What Is An Index?

Andrew W. Lo, MIT and AlphaSimplex
Conference in Honor of Burton G. Malkiel
Bendheim Center, Princeton University
April 8, 2011
Amazon Bestsellers Rank: #7,960 in Books (See Top 100 in Books)

Amazon Bestsellers Rank: #1,277,985 in Books (See Top 100 in Books)
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.
Common Wisdom:
- Beta is easy to come by
- True alpha is hard to find
- Correlation is important

Implications:
- Benchmarks
- Performance attribution
- Indexation and hedging
- Portable alpha overlays
- Risk budgeting
- Framework for fiduciary duties

\[ R_{it} = \alpha_i + \beta_i F_t + \epsilon_{it} \]
Markets Have Evolved

Buttonwood Agreement
May 17, 1792
ENIAC, 1946
- 17,468 vacuum tubes
- 7,200 crystal diodes
- 1,500 relays
- 70,000 resistors
- 10,000 capacitors
- 500 flops

Tianhe-1A CPU GPU Hybrid
2.51 petaflops LINPACK Test
October 2010
Technology Has Always Influenced Finance

Wall Street Before the Invention of the Telegraph

Wall Street After the Invention of the Telegraph

Source: Leinweber, 2009, *Nerds on Wall Street.*
Sometimes Abruptly...

London Stock Exchange
October 27, 1986
(“Big Bang”)

Source: Leinweber, 2009, *Nerds on Wall Street*. 

London Stock Exchange
Day Before October 27, 1986
(“Big Bang”)

We Have All Benefited Enormously

Vanguard Brokerage Services® commission and fee schedules

This commission schedule is effective May 4, 2010, and is subject to change.

<table>
<thead>
<tr>
<th>Assets invested in Vanguard funds and Vanguard ETFs®</th>
<th>Vanguard ETFs</th>
<th>Stocks and non-Vanguard ETFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Less than $50,000 (Standard)^2</td>
<td>• Free</td>
<td>• $7 for the first 25 trades^3</td>
</tr>
<tr>
<td>• $50,000–$500,000 (Voyager Services®)</td>
<td>• Free</td>
<td>• $20 for subsequent trades</td>
</tr>
<tr>
<td>• $500,000–$1 million (Voyager Select Services®)</td>
<td>• Free</td>
<td>• All trades: $7</td>
</tr>
<tr>
<td>• $1 million plus (Flagship Services®)</td>
<td>• Free</td>
<td>• All trades: $2</td>
</tr>
<tr>
<td>• $7 for the first 25 trades^3</td>
<td></td>
<td>• Free for first 25 trades^3</td>
</tr>
<tr>
<td>• $20 for subsequent trades</td>
<td></td>
<td>• $2 for subsequent trades</td>
</tr>
</tbody>
</table>
The Traditional Investment Paradigm Is Broken

- Long-only constraints are costly
- Diversification across stocks and bonds does not always work
- Asset allocation does not adequately control risk
Financial Markets Are Now More Complex

60-Month Rolling-Window Correlation Between S&P 500 and USD Index Returns, Dec 84 - Jun 09

Source: Bloomberg, CS/Tremont, and internal calculations.
125-Day Rolling-Window Volatility of CRSP Value-Weighted Index

June 2, 1926 to December 31, 2009

Source: CRSP and internal calculations.
The May 6, 2010 “Flash Crash”
Financial Markets Are Now More Complex

FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010

REPORT OF THE STAFFS OF THE CFTC AND SEC TO THE JOINT ADVISORY COMMITTEE ON EMERGING REGULATORY ISSUES

SEPTEMBER 30, 2010

Accenture plc, Market Depth, Aggressive Buys, and Price

2:40pm - 2:55pm

Financial Markets Are Now More Complex

World Population, 10,000 BC to 2008 AD


© 2011 by Andrew W. Lo
All Rights Reserved
One Implication: Alpha Turns To Beta

CS/Tremont Convertible Arbitrage Index vs. S&P 500
Jan 1994 to Dec 2000 (blue), Jan 2001 to Oct 2009 (lavender)

Source: Bloomberg, CS/Tremont, and internal calculations.

