Title: The Adaptive Markets Hypothesis and Financial Crisis

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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)

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- 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.

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"Prices fully reflect all available information"

Efficient Markets

ELSEVIER

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Journal of CORPORATE FINANCE

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The complexity of price discovery in an efficient market: the stock market reaction to the Challenger crash☆

Michael T. Maloney[a,*], J. Harold Mulherin[b,1]

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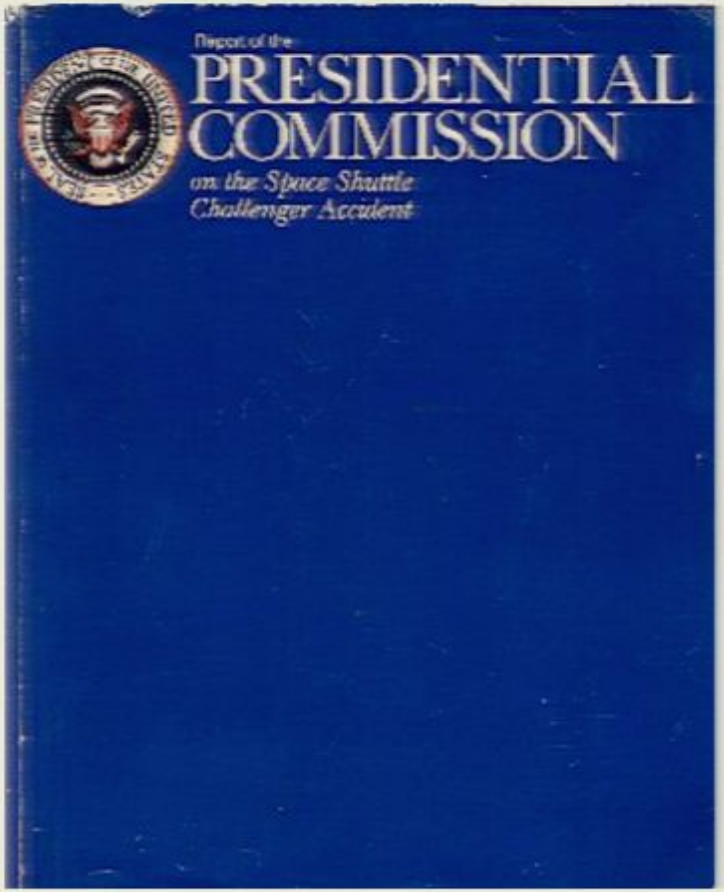
Efficient Markets

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

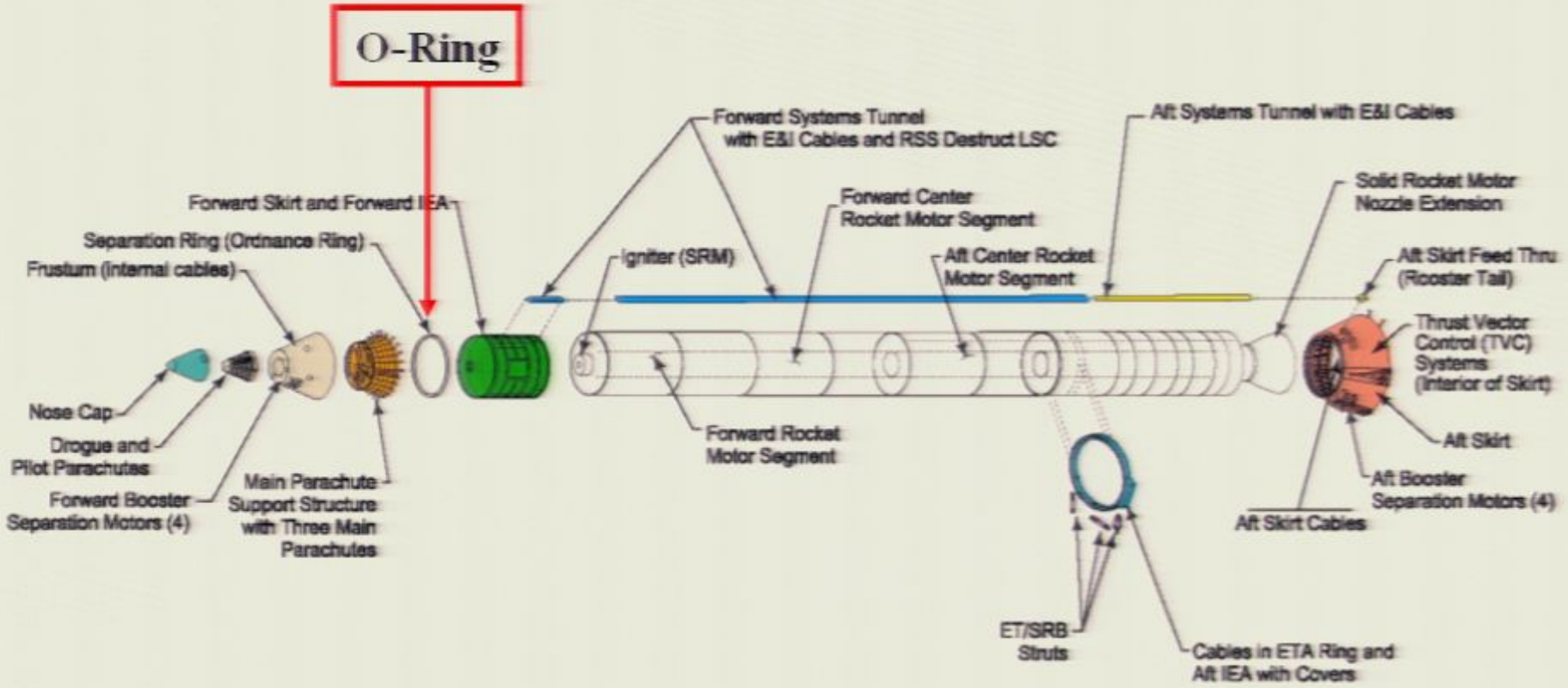
Reagan Establishes Presidential Commission To Investigate



