The Adaptive Markets Hypothesis and Financial Crisis

Andrew W. Lo
Harris & Harris Group Professor
MIT Sloan School of Management
Perimeter Institute Conference
May 1, 2009
Foundations of Modern Economics

Origins of Modern Economics

- Physics (Samuelson, 1947)
Origins of Modern Economics

- Physics (Samuelson, 1947)
- Samuelson (1998):

Perhaps most relevant of all for the genesis of *Foundations*, Edwin Bidwell Wilson (1879–1964) was at Harvard. Wilson was the great Willard Gibbs's last (and, essentially only) protege at Yale. He was a mathematician, a mathematical physicist, a mathematical statistician, a mathematical economist, a polymath who had done first-class work in many fields of the natural and social sciences. I was perhaps his only disciple... I was vaccinated early to understand that economics and physics could share the same formal mathematical theorems (Euler's theorem on homogeneous functions, Weierstrass's theorems on constrained maxima, Jacobi determinant identities underlying Le Chatelier reactions, etc.), while still not resting on the same empirical foundations and certainties.
Origins of Modern Economics

- Physics (Samuelson, 1947)
- Samuelson (1998):

Perhaps most relevant of all for the genesis of Foundations, Edwin Bidwell Wilson (1879–1964) was at Harvard. Wilson was the great Willard Gibbs's last (and, essentially only) protege at Yale. He was a mathematician, a mathematical physicist, a mathematical statistician, a mathematical economist, a polymath who had done first-class work in many fields of the natural and social sciences. I was perhaps his only disciple... I was vaccinated early to understand that economics and physics could share the same formal mathematical theorems (Euler's theorem on homogeneous functions, Weierstrass's theorems on constrained maxima, Jacobi determinant identities underlying Le Chatelier reactions, etc.), while still not resting on the same empirical foundations and certainties.
Origins of Modern Economics

- Physics (Samuelson, 1947)
- Samuelson (1998):

Perhaps most relevant of all for the genesis of *Foundations*, Edwin Bidwell Wilson (1879–1964) was at Harvard. Wilson was the great Willard Gibbs's last (and, essentially only) protege at Yale. He was a mathematician, a mathematical physicist, a mathematical statistician, a mathematical economist, a polymath who had done first-class work in many fields of the natural and social sciences. I was perhaps his only disciple... I was vaccinated early to understand that economics and physics could share the same formal mathematical theorems (Euler's theorem on homogeneous functions, Weierstrass's theorems on constrained maxima, Jacobi determinant identities underlying Le Chatelier reactions, etc.), while still not resting on the same empirical foundations and certainties.
Physics Approach In Economics Led To:
Physics Approach In Economics Led To:

- Utility theory, revealed preference (Samuelson)
Foundations of Modern Economics

Physics Approach In Economics Led To:

- Utility theory, revealed preference (Samuelson)
- General equilibrium theory (Arrow, Debreu)
Foundations of Modern Economics

Physics Approach In Economics Led To:

- Utility theory, revealed preference (Samuelson)
- General equilibrium theory (Arrow, Debreu)
- Game theory (Harsanyi, Nash, Selten)
Physics Approach In Economics Led To:

- Utility theory, revealed preference (Samuelson)
- General equilibrium theory (Arrow, Debreu)
- Game theory (Harsanyi, Nash, Selten)
- Rational expectations (Lucas, Muth, Sargent)
Physics Approach In Economics Led To:

- Utility theory, revealed preference (Samuelson)
- General equilibrium theory (Arrow, Debreu)
- Game theory (Harsanyi, Nash, Selten)
- Rational expectations (Lucas, Muth, Sargent)
- Option-pricing theory (Black, Merton, Scholes)
Foundations of Modern Economics

Physics Approach In Economics Led To:

- Utility theory, revealed preference (Samuelson)
- General equilibrium theory (Arrow, Debreu)
- Game theory (Harsanyi, Nash, Selten)
- Rational expectations (Lucas, Muth, Sargent)
- Option-pricing theory (Black, Merton, Scholes)
- Efficient markets (Fama, Samuelson)
Physics Approach In Economics Led To:

- Utility theory, revealed preference (Samuelson)
- General equilibrium theory (Arrow, Debreu)
- Game theory (Harsanyi, Nash, Selten)
- Rational expectations (Lucas, Muth, Sargent)
- Option-pricing theory (Black, Merton, Scholes)
- Efficient markets (Fama, Samuelson)

“Prices fully reflect all available information”
The complexity of price discovery in an efficient market: the stock market reaction to the Challenger crash

Michael T. Maloney\textsuperscript{a,\ast}, J. Harold Mulherin\textsuperscript{b,1}

\textsuperscript{a}Department of Economics, Clemson University, Clemson, SC 29634, USA
\textsuperscript{b}Department of Economics, Claremont McKenna College, Claremont, CA 91711, USA

Received 15 November 2001; received in revised form 8 February 2002; accepted 12 July 2002
January 28, 1986, 11:39am

- 11:47am: “Space Shuttle Explodes”
- 12:17pm: “Lockheed Has No Immediate Comment”
- 12:52pm: “Rockwell Intl Has No Comment”
Efficient Markets

Reagan Establishes Presidential Commission To Investigate
Efficient Markets

Rogers Commission Report Published June 9, 1986
- Concluded that Morton Thiokol was at fault

O-Ring
The Stock Market Reflected This Information Within Minutes

Table 2. Intraday stock market behavior around the Challenger crash

<table>
<thead>
<tr>
<th>Time</th>
<th>Morton Thiokol</th>
<th>Lockheed</th>
<th>Martin Marietta</th>
<th>Rockwell International</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:30 a.m.</td>
<td>US$37.25</td>
<td>US$47.25</td>
<td>US$35.38</td>
<td>US$34.75</td>
</tr>
<tr>
<td>Noon</td>
<td>Halt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:36 p.m.</td>
<td>US$35.00</td>
<td>US$45.00</td>
<td>US$32.50</td>
<td>US$34.13</td>
</tr>
<tr>
<td>1:00 p.m.</td>
<td>US$34.38</td>
<td>US$45.00</td>
<td>US$33.00</td>
<td>US$33.25</td>
</tr>
</tbody>
</table>

Panel A. Stock price movements

Panel B. Stock returns

- 11:30—Noon: Halt
- Noon—12:36: -6.04%
- 12:36—1:00: -1.79%

This table reports the price movements and stock returns of the four major space-shuttle firms in the period immediately surrounding the 11:39 a.m. crash of the space shuttle Challenger on January 28, 1986. There is no reported price for Morton Thiokol at noon because of an NYSE trading halt in that stock from 11:52 a.m. to 12:44 p.m. The first post-crash trade in Morton Thiokol occurred at 12:36 p.m. on NASDAQ. Data are taken from the price sheets of Francis Emory Fitch.
Fig. 1. Intraday stock price movements following the challenger disaster.
Behavioral Critique of Efficient Markets

- Rationality is not supported by the data
- Cognitive and behavioral biases
  - Loss aversion, anchoring, framing
  - Overconfidence
  - Overreaction
  - Herding
  - Mental accounting
Behavioral Critique of Efficient Markets

Even Samuelson (1947) Had Reservations:

...[O]nly the smallest fraction of economic writings, theoretical and applied, has been concerned with the derivation of operationally meaningful theorems. In part at least this has been the result of the bad methodological preconceptions that economic laws deduced from a priori assumptions possessed rigor and validity independently of any empirical human behavior. But only a very few economists have gone so far as this. The majority would have been glad to enunciate meaningful theorems if any had occurred to them. In fact, the literature abounds with false generalization.

