

A black and white photograph showing the silhouettes of five people walking from left to right against a background composed of several US dollar bills. The bills are partially visible, showing various denominations and parts of the US Treasury seal.

Adaptive Markets: Financial Evolution at the Speed of Thought

Andrew W. Lo, MIT

Museum of American Finance
January 24, 2018

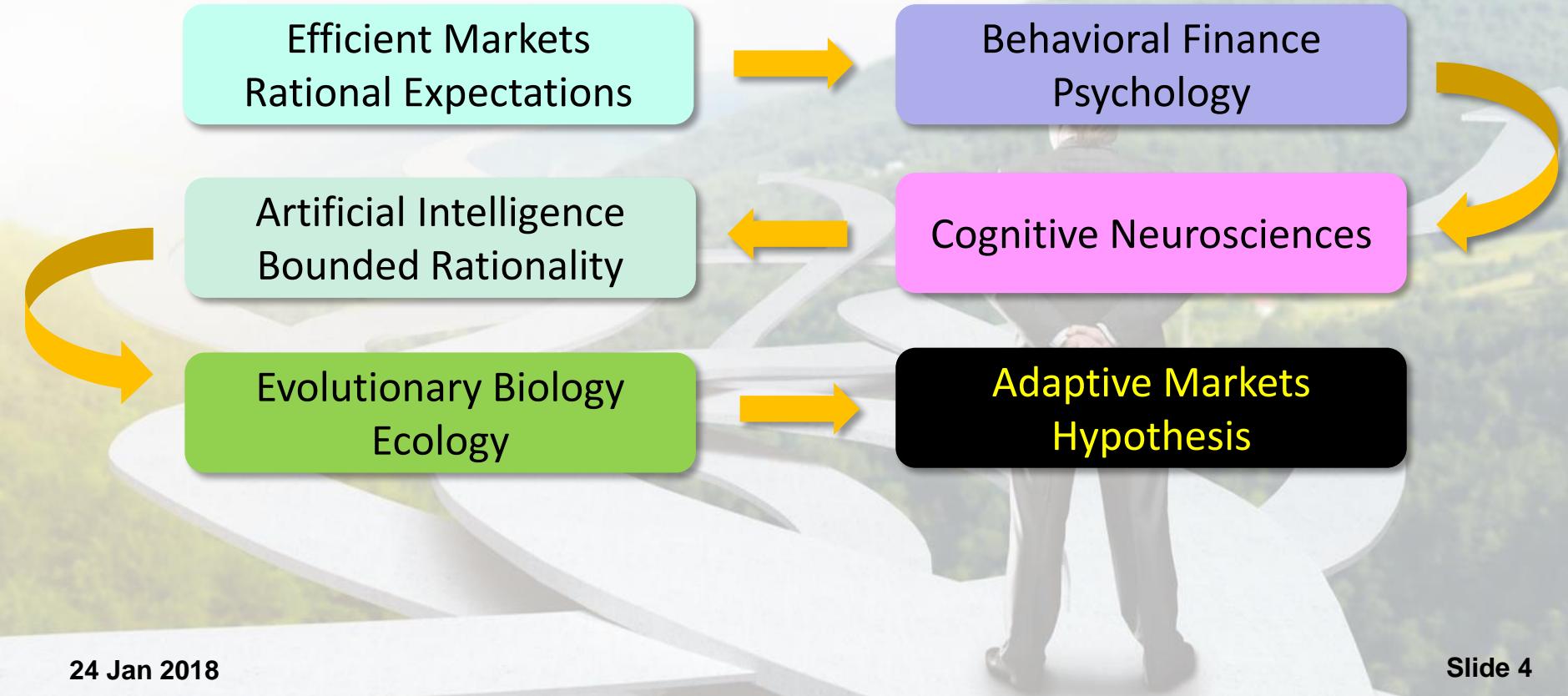
Markets
are
efficient

People
behave
irrationally





Personal Journey





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Summary

- Traditional investment framework is flawed
- Not wrong, but incomplete (physics envy)
- Stable environment \Rightarrow stable investment policies (EMH)
- Dynamic environment \Rightarrow dynamic investment policies (AMH)
- The current environment is highly **dynamic**
- We must adapt to changing market conditions
environment
- “it’s the ~~economy~~, stupid”
- **The Adaptive Markets Hypothesis provides a framework for investing, risk management, financial regulation, and more**

The Traditional Investment Paradigm

In the beginning...

$$R_{it} = \alpha_i + \beta_i F_t + \epsilon_{it}$$

Implications:

