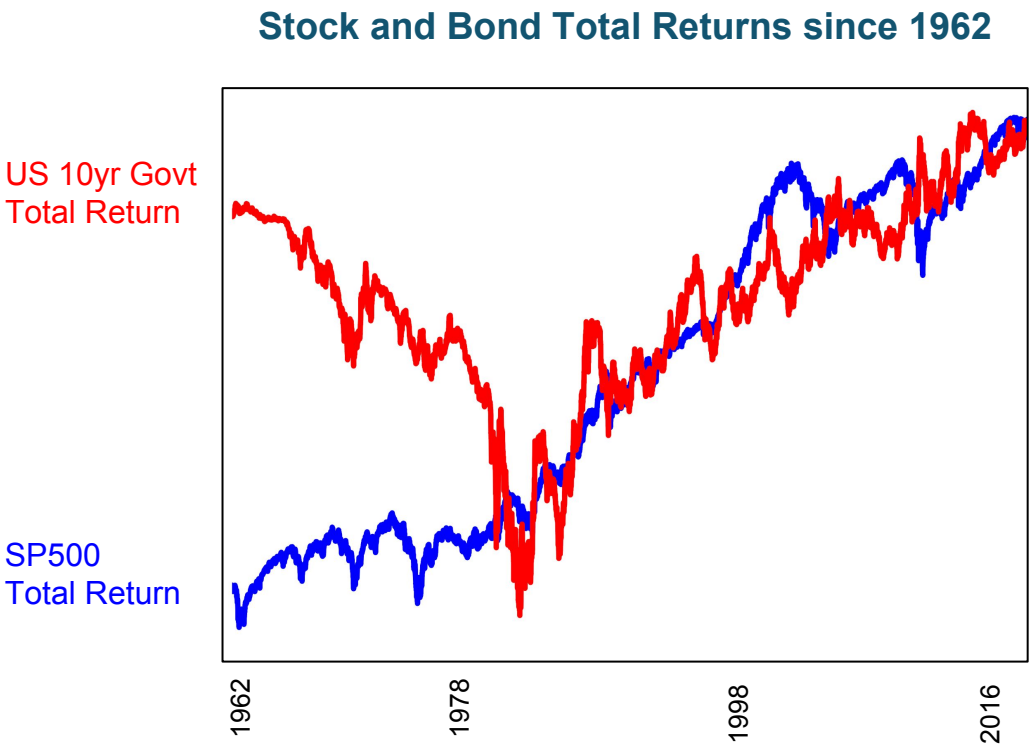
FutureAdvisor

PERSONAL CAPITAL



Source: http://www.economiapersonal.com.ar/robo-advisor-warns-the-zombies-are-coming/

Robo Advisors are stuck in 1992



Robo Advisors Process

1. Estimate Returns
2. Estimate Variance
3. Estimate Correlations
4. Minimize Risk / Return

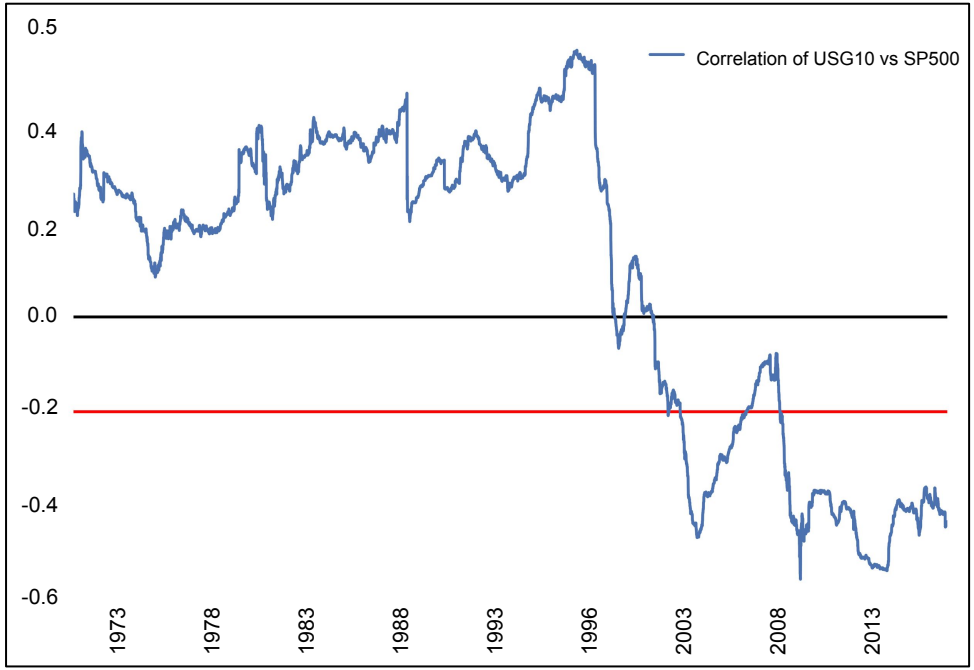
Daily Bond Data from FED H15 report.

Total Return Calculations Astrocyte Research

SP500 data from Yahoo Finance

Robo Advisors are still very simplistic

Rolling Stock and Bond Correlation since 1970



wealthfront

Assumes -0.2 Correlation of US Stocks to US Govt Bonds*

*Wealthfront likely calculated from different but related data. This page is to show possible range of correlation estimates.

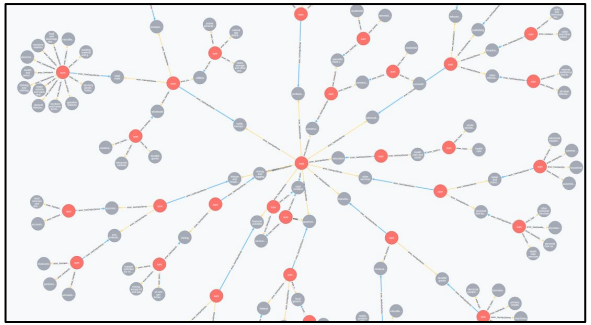
https://research.wealthfront.com/whitepapers/investment-methodology/

The Surface

The Complexity Below the Surface

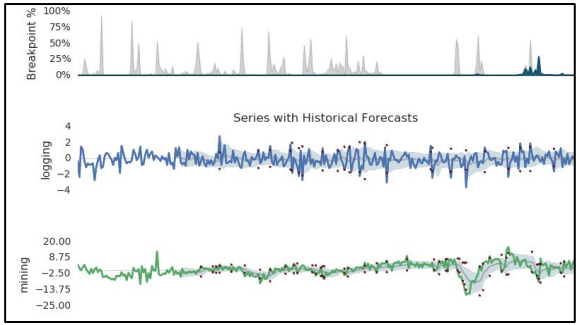
Astrocyte Research

Economic Graph



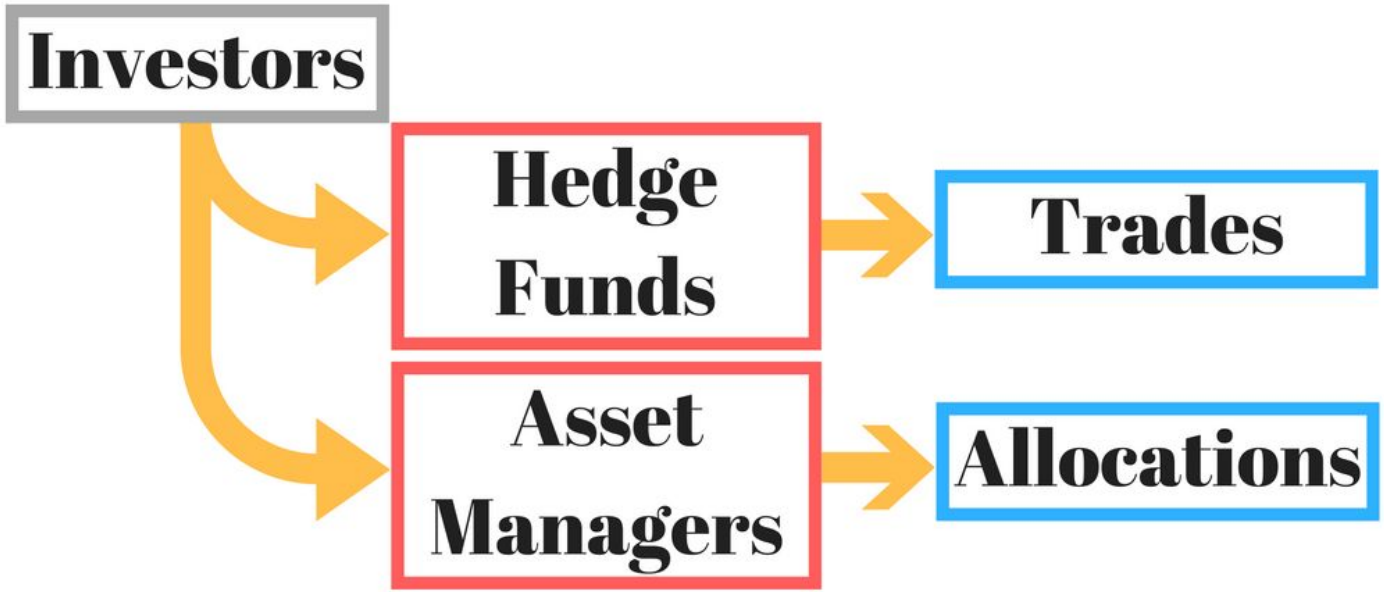
Evolving
&
Richly Connected

Financial Market Graph

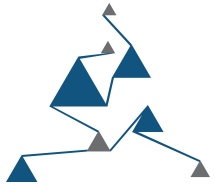


Dynamic
&
Game Theoretic

Finance: Many Objective Functions



Bayes Rule Overview

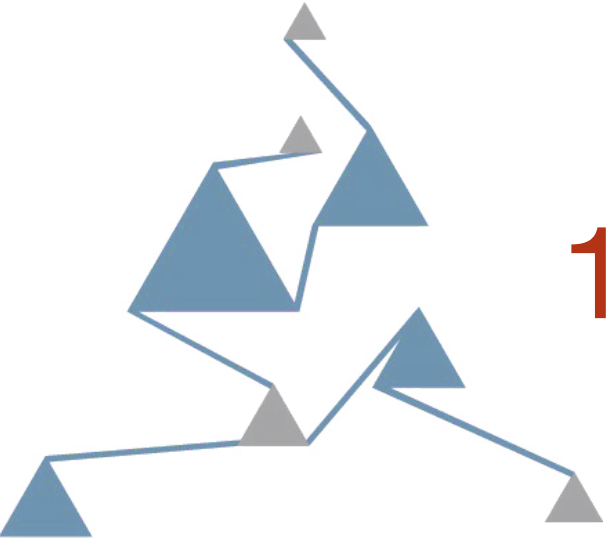


Coin Flip Example: X = flips of heads

$$P(M_{biased} \mid X) \propto P(X \mid M_{biased}) \cdot P(M_{biased})$$

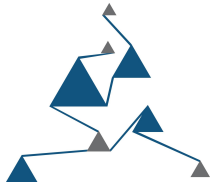
Odds Ratio = Bayes Factor ·Prior Odds Ratio

$$\frac{P(M_{biased} \mid X)}{P(M_{fair} \mid X)} = \frac{P(X \mid M_{biased})}{P(X \mid M_{fair})} \cdot \frac{P(M_{biased})}{P(M_{fair})}$$



1. Investor Decisions

Applying Machine Learning and Science to **Evaluate Portfolio Managers**

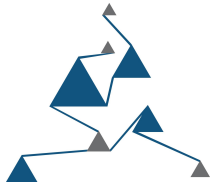


What is a **Good Sharpe** Ratio?

$$\left(\frac{R_p - R_f}{\sigma_p}\right)$$

How do we use it to evaluate portfolio managers?