We do not have to dig deep to find examples. Literally hundreds of learned papers have been written on the subject of utility. Take a little bad psychology, add a dash of bad philosophy and ethics, and liberal quantities of bad logic, and any economist can prove that the demand curve for a commodity is negatively inclined.
Behavioral Critique of Efficient Markets

www.viscog.com
The Triune Model of the Brain

- Corpus Callosum
- Cerebrum (New Cortex or New Brain)
- Limbic System (Mammalian or Mid Brain)
- Reptilian Complex (Old Brain)
- Cerebellum
- Brain Stem
The Triune Model of the Brain

Corpus Callosum

Cerebrum (Neo Cortex or New Brain)

Limbic System (Mammalian or Mid Brain)

Reptilian Complex (Old Brain)

Cerebellum

Brain Stem
The Triune Model of the Brain

- Corpus Callosum
- Cerebellum
- Brain Stem
- Limbic System (Mammalian or Mid Brain)
- Cerebrum (Neo Cortex or New Brain)
- Reptilian Complex (Old Brain)

Reptilian Brain
The Triune Model of the Brain

- Mammalian Brain
- Reptilian Brain
The Triune Model of the Brain

Hominid Brain

Mammalian Brain

Reptilian Brain
The Triune Model of the Brain

- Hominid Brain
- Mammalian Brain
- Reptilian Brain
The Triune Model of the Brain

Mammalian Brain

Reptilian Brain
The Triune Model of the Brain

- Hominid Brain
- Mammalian Brain
- Reptilian Brain
The Triune Model of the Brain

Examples of Applications
- Forced smile vs. Natural smile
- Social rejection vs. Physical pain

Emotional Stimulus Can Hinder Hominid Brain
- “The Gift of Fear”, G. de Becker
- Too flustered to speak
The Triune Model of the Brain

Say the **colors** of the following word:
The Triune Model of the Brain

Say the **colors** of the following word:

RED   GREEN   BLUE   YELLOW   ORANGE
BLUE   BROWN   RED   GREEN   PURPLE
PINK   BLACK   BLUE   YELLOW   GREEN
Say the colors of the following word:

RED  GREEN  BLUE  YELLOW  ORANGE

BLUE  BROWN  RED  GREEN  PURPLE

PINK  BLACK  BLUE  YELLOW  GREEN
The Triune Model of the Brain

Preferences Are Produced By The Three Brains

- Logical Reasoning Produced By Hominid Brain
- Emotional Stimulus Can Override Hominid Brain
- Lack of Emotion Can Also Lead To Irrationality
- Preferences May Not Be Stable Over Time
- Preferences May Not Be Stable Over Situations
- Agents Do Not Have Rational Expectations
- Neuroscientific Foundations of Behavior
The Triune Model of the Brain

Preferences Are Produced By The Three Brains

- Logical Reasoning Produced By Hominid Brain
- Emotional Stimulus Can Override Hominid Brain
- Lack of Emotion Can Also Lead To Irrationality
- Preferences May Not Be Stable Over Time
- Preferences May Not Be Stable Over Situations
- Agents Do Not Have Rational Expectations
- Neuroscientific Foundations of Behavior
The Adaptive Markets Hypothesis

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
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)

5-Year Rolling-Window Autocorrelation - S&P Composite Index Level

© 2007–2009 by Andrew W. Lo
All Rights Reserved
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)

- Autocorrelation
- S&P Composite Index Level

5-Year Rolling-Window Autocorrelation
S&P Composite Index Level
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)
Adaptive Markets At Work

Rolling 5-Year Autocorrelation and Level of S&P Composite Index
January 1871 to March 2009 (Data Source: R. Shiller)
Where Do Heuristics Come From?
Where Do Heuristics Come From?
Where Do Heuristics Come From?

Consider Getting Dressed:
Where Do Heuristics Come From?

Consider Getting Dressed:

- 5 Jackets, 10 Pants, 20 Ties, 10 Shirts, 10 Pairs of Socks, 4 Pairs of Shoes, 5 Belts
Where Do Heuristics Come From?

Consider Getting Dressed:

- 5 Jackets, 10 Pants, 20 Ties, 10 Shirts, 10 Pairs of Socks, 4 Pairs of Shoes, 5 Belts
- 2,000,000 Possible Outfits!
Where Do Heuristics Come From?