Efficient Markets

Rogers Commission Report Published June 9, 1986

- Concluded that Morton Thiokol was at fault



Efficient Markets

The Stock Market Reflected This Information Within Minutes

Table 2
Intraday stock market behavior around the Challenger crash

Time	Morton Thiokol	Lockheed	Martin Marietta	Rockwell International
Panel A. Stock price movements				
11:30 a.m.	US$37.25	US$47.25	US$35.38	US$34.75
Noon	Halt	US$44.50	US$34.25	US$32.75
12:36 p.m.	US$35.00	US$45.00	US$32.50	US$34.13
1:00 p.m.	US$34.38	US$45.00	US$33.00	US$33.25
Panel B. Stock returns				
11:30–Noon	Halt	−5.82%	−3.18%	−5.76%
Noon–12:36	−6.04%	1.12%	−5.11%	4.20%
12:36–1:00	−1.79%	0.00%	1.54%	−2.56%

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.

Efficient Markets

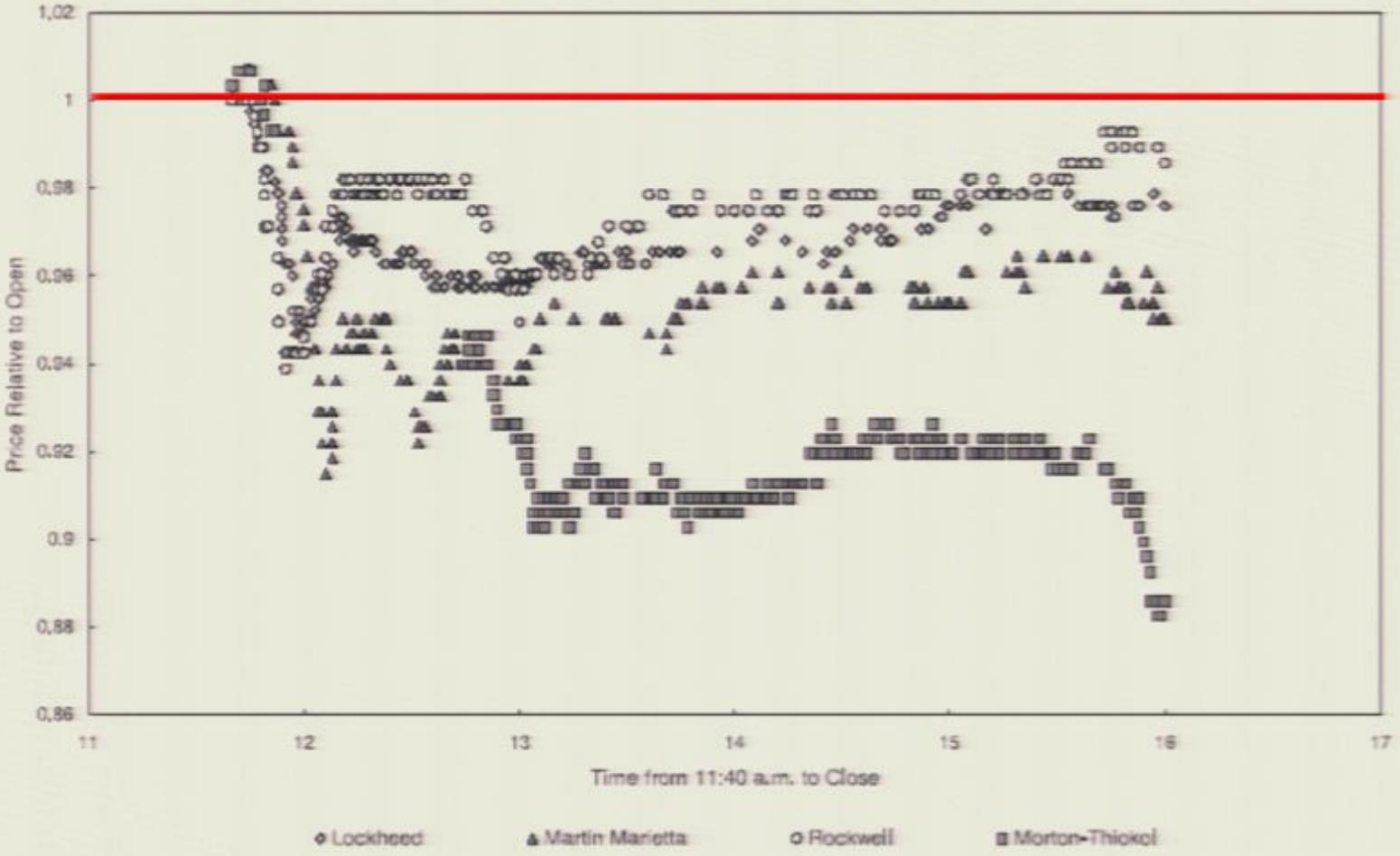


Fig. 1. Intraday stock price movements following the challenger disaster.

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

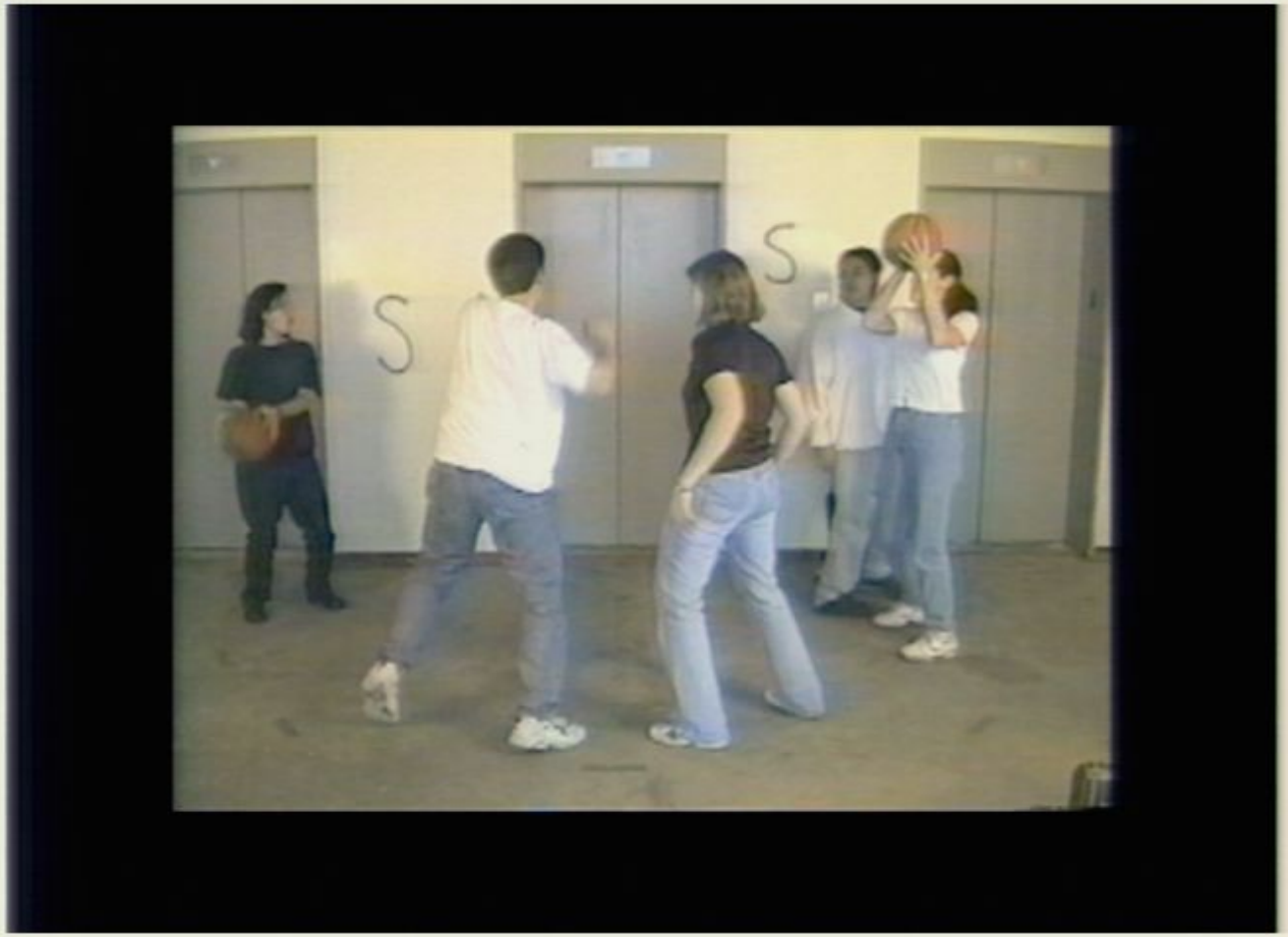
Even Samuelson (1947) Had Reservations:

...[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

Perimeter



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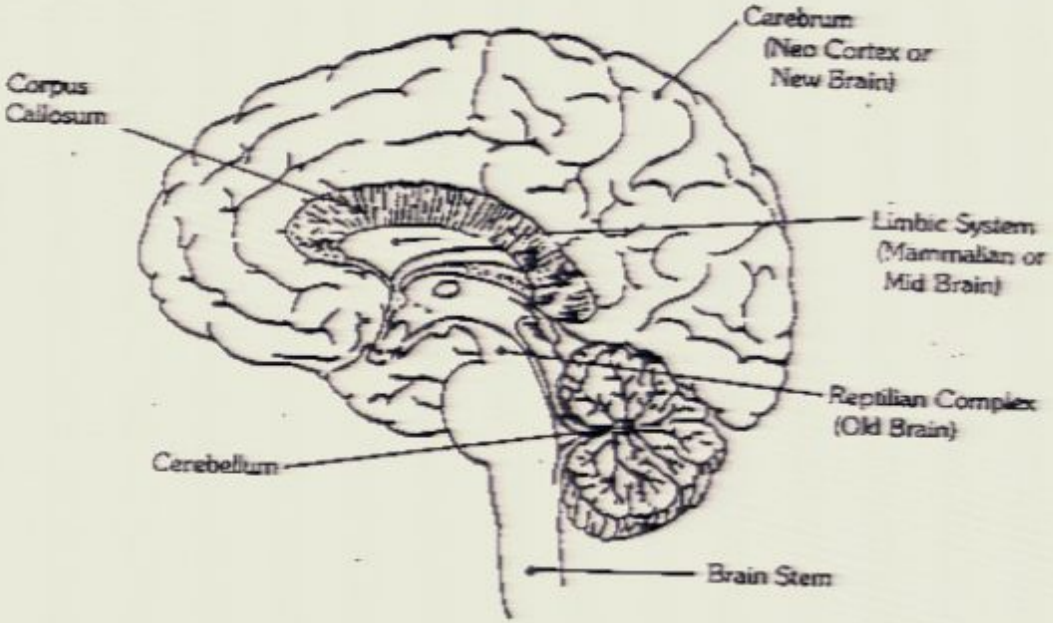
The Triune Model of the Brain