- Correlation matters; diversification
- Benchmarks, performance attribution
- Passive investing
- Indexation, hedging, portable alpha
- Risk budgeting
- **Framework for fiduciary duties**



The Traditional Investment Paradigm

But This Framework Requires Several Key Assumptions:

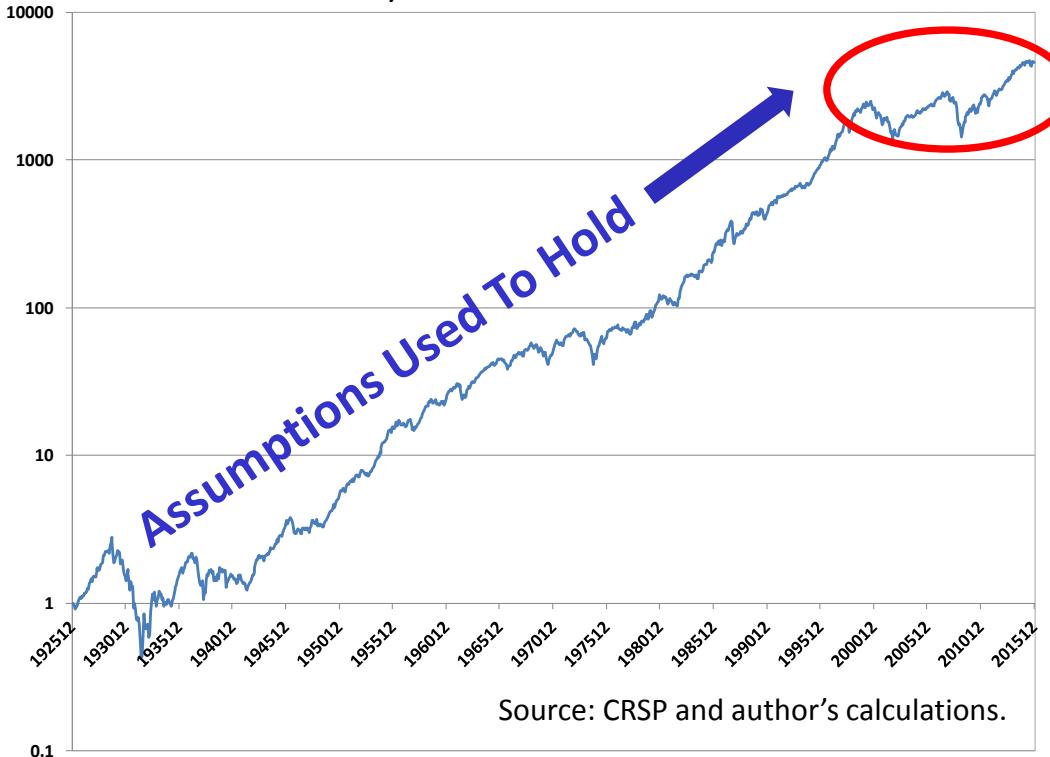
- Relationship is **linear**
- Relationship is **static** across time and circumstances
- Parameters can be **accurately estimated**
- Investors behave **rationally**
- Markets are **stationary** (static probability laws)
- Markets are **efficient**

What If Some of These Assumptions Don't Hold?

The Traditional Investment Paradigm

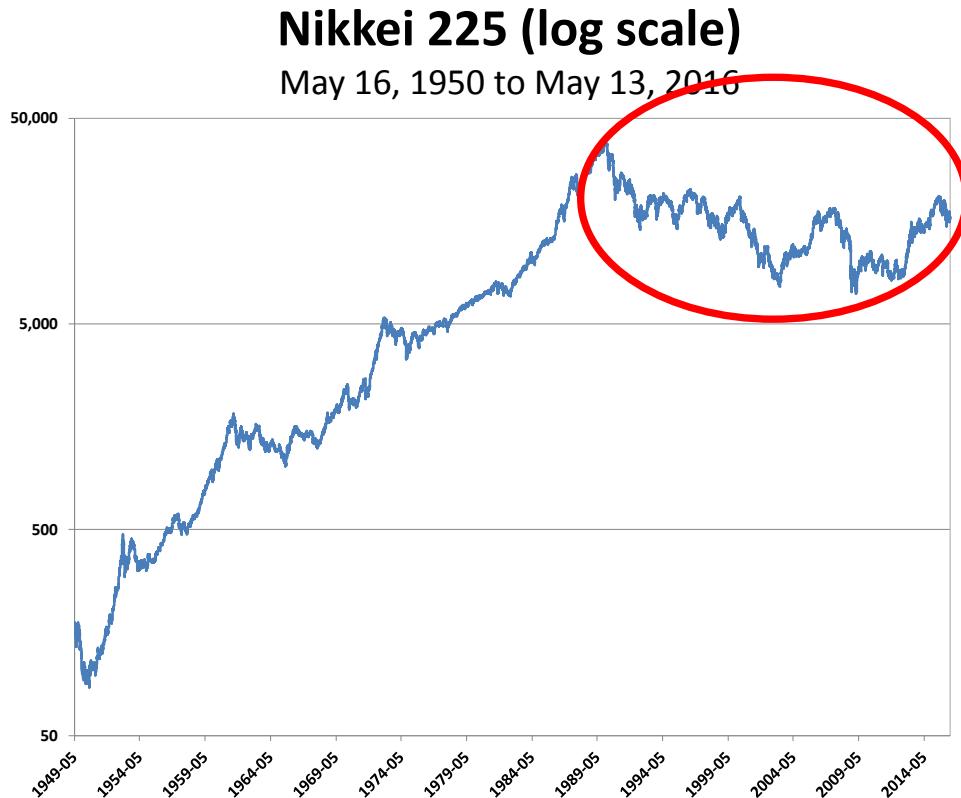
Cumulative Return of S&P 500 (log scale)