Manager Decisions: Target Sharpes



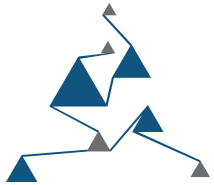
Asset Managers - Ratio > 1.0

- Investors evaluate them on 3-5 year horizons

Hedge Fund Portfolio Managers - Ratio > 2.0

- Your boss evaluates you every couple of months + paid yearly

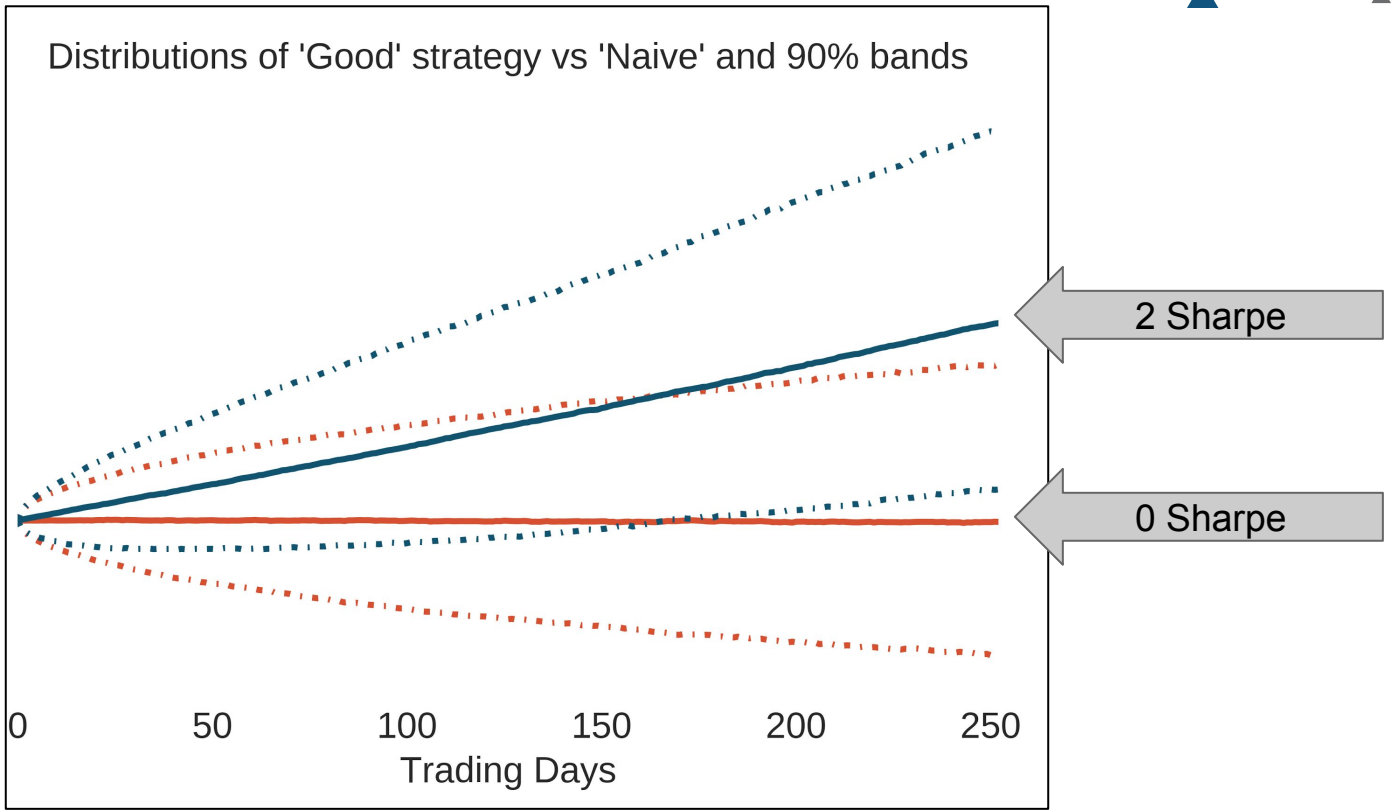
Prob of Loss:	3 months	6 months	1 year	3 years
Sharpe = 1	31%	24%	16%	**4%**
Sharpe = 2	16%	8%	**2%**	0%



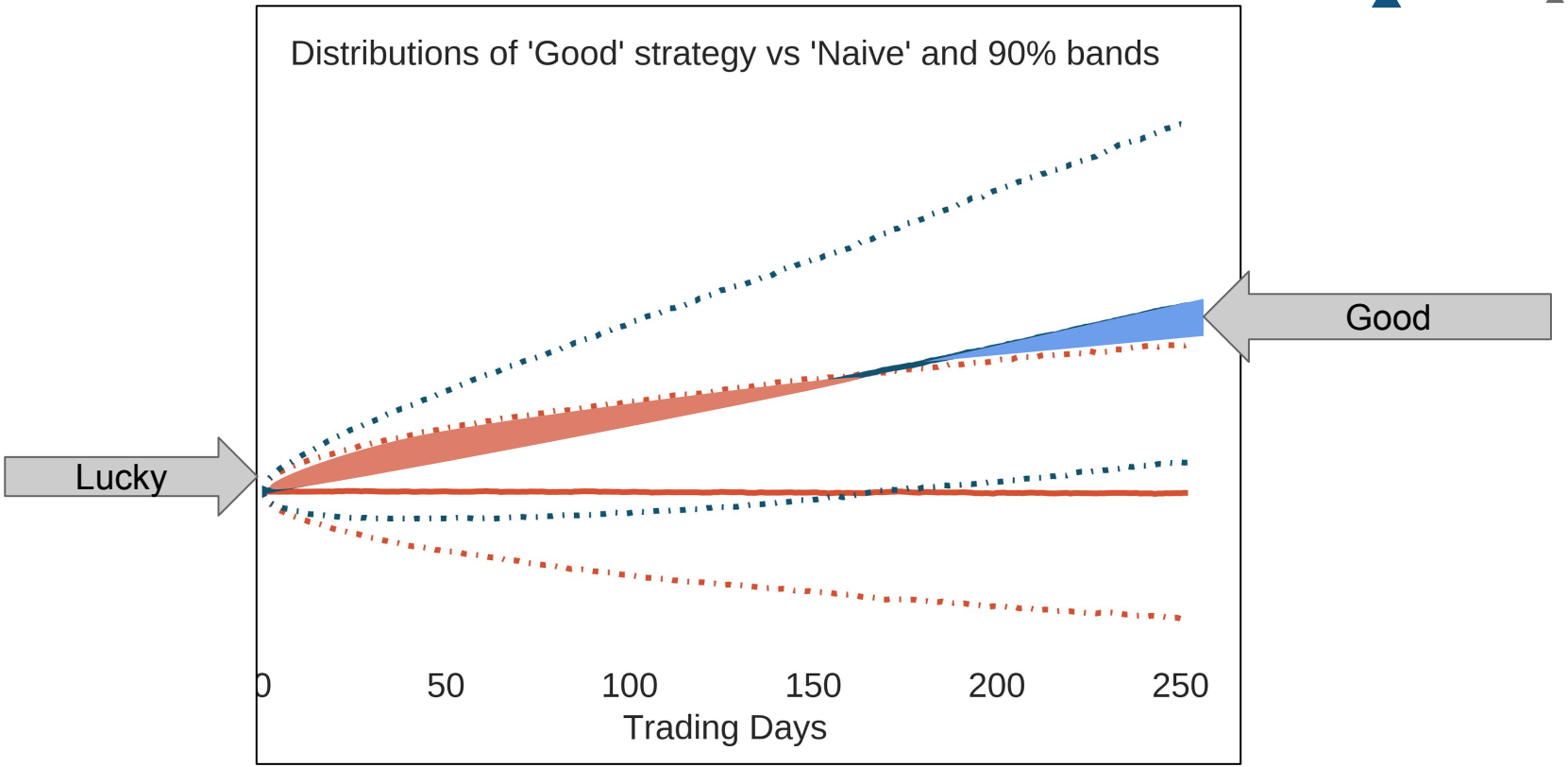
Is my Sharpe Ratio > 2.0?