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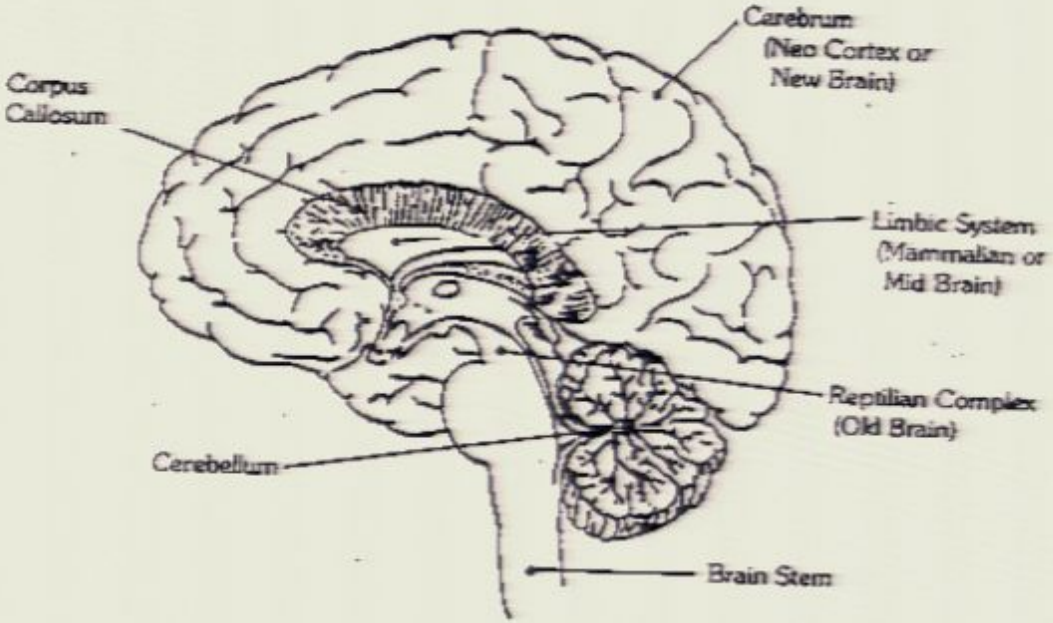

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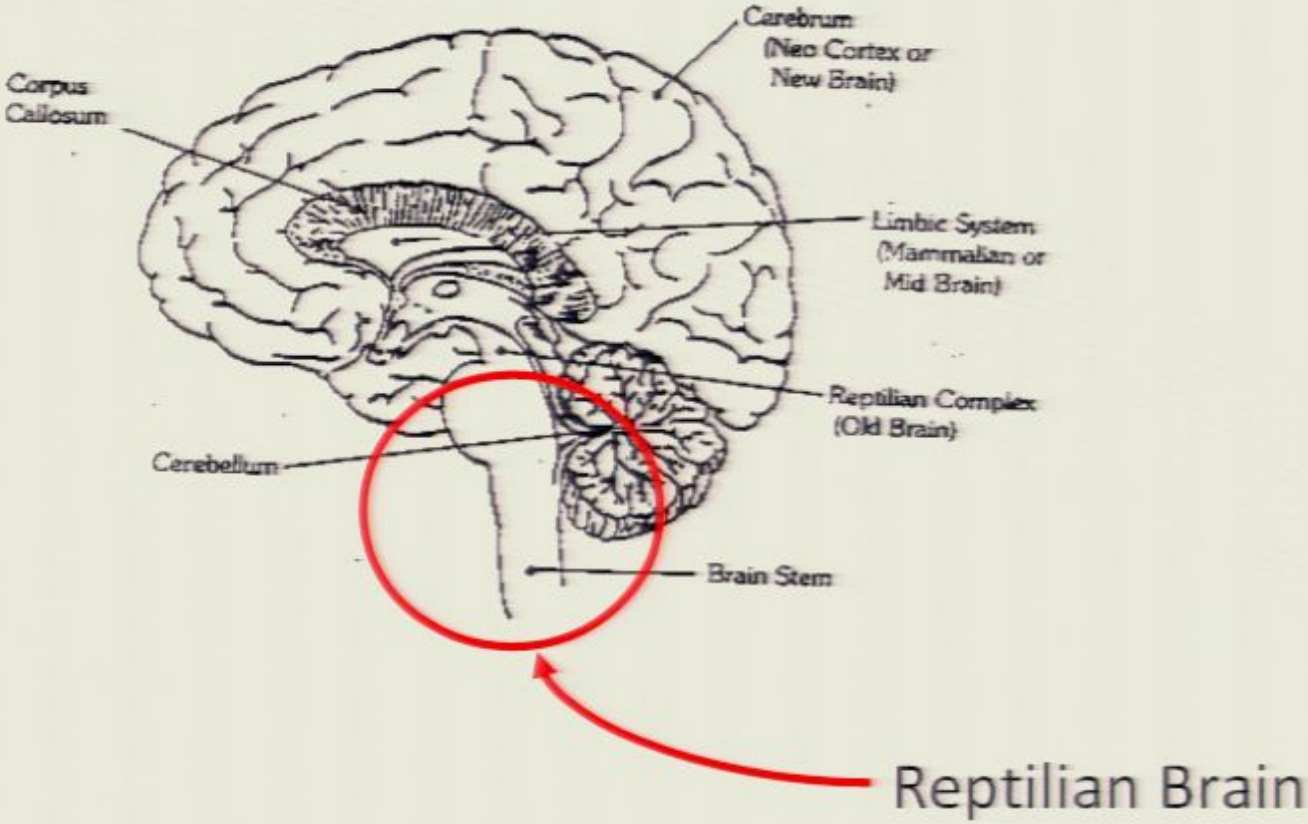