Consider Getting Dressed:

- 5 Jackets, 10 Pants, 20 Ties, 10 Shirts, 10 Pairs of Socks, 4 Pairs of Shoes, 5 Belts
- 2,000,000 Possible Outfits!
- Takes 1 Second To Evaluate Each Outfit
Where Do Heuristics Come From?

Consider Getting Dressed:

- 5 Jackets, 10 Pants, 20 Ties, 10 Shirts, 10 Pairs of Socks, 4 Pairs of Shoes, 5 Belts
- 2,000,000 Possible Outfits!
- Takes 1 Second To Evaluate Each Outfit
- How Long To Get Dressed?
Where Do Heuristics Come From?

Consider Getting Dressed:

- 5 Jackets, 10 Pants, 20 Ties, 10 Shirts, 10 Pairs of Socks, 4 Pairs of Shoes, 5 Belts
- 2,000,000 Possible Outfits!
- Takes 1 Second To Evaluate Each Outfit
- How Long To Get Dressed?
- 23.1 Days!

How Do We Get Dressed So Quickly?
The Financial Crisis

What Happened?

- Late 1990’s: low interest rates, “ownership society”, housing boom
- Lots of mortgages issued due to ARMs, securitization, Fannie, Freddie
- Lots of investors holding MBS (thanks to AAA ratings and CDS)
- Many of these securities were leveraged (AAA ratings and CDS)
- 2004: interest rates rise; 2006: housing market declines, defaults begin
- Losses are magnified by securitization, leverage, illiquidity
- Securities are downgraded, collateral deteriorates, firesales
- Investors, dealers, insurers, originators, GSEs lose money
- Loss of confidence triggers further losses, downgrades, more firesales
- Leads to “death spirals”, reduction in credit, general flight to quality
- Regulators intervene to forestall even more serious repercussions
The Financial Crisis

What Happened?

- Late 1990’s: low interest rates, “ownership society”, housing boom
- Lots of mortgages issued due to ARMs, securitization, Fannie, Freddie
- Lots of investors holding MBS (thanks to AAA ratings and CDS)
- Many of these securities were leveraged (AAA ratings and CDS)
- 2004: interest rates rise; 2006: housing market declines, defaults begin
- Losses are magnified by securitization, leverage, illiquidity
- Securities are downgraded, collateral deteriorates, firesales
- Investors, dealers, insurers, originators, GSEs lose money
- Loss of confidence triggers further losses, downgrades, more firesales
- Leads to “death spirals”, reduction in credit, general flight to quality
- Regulators intervene to forestall even more serious repercussions

How Could This Have Happened To Us???
The Financial Crisis

“Hall of Shame”?

- Homeowners
- Commercial banks
- Investment banks and other issuers of MBSs, CDOs, and CDSs
- Mortgage lenders, brokers, servicers, trustees
- Credit rating agencies (S&P, Moody, Fitch)
- Insurance companies ( multiline, monoline)
- Investors (hedge funds, pension funds, mutual funds, others)
- Regulators (SEC, OCC, CFTC, Fed, etc.)
- Government sponsored enterprises
- Politicians
The Financial Crisis

“Hall of Shame”?  
- Homeowners  
- Commercial banks  
- Investment banks and other issuers of MBSs, CDOs, and CDSs  
- Mortgage lenders, brokers, servicers, trustees  
- Credit rating agencies (S&P, Moody, Fitch)  
- Insurance companies (multiline, monoline)  
- Investors (hedge funds, pension funds, mutual funds, others)  
- Regulators (SEC, OCC, CFTC, Fed, etc.)  
- Government sponsored enterprises  
- Politicians

Is Human Behavior The Culprit?
Complexity, Tight Coupling, and Human Behavior
Complexity, Tight Coupling, and Human Behavior

What Causes Crises In Other Technology-Based Industries?
Complexity, Tight Coupling, and Human Behavior

Perrow’s (1984) Modified Theory of “Normal Accidents”

- Three conditions:
  1. Complex systems (nonlinearities)
  2. Tight coupling
  3. Third condition (Lo, 2004): Absence of negative feedback over a period of time

Perrow Does Not Explain Why Such Accidents Are “Normal”

⇒ Human Behavior Is The Reason

- Investors
- Managers
- Legislators
- Regulators
Has This Happened Before?