Understanding **Lucky** vs **Good**

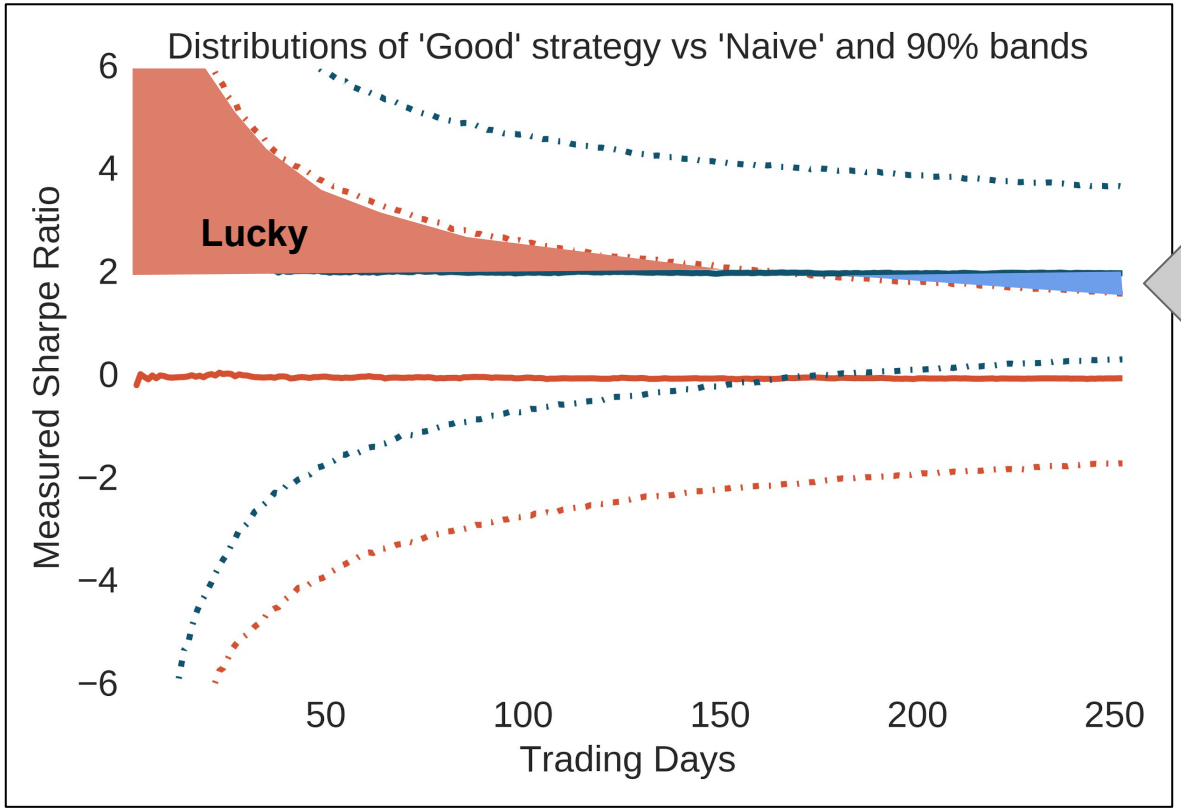
Investor Decisions: Returns



Investor Decisions: Returns

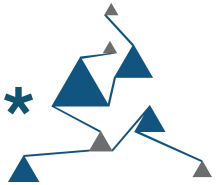


Investor Decisions: Sharpe Ratios



Good

Classical Approach for Evaluating PM's*



1. How much money have they lost in **1 day?**

2. How much money have they lost **overall?**

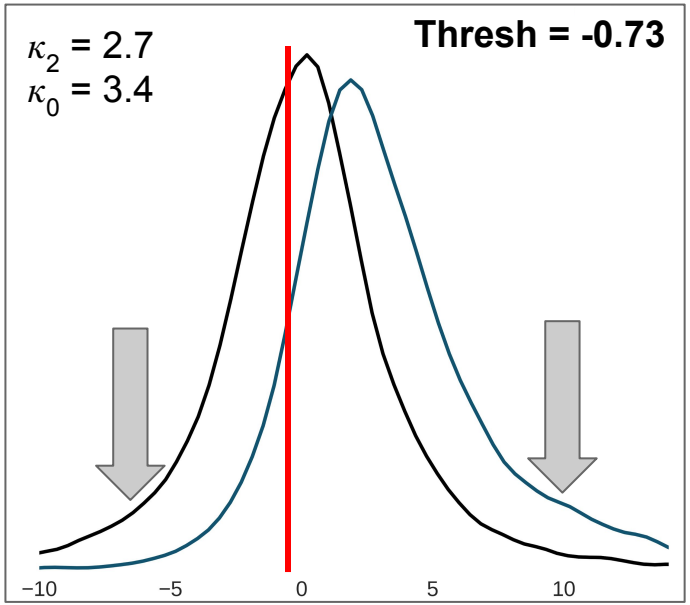
3. What is my **faith** in their ability to continue to be profitable?

Excluding other important factors like negligence, style drift, fees, etc...

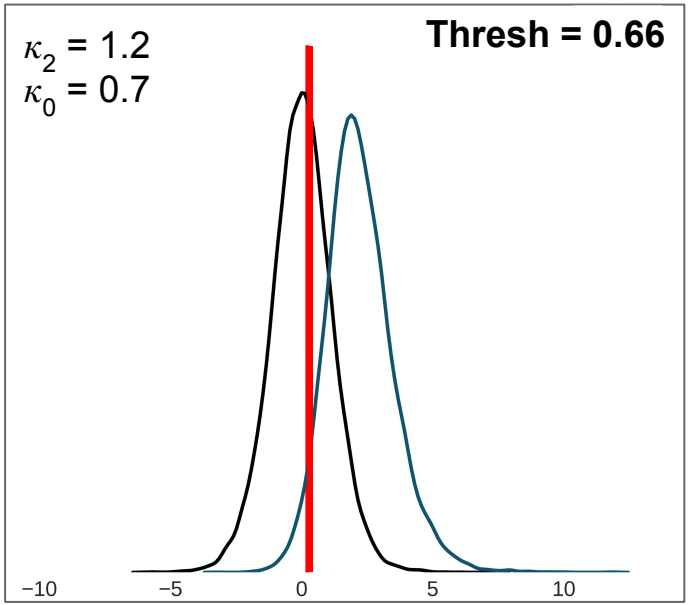
3 Month or 1 Year Check-in

Prior Odds Ratio = 1/10 Odds Ratio = T = 1/20
Fire investor if Bayes Factor < 1/2

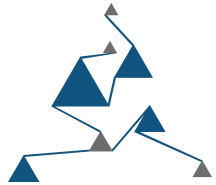
Sharpe Ratio after 3 months - MONTHLY



Sharpe Ratio after 1 year - MONTHLY



Trading Rules = Classification



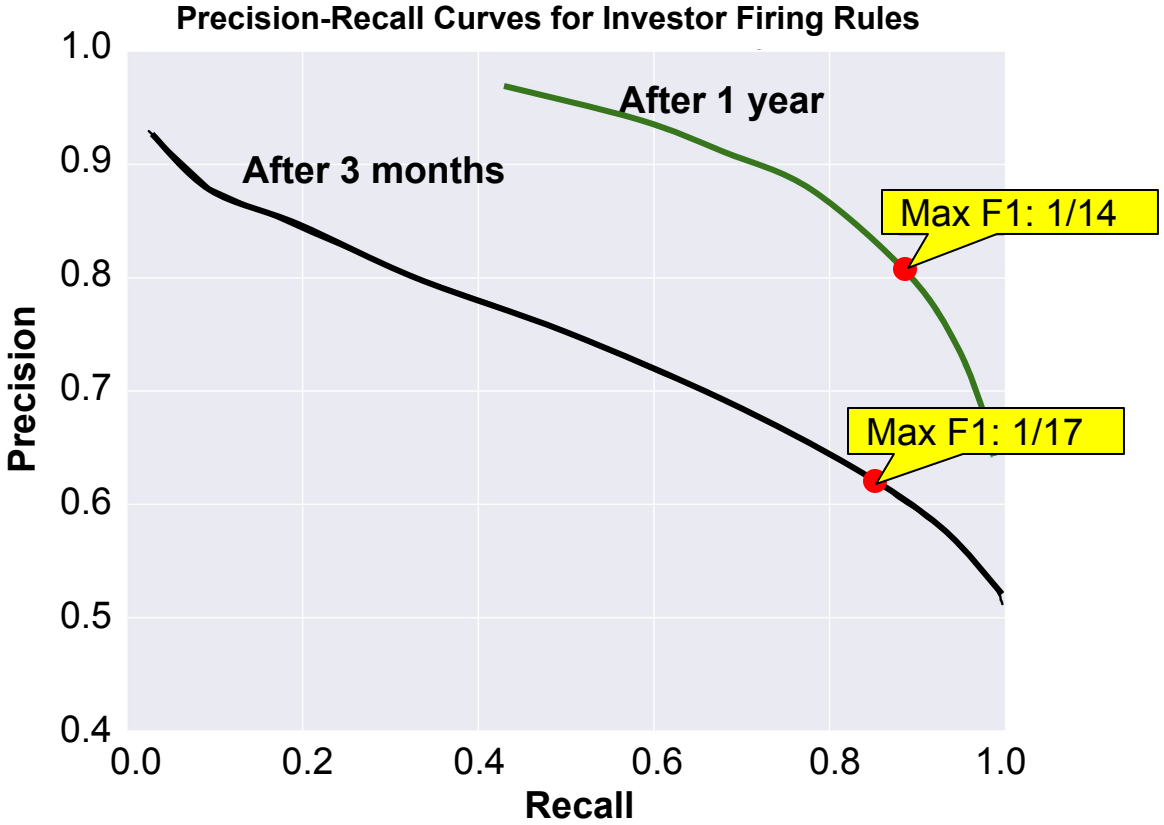
Precision:
Probability that a fund with capital has a 2 Sharpe

Recall:
Percent of all funds with a 2 Sharpe that have capital

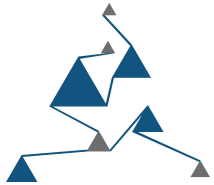
$$\text{Precision} = \frac{tp}{tp + fp}$$

$$\text{Recall} = \frac{tp}{tp + fn}$$

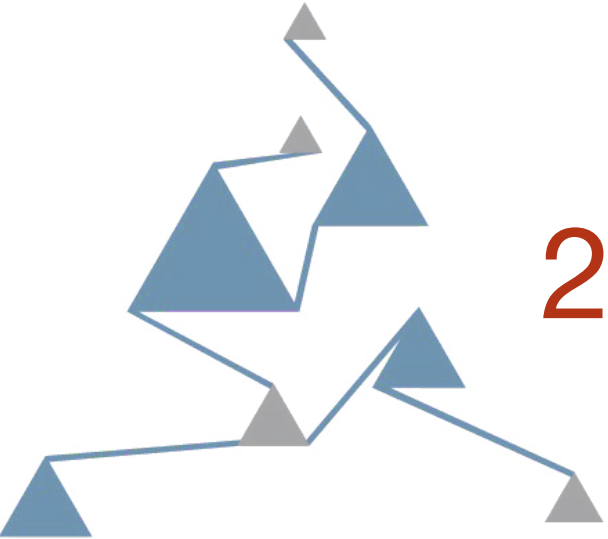
Precision Recall Curves



Modern Approach for Evaluating PM's



Classical	Modern / ML
Arbitrary Faith in Performance	Faith = Prior Probabilities
Focus on $ Loss	Compare $ vs 'Noise' Distributions
Look at Arbitrary Time Periods	Time-dependent Threshholds



2. Trade Entry and Exit

Applying Machine Learning and Science
to **Enter** and **Exit** Trades

Global Macro Case Study

Global Macro Case Study

Travel back to December 27, 2012:

- **Oct:** Hurricane Sandy
- **Nov:** Obama Re-elected
- **Dec:** US `Fiscal Cliff` Negotiations
- `Gangnam Style` is viral…