January 1926 to December 2015



But Do They
Still Hold
Today??

The Traditional Investment Paradigm



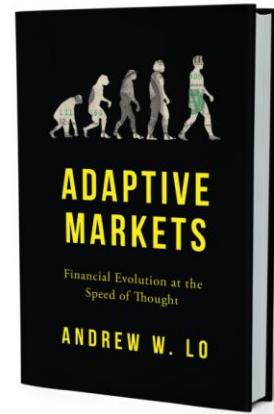
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The Adaptive Markets Hypothesis

“Nothing makes sense in biology except in the light of evolution,”
Dobzhansky (1973)

“Nothing makes sense in the hedge fund industry except in the light
of the Adaptive Markets Hypothesis,” Lo (2017)

1. Individuals act in their own self-interest
2. Individuals make mistakes (“satisfice”)
3. Individuals learn and adapt (heuristics)
4. Competition drives adaptation and innovation
5. Evolution determines market dynamics



What Do Investors Want?



Risk Perception and Adaptive Behavior

The Effects of Automobile Safety Regulation

Sam Peltzman

University of Chicago

Technological studies imply that annual highway deaths would be 20 percent greater without legally mandated installation of various safety devices on automobiles. However, this literature ignores offsetting effects of nonregulatory demand for safety and driver response to the devices. This article indicates that these offsets are virtually complete, so that regulation has not decreased highway deaths. Time-series (but not cross-section) data imply some saving of auto occupants' lives at the expense of more pedestrian deaths and more nonfatal accidents, a pattern consistent with optimal driver response to regulation.

Journal of Political Economy 83(1975), 677–726.

Risk Perception and Adaptive Behavior

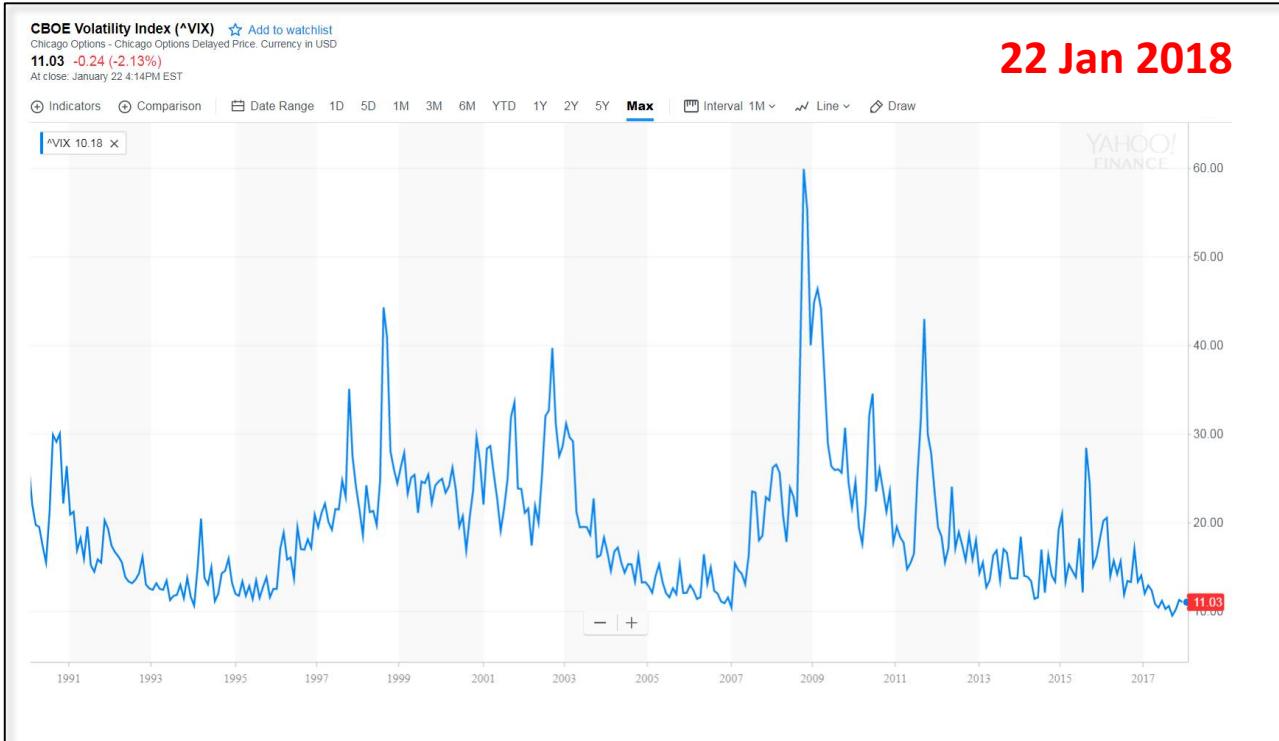
Automobile Safety Regulation and the Incentive to Drive Recklessly: Evidence from NASCAR