Yes, Many Times (see Reinhart and Rogoff, 2008):

- 18 times since 1974
- 5 big bank-related crises:
  - 1977: Spain
  - 1987: Norway
  - 1991: Finland
  - 1991: Sweden
  - 1992: Japan

- Common themes:
  - Rising housing and stock markets
  - Capital inflows
  - Large public debt
  - Financial liberalization
Could The Crisis Have Been Avoided?

What If We Knew This Was Going To Happen In 2005?

**ECONOMIC VIEW**

**MARK GOREIN**

**Is a Hedge Fund Shakeout Coming Soon? This Insider Thinks So**

**Andrew W. Lo**

The recent crisis in the financial system has raised important questions about the potential for a hedge fund shakeout. The hedge fund industry has been under pressure due to a combination of factors, including regulatory changes, market volatility, and a series of high-profile failures. This has raised concerns about the sustainability of the industry and the potential for a shakeout.

Andrew W. Lo of MIT, a renowned finance professor, has expressed his concerns about the industry’s stability. Lo argues that the recent events have highlighted the need for greater transparency and regulation. He warns that a shakeout is likely, noting that many hedge funds are under pressure and may struggle to meet their obligations.

Lo’s concerns are supported by several indicators. The number of hedge funds has declined significantly, and many have been forced to liquidate. This has put pressure on the remaining funds, which may have to reduce their leverage or take on riskier strategies to attract new investors.

The shakeout could have significant consequences, as it could lead to a decline in the industry’s reputation and reduce the investment opportunities available to investors. It is important for investors to stay informed about the industry’s developments and to evaluate the risk associated with their investments.

**AlReady, his work has prompted a debate among hedge fund managers and investors about the potential for a shakeout. Lo’s research has highlighted the importance of transparency and regulation in maintaining the industry’s stability.**

**Andrew W. Lo** of MIT, a finance professor known for his work on the performance of hedge funds, has stated that a shakeout is likely in the near future. He warns that many hedge funds are struggling to meet their obligations and may have to liquidate.

Lo notes that the recent events have highlighted the importance of transparency and regulation. He calls for greater oversight of the hedge fund industry to prevent a shakeout and to protect investors.

**The New York Times, Sunday, September 6, 2009**

**THE NEW YORK TIMES, Sunday, September 6, 2009**

Andrew W. Lo, a finance professor at MIT, has warned of the possibility of a hedge fund shakeout. Lo's research indicates that many hedge funds are struggling to meet their obligations and may have to liquidate.

Lo argues that greater transparency and regulation are needed to prevent a shakeout. He calls for a review of the industry's practices and for greater oversight to protect investors.

**Andrew W. Lo** of MIT, a finance professor known for his work on the performance of hedge funds, has stated that a shakeout is likely in the near future. He warns that many hedge funds are struggling to meet their obligations and may have to liquidate.

Lo notes that the recent events have highlighted the importance of transparency and regulation. He calls for greater oversight of the hedge fund industry to prevent a shakeout and to protect investors.

**The New York Times, Sunday, September 6, 2009**

Andrew W. Lo, a finance professor at MIT, has warned of the possibility of a hedge fund shakeout. Lo's research indicates that many hedge funds are struggling to meet their obligations and may have to liquidate.

Lo argues that greater transparency and regulation are needed to prevent a shakeout. He calls for a review of the industry's practices and for greater oversight to protect investors.
Could The Crisis Have Been Avoided?

What If We Knew This Was Going To Happen In 2005?