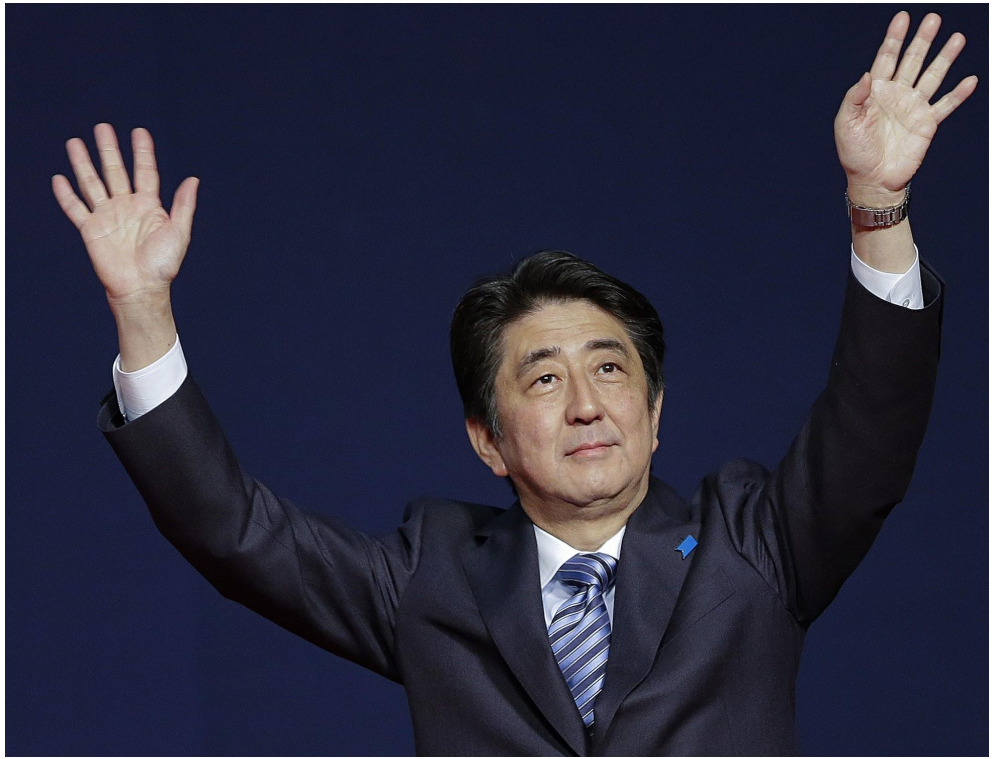
Global Macro Case Study: Abenomics

Around the World: Japan

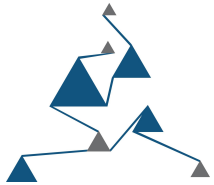
16th December 2012

Liberal Democratic Party (LDP) has ‘landslide victory’ over Democratic Party of Japan (DPJ)

Shinzō Abe is elected as Prime Minister of Japan



Global Macro Case Study: Abenomics



Your boss believes Abe will follow through with the goals outlined in his first speech:

"I will generate results by vigorously advancing economic policy under the **three prongs** of bold monetary policy, flexible public finance policy, and a growth strategy that encourages private sector investment."

What do you do?

Source: http://japan.kantei.go.jp/96_abe/statement/201212/26kaiken_e.html

The Case Study is a fictional account based loosely on experiences of investors at the time. Any relation to realy portfolio managers or hedge fund strategies is purely coincidental

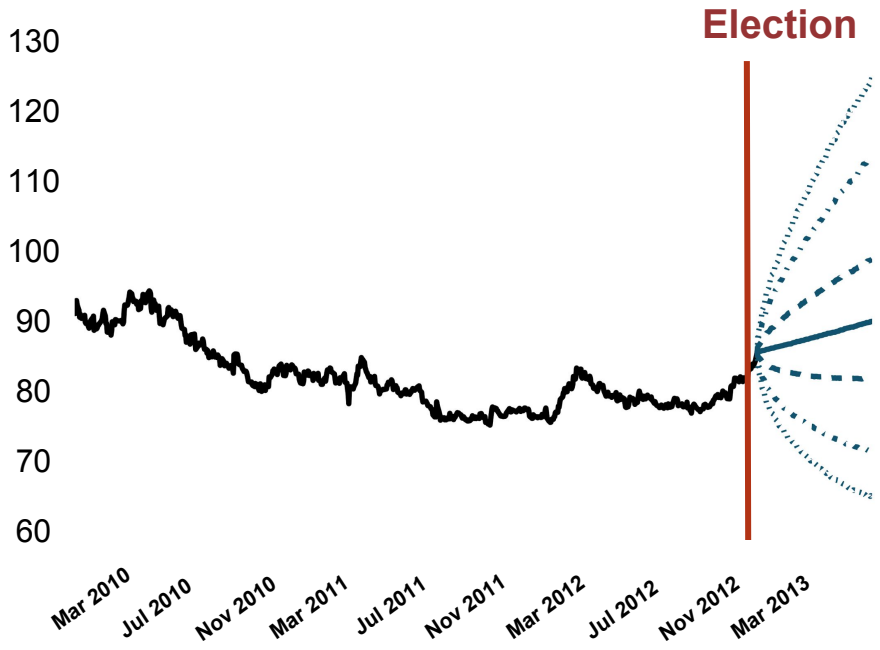
Global Macro Case Study: Abenomics

Boss's View:

μ = 10%

Global Macro Case Study: Abenomics

Step 2: Quantify Distribution of the Opinion



Boss's View:

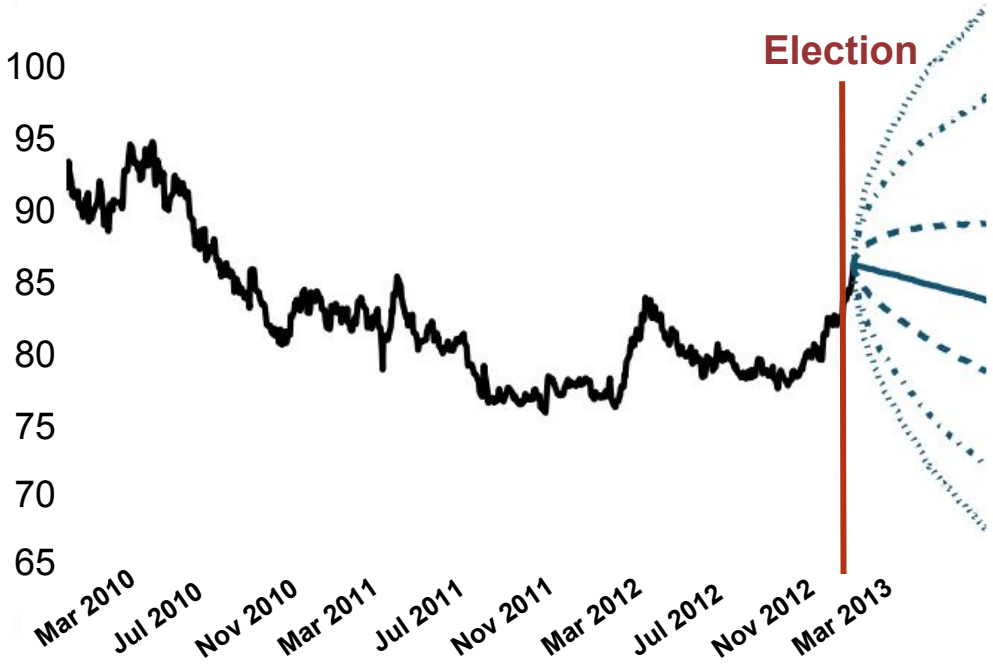
μ = 10%

σ = 19.6%

Sharpe = +0.51

Global Macro Case Study: Abenomics

Step 3: Compare with Risk Manager



Boss's View:

μ = 10%

σ = 19.6%

Sharpe = +0.51

Risk Model:

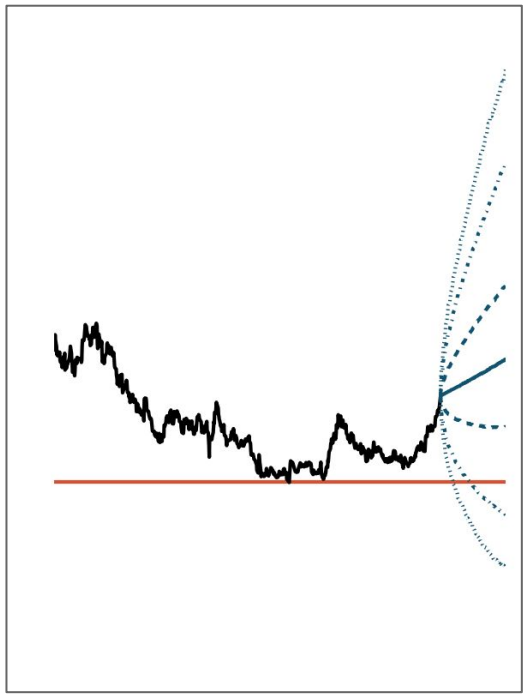
μ = -5.5%

σ = 13.1%

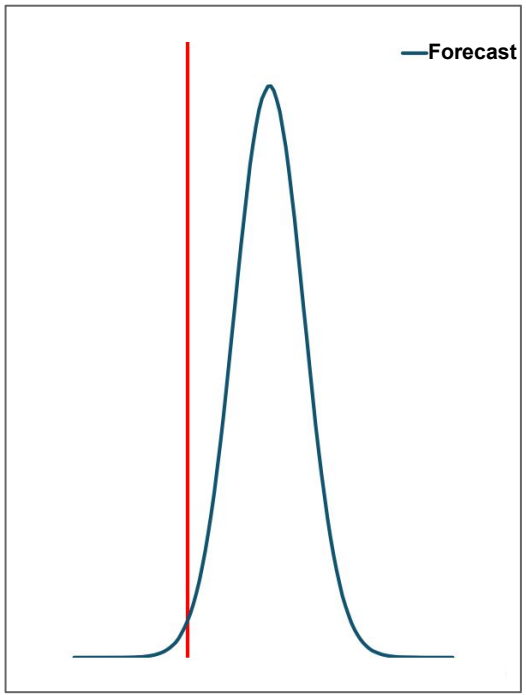
Sharpe = -0.42

Classical Size + Exit Methods

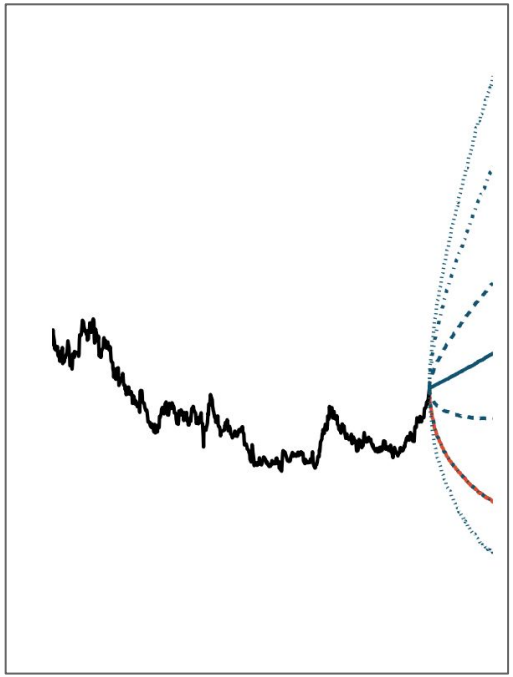
Set $ to Risk



Allocate by Daily Risk



Losses Over Time



*Making several huge assumptions, including of 0 correlation of USDJPY to other trades in portfolio