© 2011 by Andrew W. Lo
All Rights Reserved
One Implication: Alpha Turns To Beta

Example: Paulson & Co. (Wall Street Journal, January 5, 2009)
One Implication: Alpha Turns To Beta

Other Examples
- Value, growth, momentum, earnings surprise
- ABS, MBS, CDO, structured credit
- Equity market neutral
- The “carry” trade
- Merger arbitrage
- Trend-following

Wall Street Journal
September 7, 2007

How Market Turmoil Waylaid the ‘Quants’
Morgan Stanley Star Is Among Those Battered; No Time for Music Now

Adding Up
Estimated assets in quantitative funds using two common strategies: “market neutral” and “statistical arbitrage”: quarterly data
Source: HedgeFund.net

© 2011 by Andrew W. Lo
All Rights Reserved
Slide 18
One Implication: Alpha Turns To Beta

Unique → Novel → Popular → Common
One Implication: Alpha Turns To Beta

New View of Risk and Return:
- There are multiple betas, each with its own factor
- Factors differ in “risk premia” and correlations
- Premiums vary through time
- Correlations also vary

Implications for Alternatives:
- Benchmarks
- Performance attribution
- Indexation and hedging
- Portable alpha overlays
- Risk budgeting
- Framework for fiduciary duties

Manager A
Manager B
Manager C

Expected Return

© 2011 by Andrew W. Lo
All Rights Reserved
Why Haven’t We Seen These Betas Before?

- Not enough AUM in alternatives to impact the market until recently (alpha decay vs. beta proliferation)
- Recent technological advances in trading
- Financial innovation takes time
- Markets are not stationary
- Physics envy!
What Is An Index?

- An index should have three properties:
  - Transparent
  - Investable
  - Passive

- Market-cap-weighted portfolios are TIPical

- But other portfolios can be TIPical too
  - Target-date funds, 130/30, stable risk, trend-following, risk arbitrage, equity mean reversion, etc.
What Is An Index?

- Technological innovations make this possible
  - ECNs, flash orders, order display rules, etc.
  - Automated trading algorithms
  - Cheaper, faster, more reliable computers
  - Competition

- New perspective on indexation
  - “Plain-vanilla” strategies, e.g., carry trade
  - Automatic rebalancing is now practical
  - Cruise control, anti-lock brakes, etc.
Full-Spectrum Investing

- Sharpe Ratio: High Low
- Transparency: Low High
- Liquidity: Low High
- Risk Exposures: Complex Simple
- Controls: Few Many
- Capacity: Limited High
- Turnover: Hyperactive Passive
- Fees: High Low

Untapped New Investment Opportunities
Consider Investment Strategy Θ–2005

- Based on Pierre Fermat's Prime Number ``Test''

\[ p \text{ Prime } \Rightarrow 2^{p-1} = 1 \pmod{p} \]
\[ 2^{13-1} = 4096 = 13 \times 315 + 1 \]

- However, Some Non-Primes Can Pass Test
- Such “Carmichael Numbers” Are Extremely Rare
- All Carmichael Numbers Less Than 100,000:

<table>
<thead>
<tr>
<th>561</th>
<th>1,105</th>
<th>1,729</th>
<th>2,465</th>
<th>2,821</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,601</td>
<td>8,911</td>
<td>10,585</td>
<td>15,841</td>
<td>29,341</td>
</tr>
<tr>
<td>41,041</td>
<td>52,633</td>
<td>62,745</td>
<td>63,973</td>
<td>75,361</td>
</tr>
</tbody>
</table>

- Select stocks with CUSIP K such that:

\[ \frac{3 \times K}{561} = \text{Integer} \text{ or } 3 \times K = 0 \pmod{561} \]
Consider Investment Strategy 2005–2005

- Perform “backtest” using monthly data from 1926:1 to 2005:4*
- Result: PEOPLE ENERGY CORP, CUSIP 71103010

*Empirical results based on a sub-sample of continuously listed stocks.
Technology has transformed everything!
We are vastly better off
But new betas have emerged
We can do better
We have to do better
Index funds of the future will play a role
Thank You!