- Through what mechanism can this information be acted on?
  - As CEO, reduce business exposure ⇒ lose market share
  - As CRO, hedge exposure ⇒ lose money until 2007
  - As portfolio manager, turn away assets ⇒ lose key personnel

- Success and prosperity are potent anesthetics ("feeling no pain")
- But pain is necessary to guard against dangers
- Prolonged bull market dulls the sense of danger and risk aversion
Could The Crisis Have Been Avoided?

What If We Knew This Was Going To Happen In 2005?

Is a Hedge Fund Shakeout Coming Soon? This Insider Thinks So

ECONOMIC VIEW
MARK GOREK

If all the sectors of the financial universe, the hedge fund world is probably the most secretive and potentially the most alluring. Openly to institutions and the wealthy, hedge funds offer unrivaled freedom of risk, access to the top financial minds and the chance for outsized returns. According to forced-advisors, hedge fund assets have topped a trillion dollars.

But, unfortunately, is that occasional secrecy may be subject to catastrophic, unanticipated losses. In 1998, many hedge fund managers lost their careers.

Andrew W. Lo, a finance professor at the Sloan School of Management at the Massachusetts Institute of Technology, has been studying hedge fund failures and risks, as if they were another hedge fund industry shakeout is likely in the near future. Mr. Lo, a company, Alphadump, that manages $40 billion in hedge fund assets, has focused on a crucial issue: hedge funds are vulnerable to the same kind of problems that other financial companies have encountered in recent years.

Andrew W. Lo of MLT, says he has found warning signs for the hedge fund industry.

Andrew W. Lo of MLT, says he has found warning signs for the hedge fund industry. His work shows that the average price of a hedge fund has declined by 10% since January 1998, a period when many hedge fund investors have come under scrutiny. The result is a decline in the value of hedge fund assets by more than 20% in the past year. This is a dramatic decline in value that many hedge fund investors have found surprising.

But Mr. Lo quickly notes that the hedge fund industry is not immune to risks. As a result, hedge fund investors need to be aware of the risks and take steps to protect their money.

Mr. Lo's work has prompted him to re-examine the way he invests in hedge funds. His research has led him to conclude that hedge funds are vulnerable to the same kind of problems that other financial companies have encountered in recent years.

ALREADY, his work has prompted hedge fund managers and investors to pay more attention to the hidden risks of funds that seem to be performing quite well. Clifford S. Asness, managing principal at AQR Capital Management, a large and successful hedge fund based in Greenwich, Conn., says Mr. Lo's work forces fund managers to consider the risks. He says, "It demonstrates simple models that generally show a warning signal but occasionally really don't work."

"In what ways is Mr. Lo's work to eliminate the cyclical nature of the hedge fund industry?" Mr. Lo asks. "I think we need to learn from the mistakes of others and be prepared to act accordingly."

The nightmare script for Mr. Lo would be a series of failures of highly leveraged hedge funds that bring down the major banks and cause a dramatic 20% return on a single investment. Mr. Lo is concerned about the potential for this kind of crisis.

"The concern that I and others have is that we are approaching the perfect financial storm where all the arrows are lined up in one direction," Mr. Lo says. "We need to be aware of the risks and take steps to protect our money."
Crisis Preparation vs. Crisis Prevention

- Break up banks and broker/dealers that are “too big to fail”
- Create exchanges for CDSs and other large OTC contracts
- Create financial NTSB for analyzing all blow-ups
- Require confidential disclosure regarding “network” exposures
- Implement counter-cyclical leverage constraints for bank-like entities
- Enforce “suitability” requirements for mortgage-broker advice
- Require certification for mgmt. and boards of complex financial institutions
- Impose more mark-to-market accounting and risk controls
- Impose capital adequacy requirements for all bank-like entities
- Create new discipline of “risk accounting”
- Impose small derivatives tax to fund financial engineering programs
- Revise laws to allow “pre-packaged” bankruptcies for finance companies
- Change corporate governance structure (compensation, CRO role, etc.)
- Teach economics, finance, and risk management in high school
Thank You!
Thank You!