Russell S. Sobel* and Todd M. Nesbit†

When safety regulation makes automobiles safer, drivers may drive more recklessly, partially or completely offsetting effects on the overall level of safety. Evidence of these offsetting effects has been hard to find, however, primarily because of the aggregate nature of accident data. In this paper we explore how changes in the safety of automobiles used in the National Association for Stock Car Auto Racing (NASCAR) has altered the incentive of drivers to drive recklessly. This unique data set allows more accurate and objective measurement of the necessary variables to test for these effects at a microlevel. Our results strongly support the presence of these offsetting behavioral effects.

Southern Economic Journal 74(2007), 71–84.

Implications for the Current Ecosystem



A New Investment Paradigm Is Emerging

Efficient Markets

- Long-only constraint
- Diversify across stocks and bonds
- Market-cap-weighted indexes
- Manage risk via asset allocation
- Alpha vs. market beta
- Markets are efficient
- Equities in the long run

Adaptive Markets

- Long/short strategies
- Diversify across more asset classes and strategies
- Passive transparent indexes
- Manage risk via active volatility scaling algorithms
- Alphas \Rightarrow multiple betas
- Markets are **adaptive**
- “In the long run we’re all dead,” but make sure the short run doesn’t kill you first

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What Is An Index??

- Market-cap-weighted portfolio?

Jack Bogle (1997) on the Origins of the Vanguard Index Trust:

The basic ideas go back a few years earlier. In 1969–1971, Wells Fargo Bank had worked from academic models to develop the principles and techniques leading to index investing. John A. McQuown and William L. Fouse pioneered the effort, which led to the construction of a \$6 million index account for the pension fund of Samsonite Corporation. **With a strategy based on an equal-weighted index of New York Stock Exchange equities, its execution was described as “a nightmare”.** The strategy was abandoned in 1976, replaced with a market-weighted strategy using the Standard & Poor's 500 Composite Stock Price Index. The first such models were accounts run by Wells Fargo for its own pension fund and for Illinois Bell.

What Is An Index??

- Market-cap weighting requires little trading
- “Buy-and-hold” portfolio
- What if trading were cheaper, faster, and automatable?

In·dex \'in-,deks\ noun

An index is any portfolio strategy satisfying three properties: (1) it is completely transparent; (2) it is investable; and (3) it is totally systematic.

What Is An Index??

Value-weighted average?

<u>Yes</u>	<u>No</u>	<u>Maybe</u>
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Equal-weighted average?



Target-date fund?



FHFA House Price Index?



Hedge Fund Index?