A Trade as a Hypothesis Test

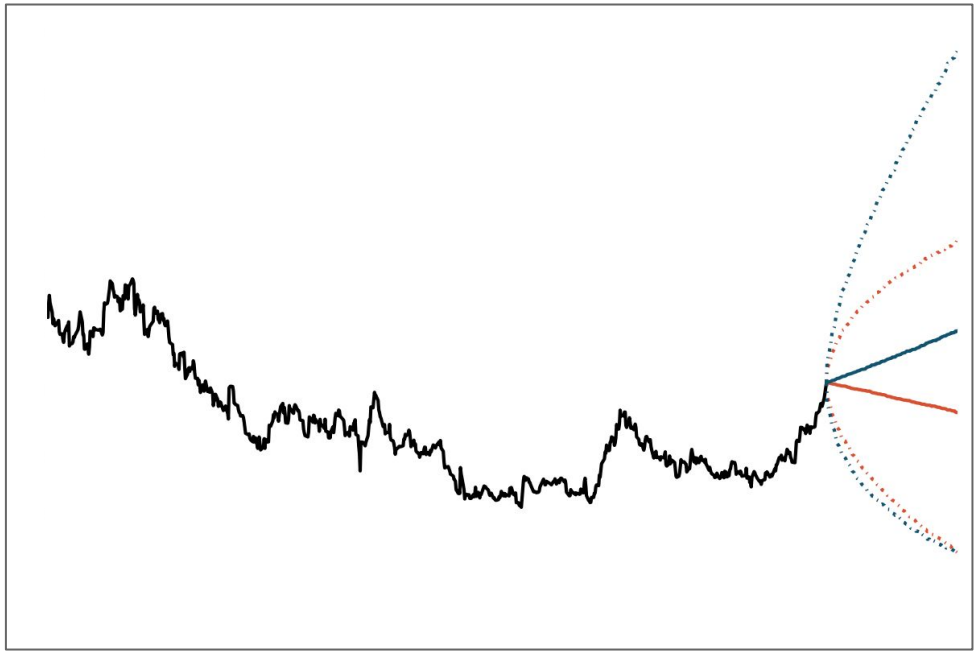
PM Hypothesis: Abe and his ‘Three Arrows’ will be primary driver of USDJPY higher in 1H2013

Risk Hypothesis: USDJPY moves like it had in 2010-2012

Assumptions: Abe’s ‘Abenomics’ are successfully implemented:

- Monetary Policy is Eased
- Currency depreciation results from that easing
- 6 Month Horizon

Comparison of Expected Trajectories

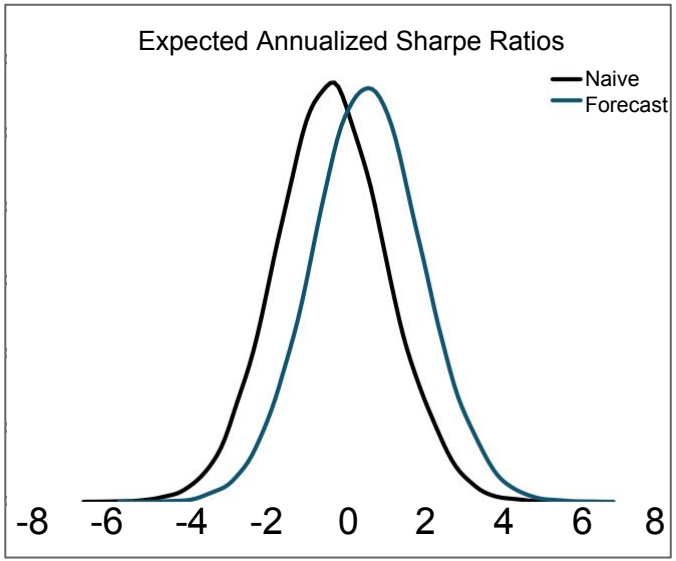


Global Macro Case Study: Abenomics

$$P(M_i \mid X) \propto P(X \mid M_i) \cdot P(M_i)$$

X: Sharpe

Risk Manager: Sharpe = -0.42
Portfolio Manager: Sharpe = +0.51



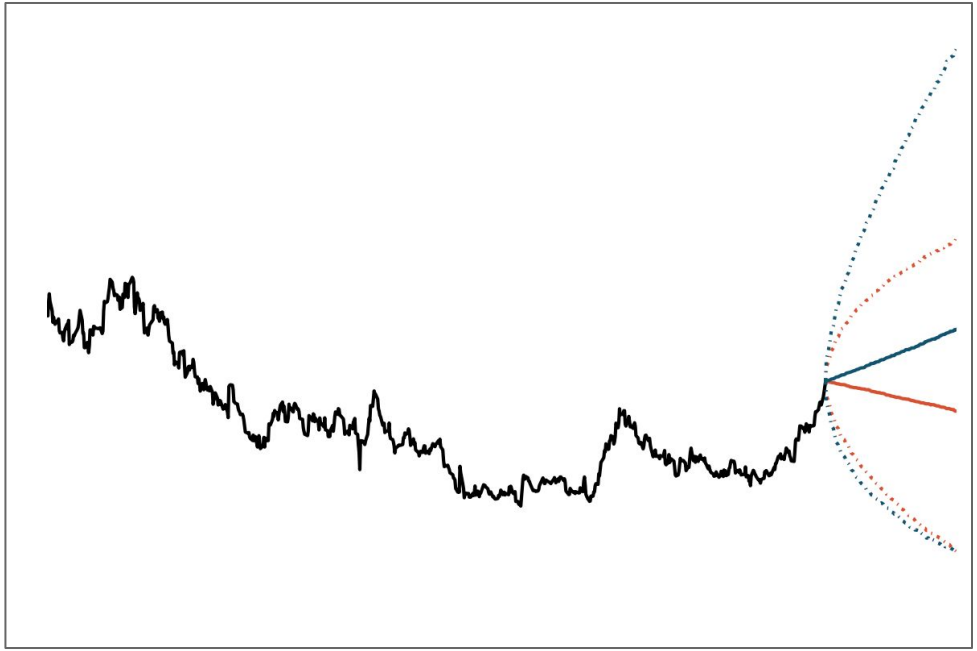
A trade as a hypothesis test

$$P(M_i \mid X) \propto P(X \mid M_i) \cdot P(M_i)$$

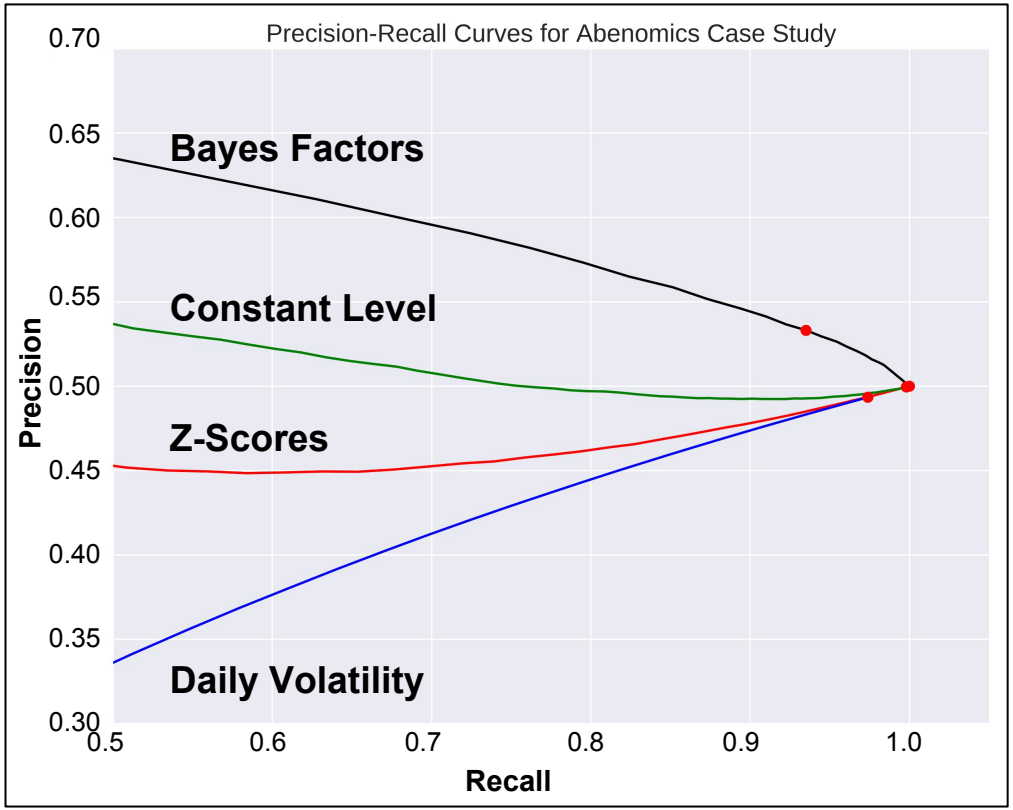
How to Choose: $P(M_{fcast})$

How complex or crazy is M_{fcast}?

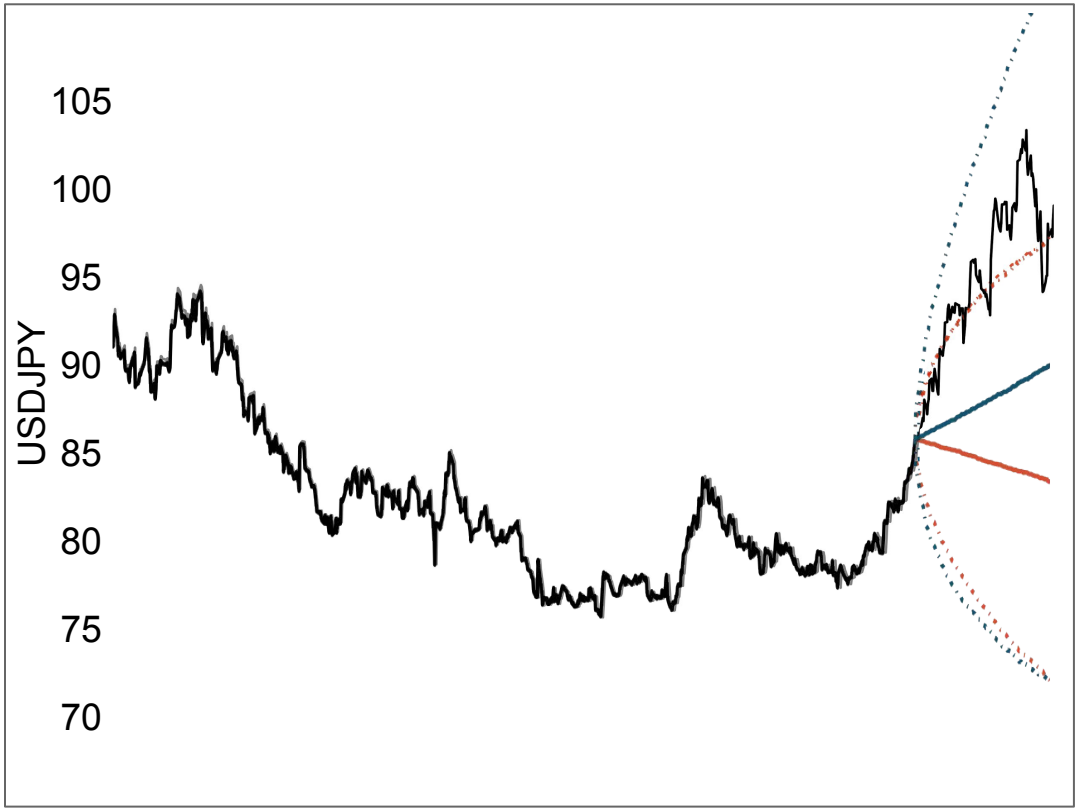
How robust is process of finding M_{fcast}?