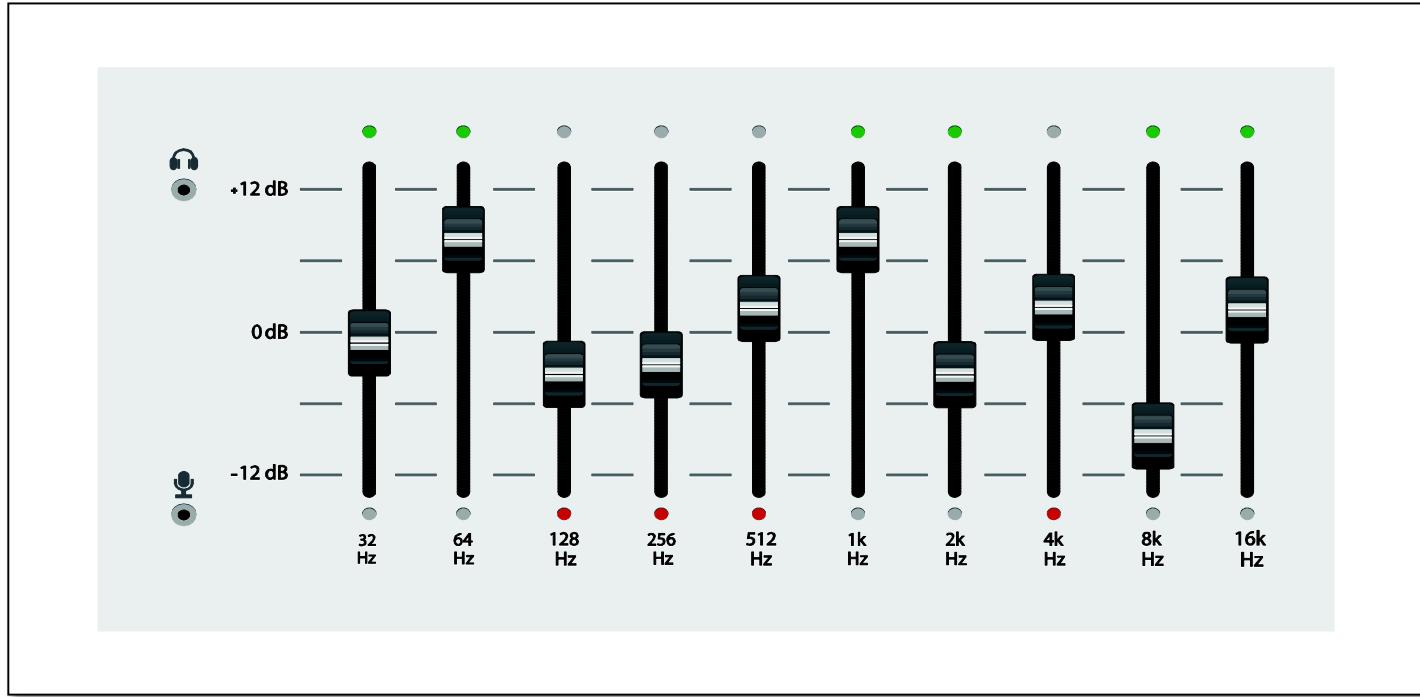
Trend-following futures?



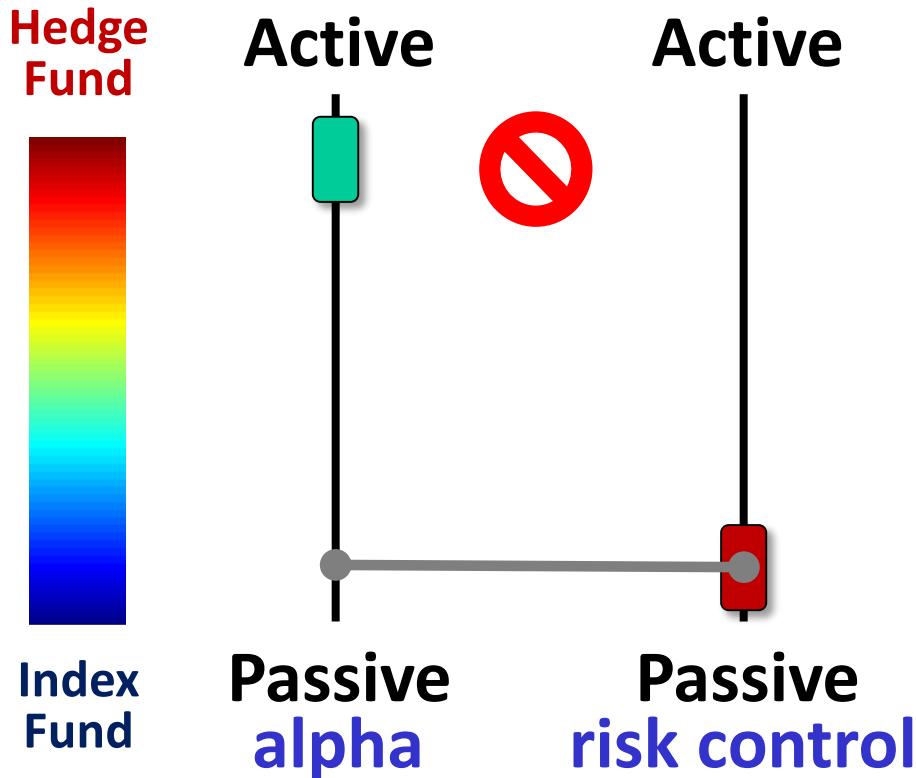
Risk-managed large-cap core?



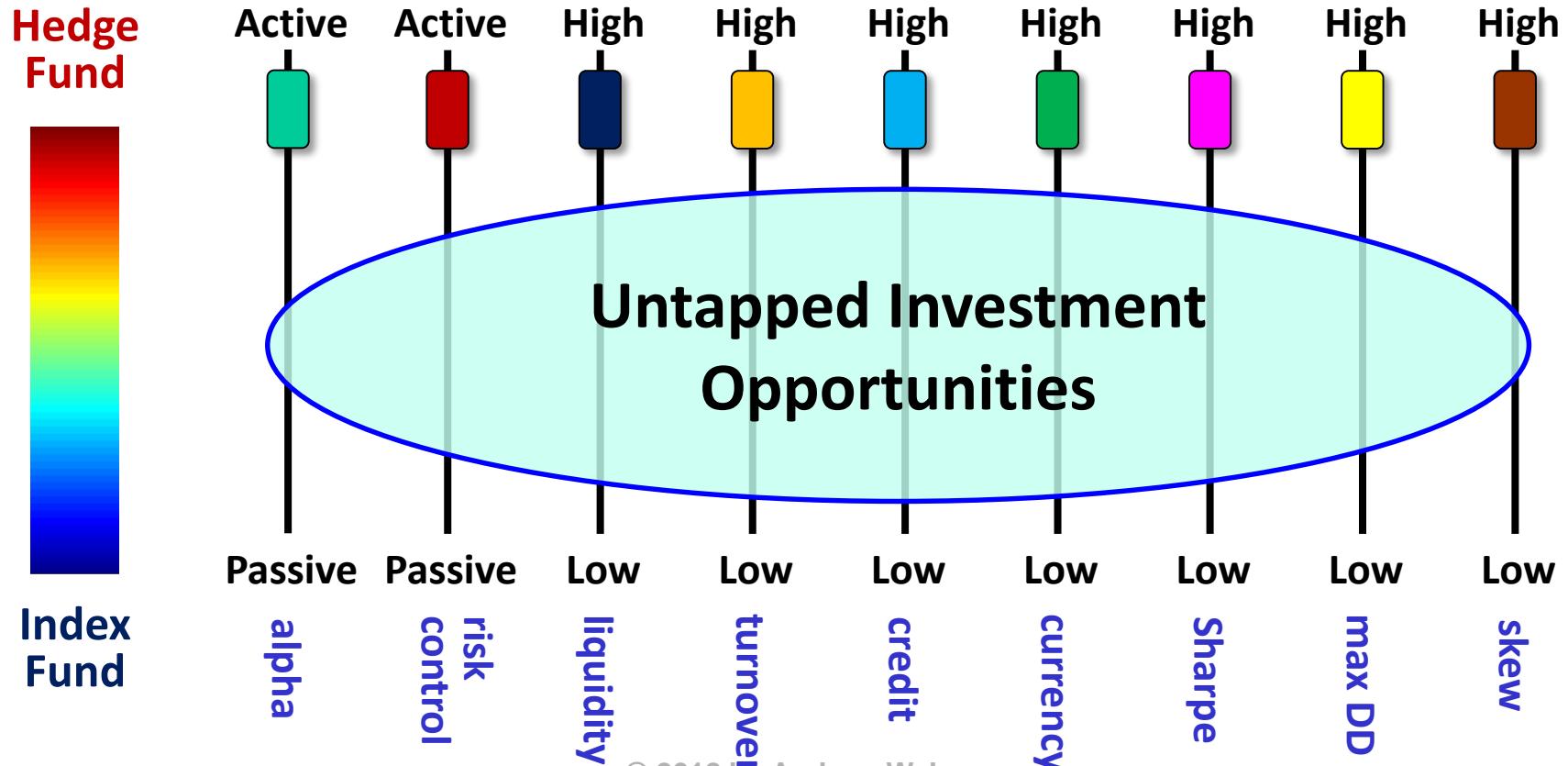
What Is An Index??



What Is An Index??