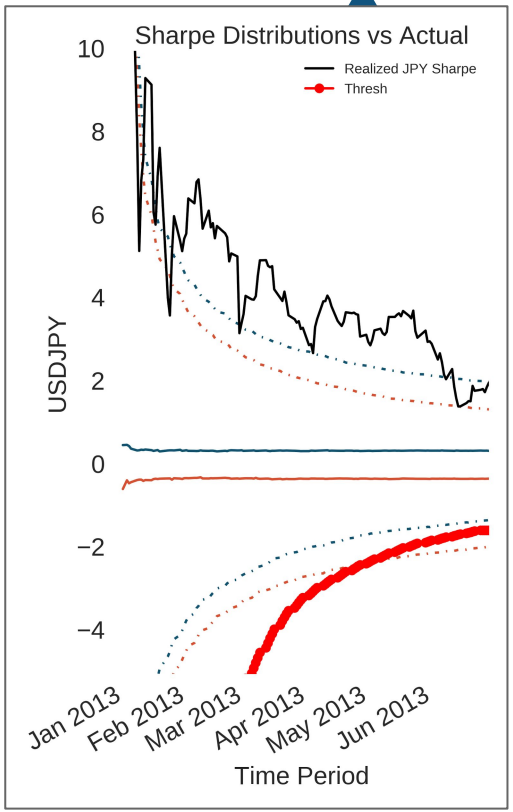


Bayes Factors is Highest Power Test

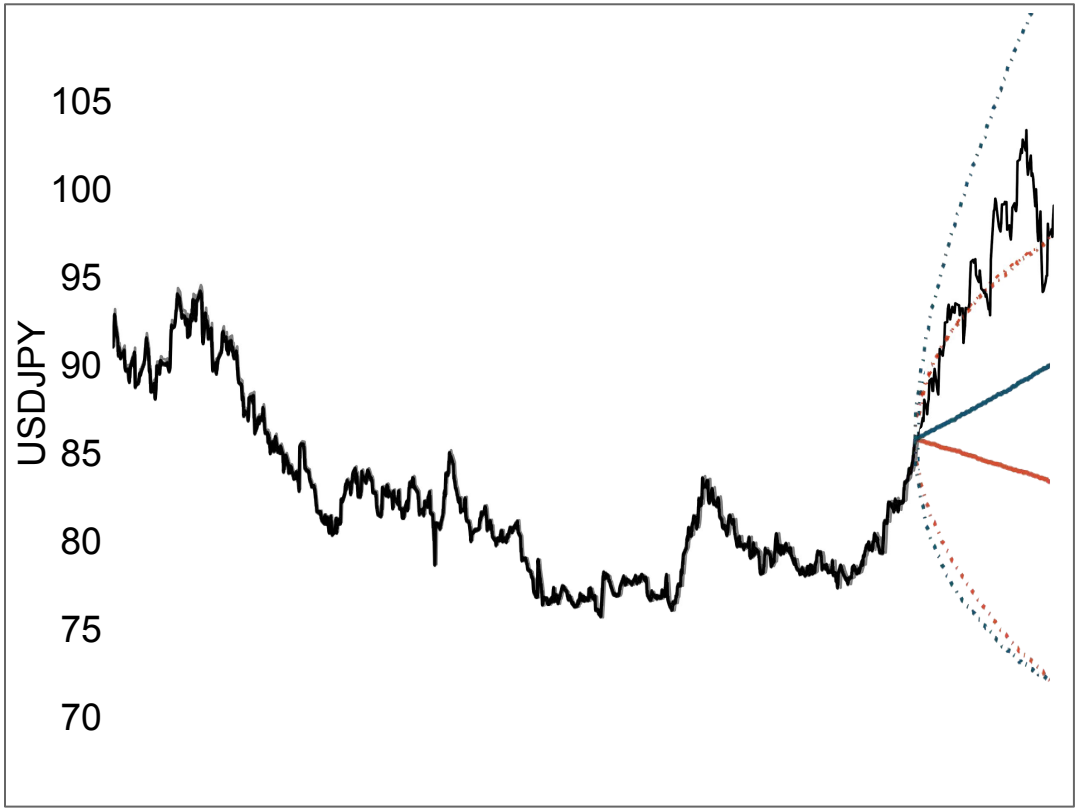


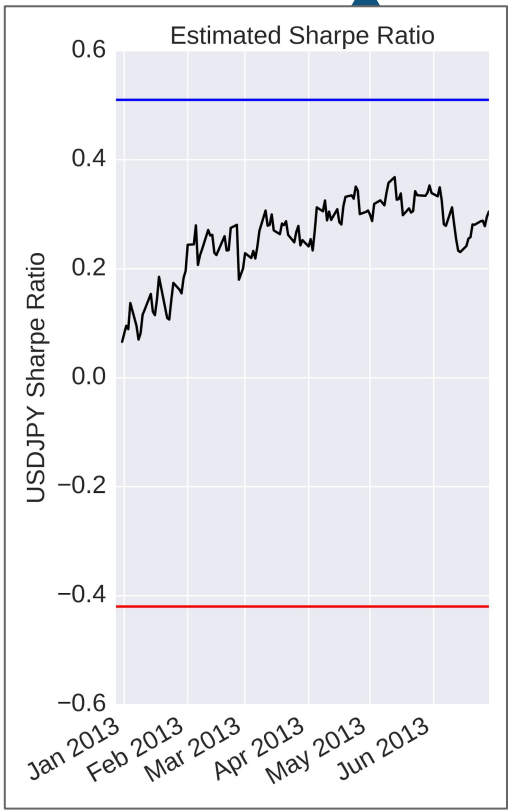
Global Macro Case Study: Results



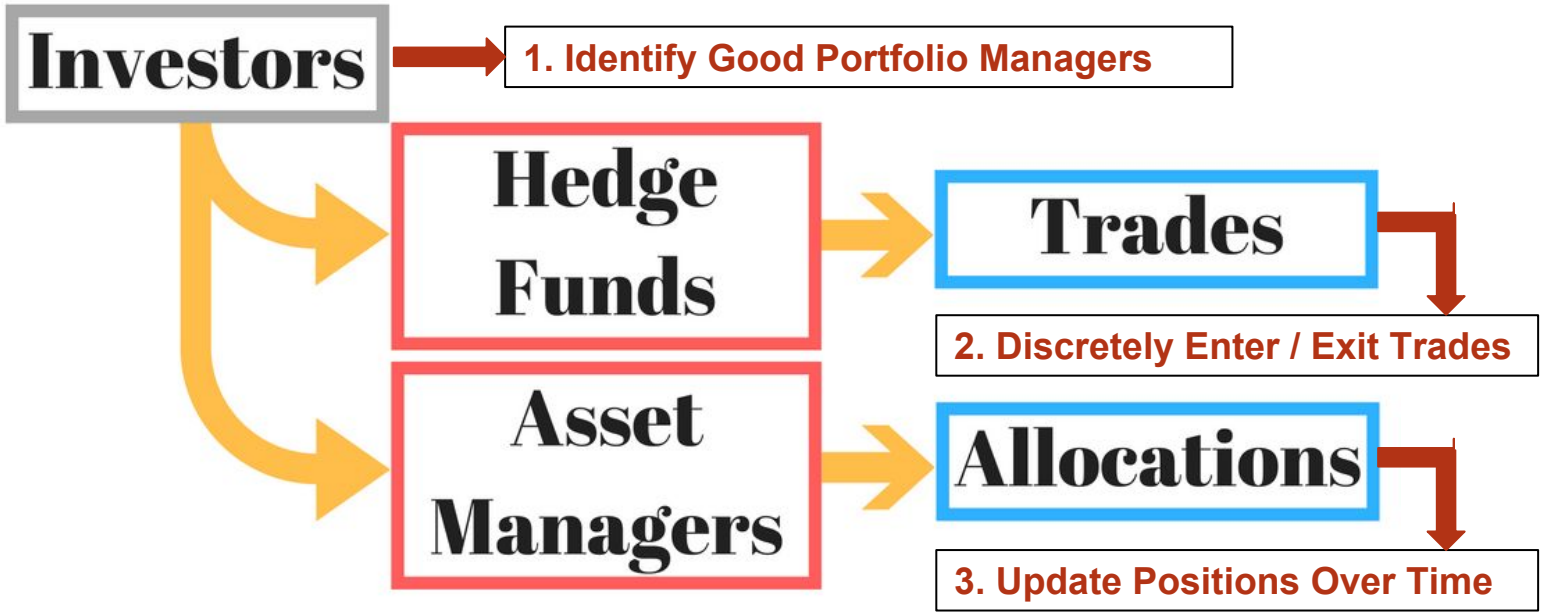


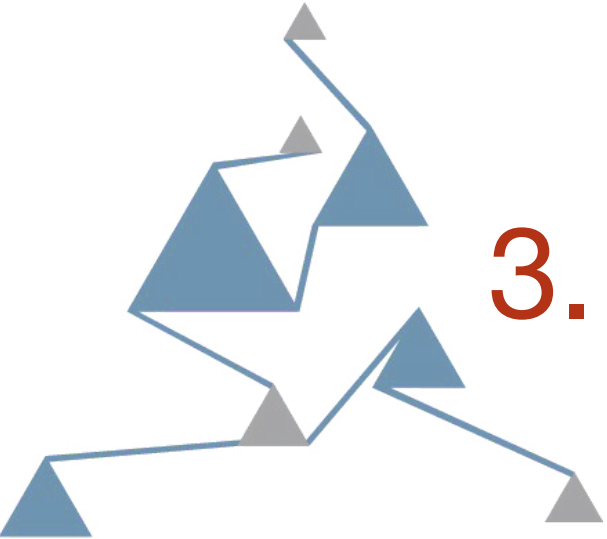
Asset Managers Adjust to New Views





Finance: Many Applications of Bayes

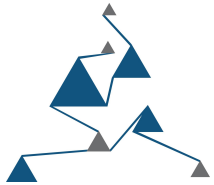




3. Factors as Investment Heuristics

Applying Machine Learning and Science to **Factor Shifts**

Optimal Rock-Paper-Scissors



Random Strategy

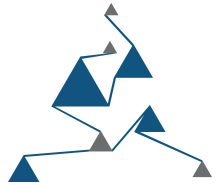
Never Loses & Never Wins

Predict Breaks in Opponent's Strategy

Complex and Evolving

Image Sources: http://www.rockpaperscissors.com/images/rps-logo.png

Optimal Trading Decisions