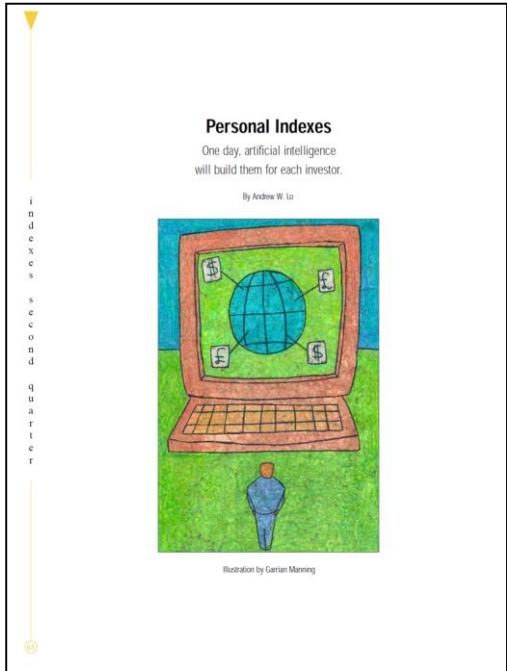
Full-Spectrum Investing



The Opportunity: Precision Indexes

- Instead of the DowJones30®, FTSE100®, or S&P500®, imagine investing in the:
 - JaneDoe30®, RichardRoe100®, or <YourNameHere>500®
- Imagine if such portfolios took into account income, expenses, age, health, taxes, and behavior
- Imagine if such portfolios were automated
- We have the hardware and software; we need the algorithms

This Idea Is Not New



“Artificial intelligence and active management are not at odds with indexation, but instead imply a more sophisticated set of indexes and portfolio management policies for the typical investor, something each of us can look forward to, perhaps within the next decade.”

– Andrew W. Lo, *Journal of Indexes Q2, 2001*

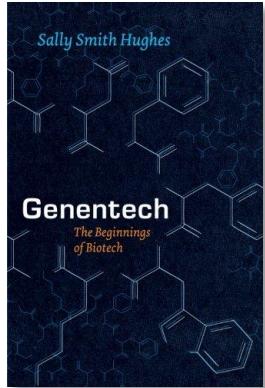
So What's Missing?

...Not Artificial Intelligence

Artificial **Humanity**

- We need an algorithm for investor behavior so we can counterbalance our least productive actions (e.g., loss aversion, overconfidence, overreaction, etc.)

Artificial vs. Natural Intelligence

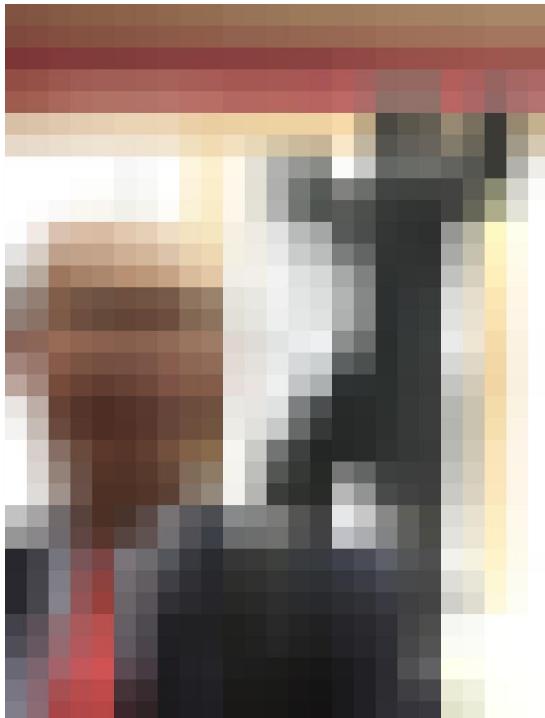
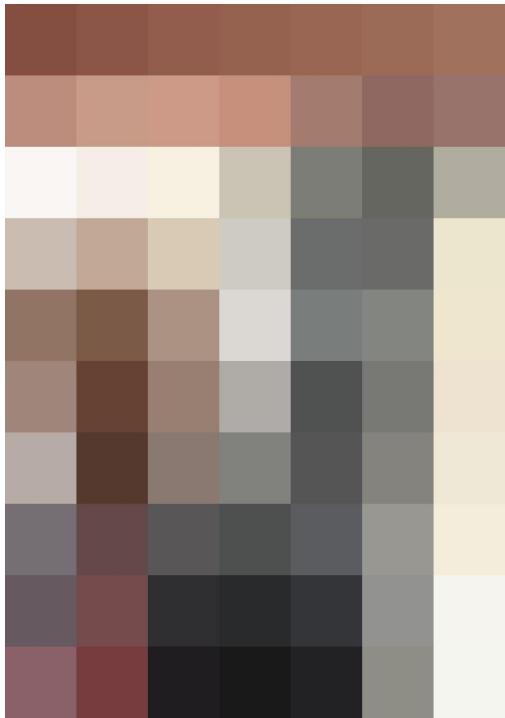