Robo + Classical Approach

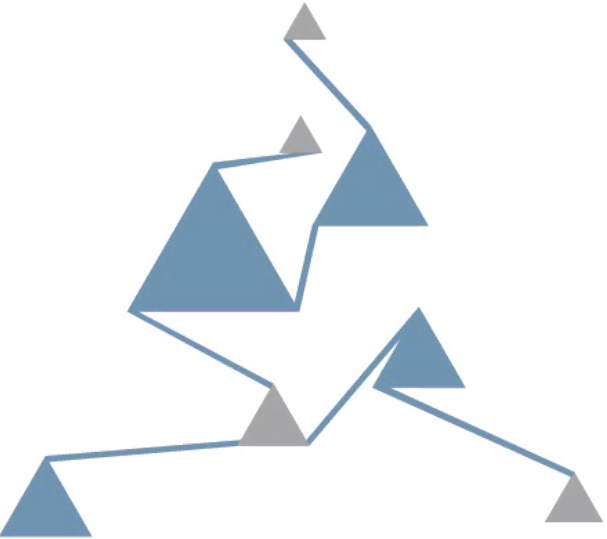
Black-Litterman + Simple APT

1. Trends
2. Betas
3. Correlations
4. Simple Factors

Next Generation Techniques

Alpha = Knowledge Growth

1. Trends
2. Betas
3. Correlations
4. New Factor Discovery
5. Changes to Above

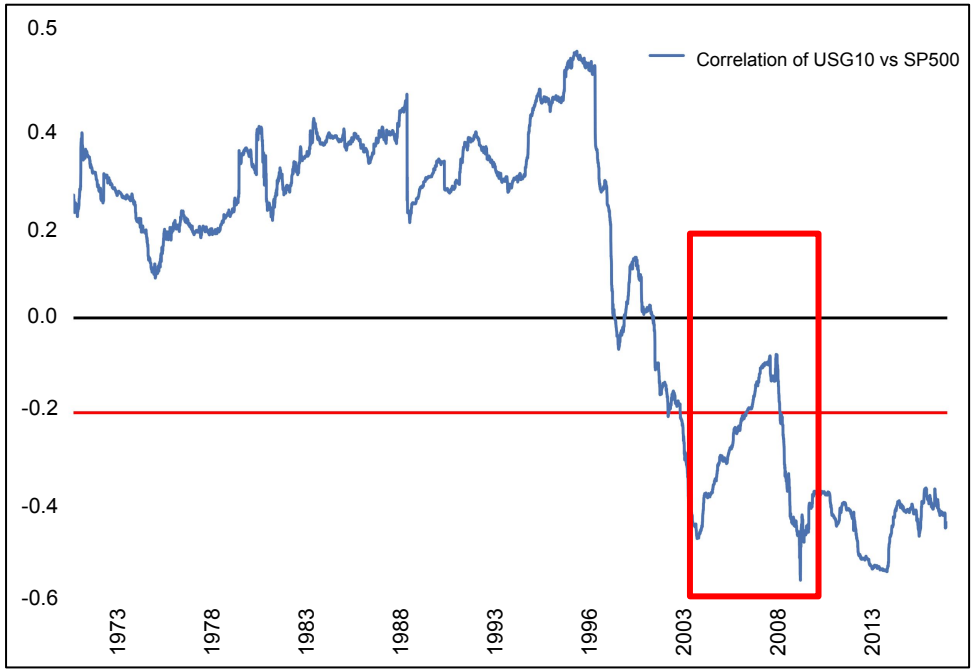


4. Next Generation Techniques

When your models break
you learn something

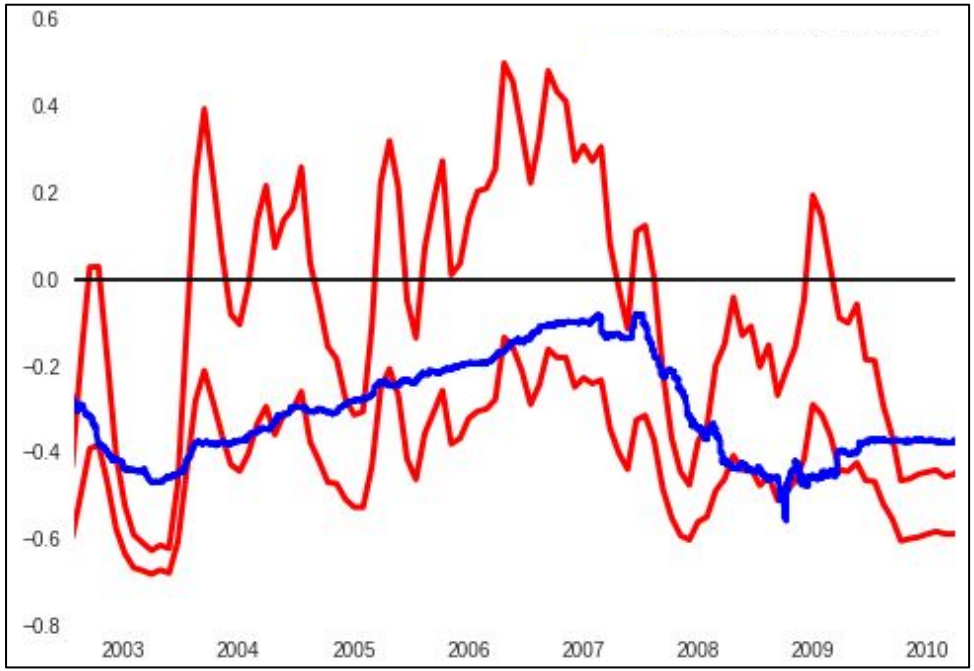
Correlations Change Quickly

Rolling Stock and Bond Correlation since 1970 vs Astrocyte Model



Correlations Change Quickly

Rolling Stock and Bond Correlation since 1970 vs Astrocyte Model



Astrocyte Model 10% and 90% bands

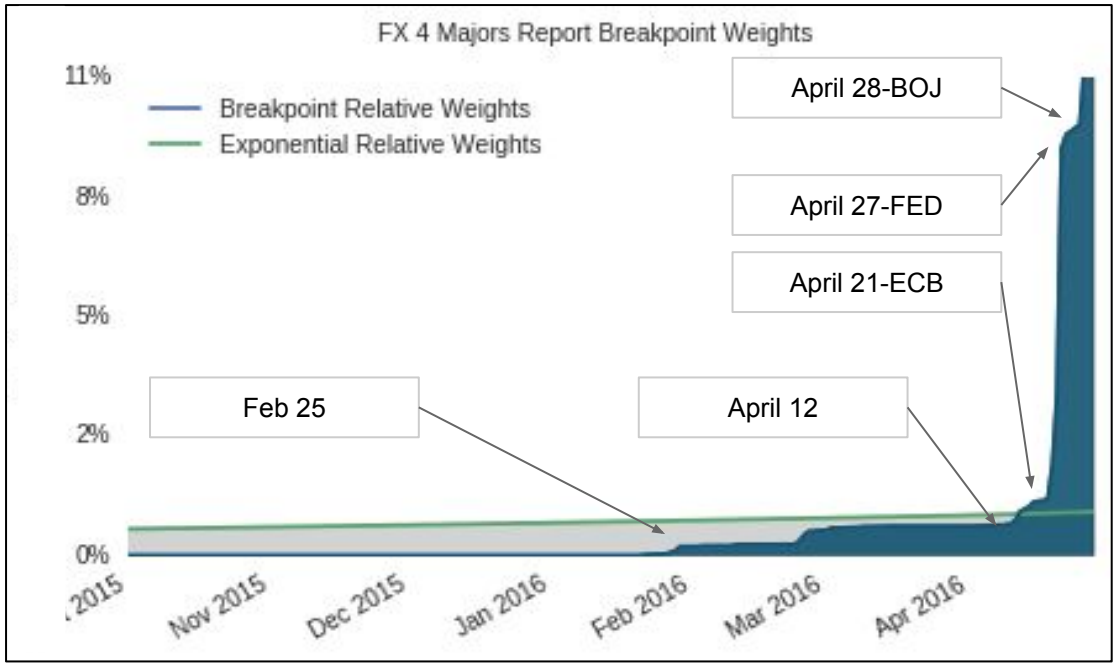
Exponentially Weighted Trailing Correlation

Astrocyte Factor Model:

- Yield Curve
- Crude Oil
- Baa Credit Spread

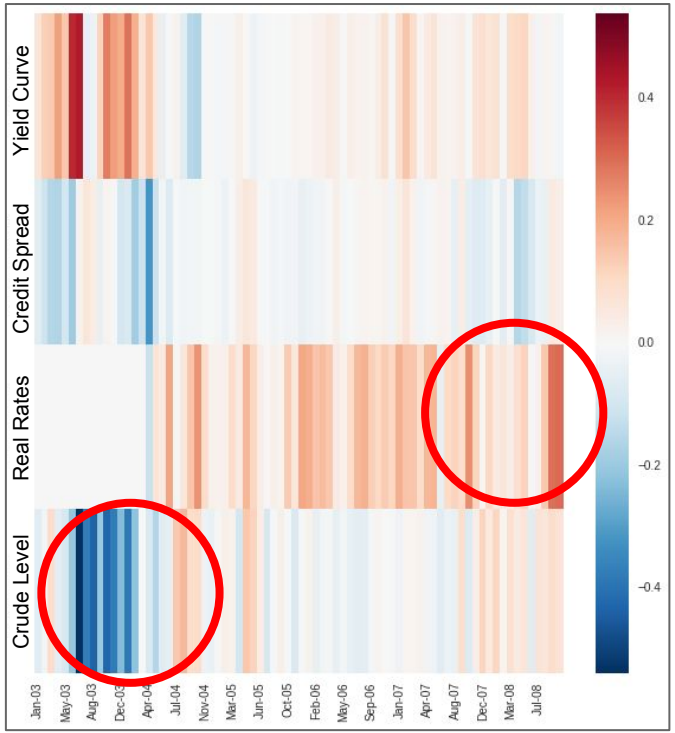
Stop using 1y trailing windows

Astrocyte FX Model: EUR & GBP & JPY & AUD on May 1st

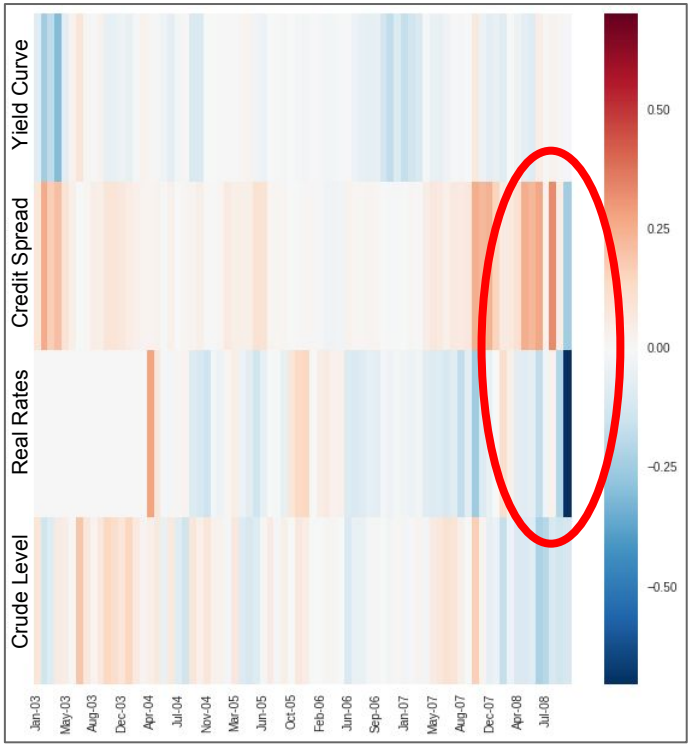


Factors and Betas Shift

Pre 2008 Bond Factors

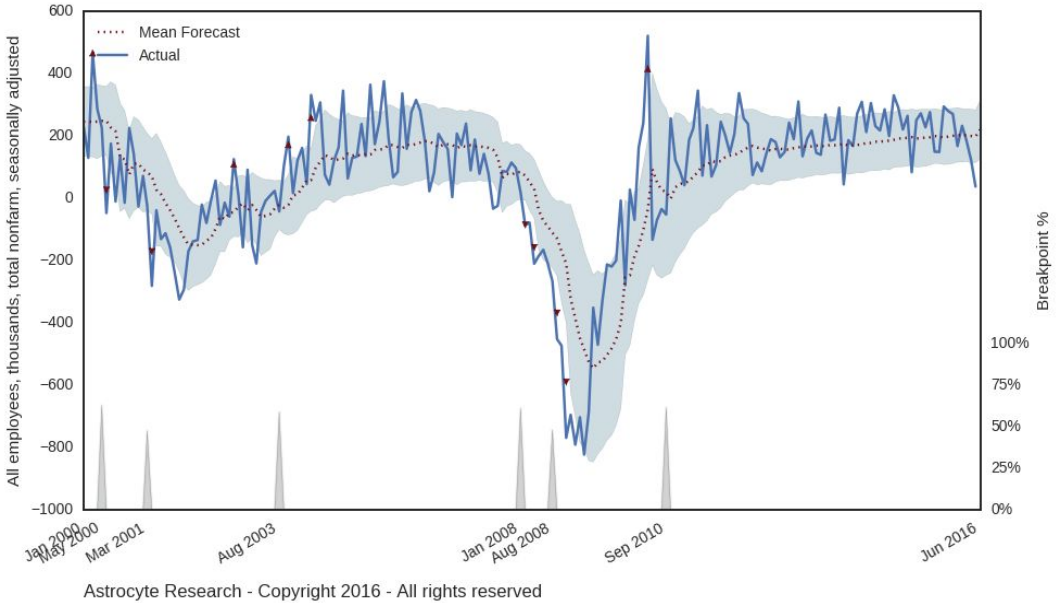


Pre 2008 Stock Factors



Economic Structure Matters

Astrocyte Model: Non-Farm Payroll Forecast

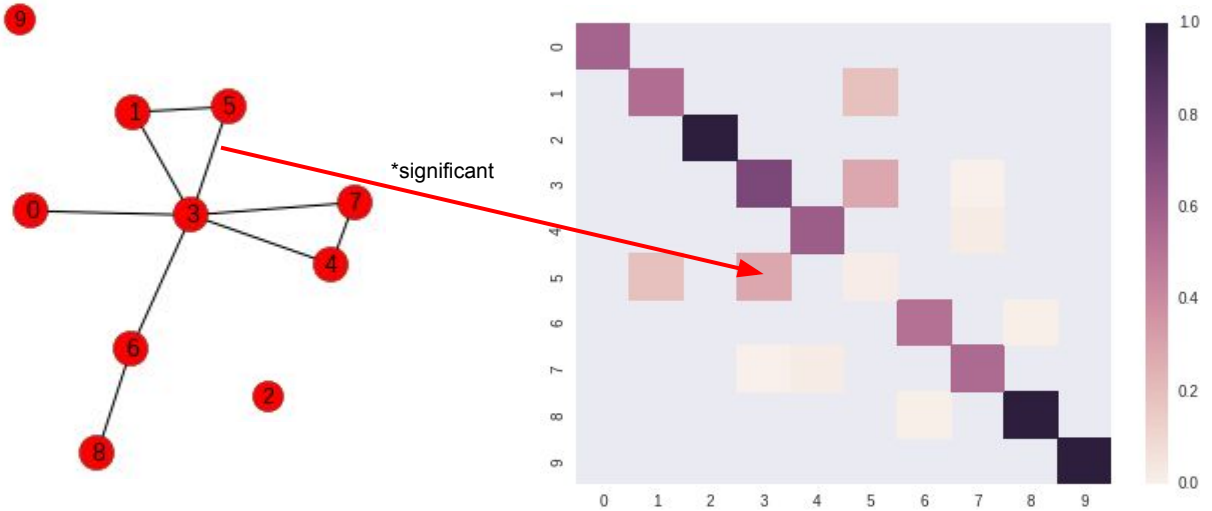


Composed of Models generated out of possible 26,000 sub-series and related series

Learned Market Structure

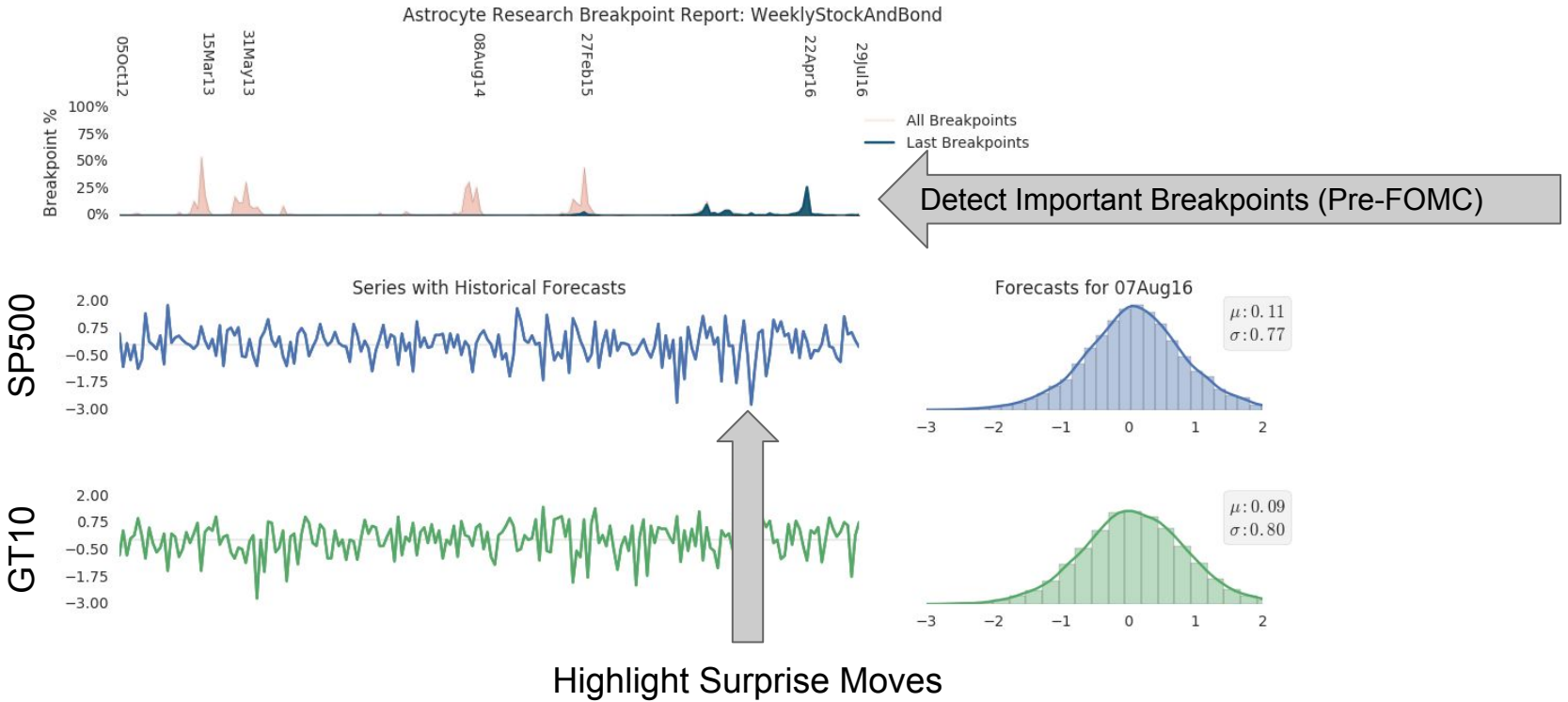
Astrocyte Model: Correlations between data series

0. Alcoholic Bevs
1. Clothing and Footwear
2. Communication
3. Food
4. Health
5. Household Contents
6. Housing and Utilities
7. Misc Goods and Services
8. Recreation and Culture
9. Transport

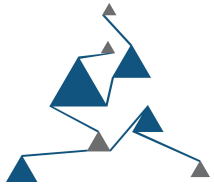


Each Node in the chart represents 1 Subcomponent of NZ Tradeable CPI
Each Edge represents Conditional Dependencies between the error terms in a series

Automated Trade Idea Generation



Thank you



http://bit.ly/astrocyte-meetup

Biography

Sean Kruzel

- Founded Astrocyte Research to better address the intelligence and forecasting needs of professional investors.
- Former Portfolio Manager at a NYC global macro hedge fund
    - Designed and implemented an event-based macroeconomic strategy using bonds, equities, currencies and commodities.
- Exotic FX Global Macro Associate in a 12-person, $1 Billion AUM west-coast hedge fund
    - Managed exotic options portfolios and studied the policies of global central banks.
- JPMorgan Asset Management Fixed Income Trading & Economic Analyst
    - Developed fixed income relative-value strategies and novel forecasts to track economic and central bank news.
- Sean Kruzel graduated MIT in 2008 with a BS in Economics and a BS in Mathematics.

Astrocyte Research

- Astrocyte Research delivers real-time insight and predictions on the interaction between policy makers, news and financial markets; specializing in the macroeconomic influences on global financial markets.