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THE ANTIDOTE	Barry Werth	4.5 stars	\$15.36 Prime
SCIENCE LESSONS	Gordon Binder	4.5 stars	\$28.71 Prime
NEW DRUGS	Lawrence T. Friedhoff	4.5 stars	\$23.70 Prime

- Expert systems vs. machine-learning techniques
- Expensive storage ⇒ small data, complex code
- Cheap storage ⇒ big data, simpler code
- This is closer to natural intelligence! Narrative vs. facts

Friend or Foe?



Friend or Foe?

José

Susan

- Gender and sex orientation (4)
- Race/ethnicity (4)
- Age (4)
- Current home state (50)
- Religious affiliation (4)
- Political party (3)
- Economic status (3)
- Education (3)

345,600 Possible Types!

But Beware of Learning With Sparse Data

128
CAMBRIDGE SAVINGS BANK

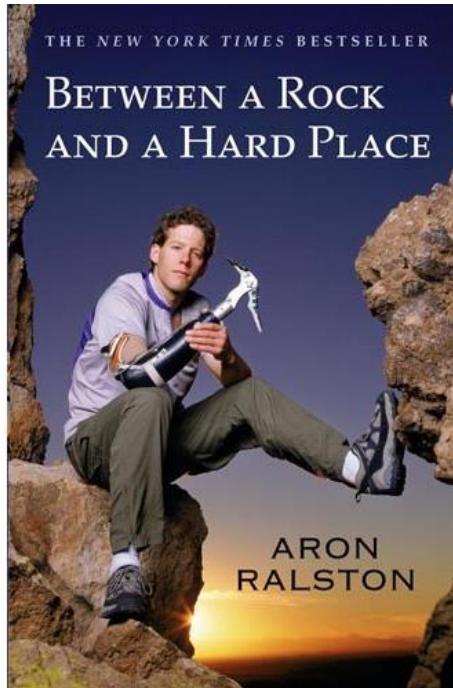
Bud

Make The BETTER Mo



Evolution at the Speed of Thought

Aron Lee Ralston, 4/26/03



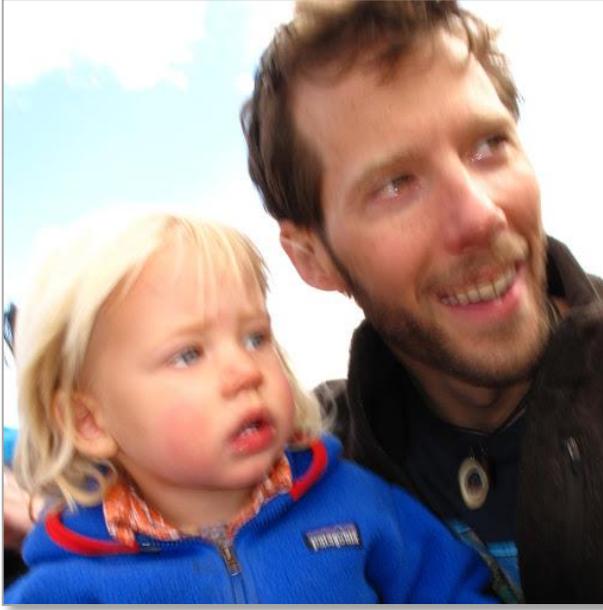
Evolution at the Speed of Thought

A blond three-year-old boy in a red polo shirt comes running across a sunlit hardwood floor in what I somehow know is my future home. By the same intuitive perception, I know the boy is my own. I bend to scoop him into my left arm, using my handless right arm to balance him, and we laugh together as I swing him up to my shoulder... Then, with a shock, the vision blinks out. I'm back in the canyon, echoes of his joyful sounds resonating in my mind, creating a subconscious reassurance that somehow I will survive this entrapment. Despite having already come to accept that I will die where I stand before help arrives, now I believe I will live.

That belief, that boy, changes everything for me.

– Aron Lee Ralston (2005)

Evolution at the Speed of Thought



We Need New Narratives In Finance!

Thank You!

For more on Adaptive Markets:

- <http://bit.ly/2t3Sre6> (MIT Sloan Lecture)
- <http://bit.ly/2ty6Rqp> (Clarendon Lectures)
- <http://alo.mit.edu> (website)
- @AndrewWLo (Twitter)