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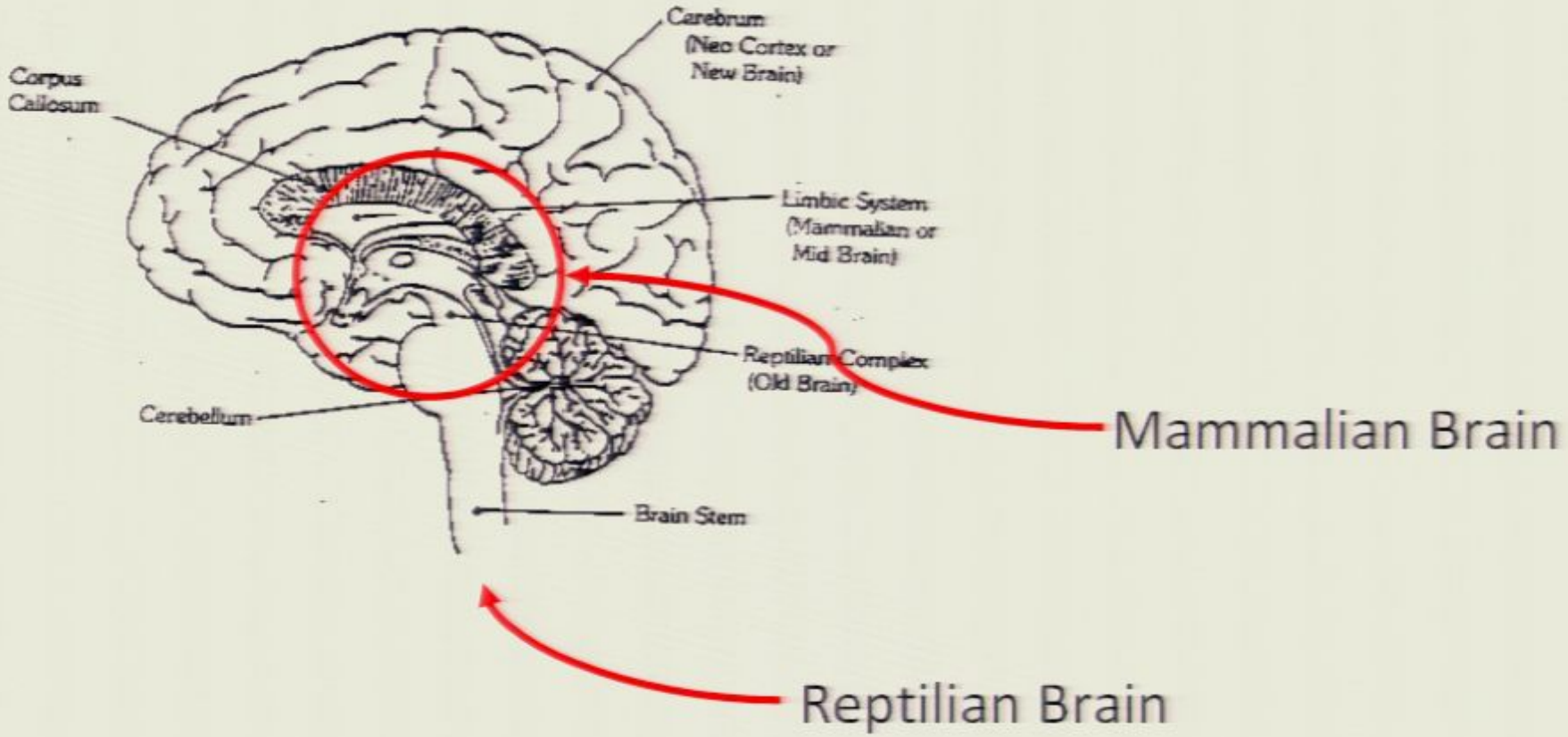

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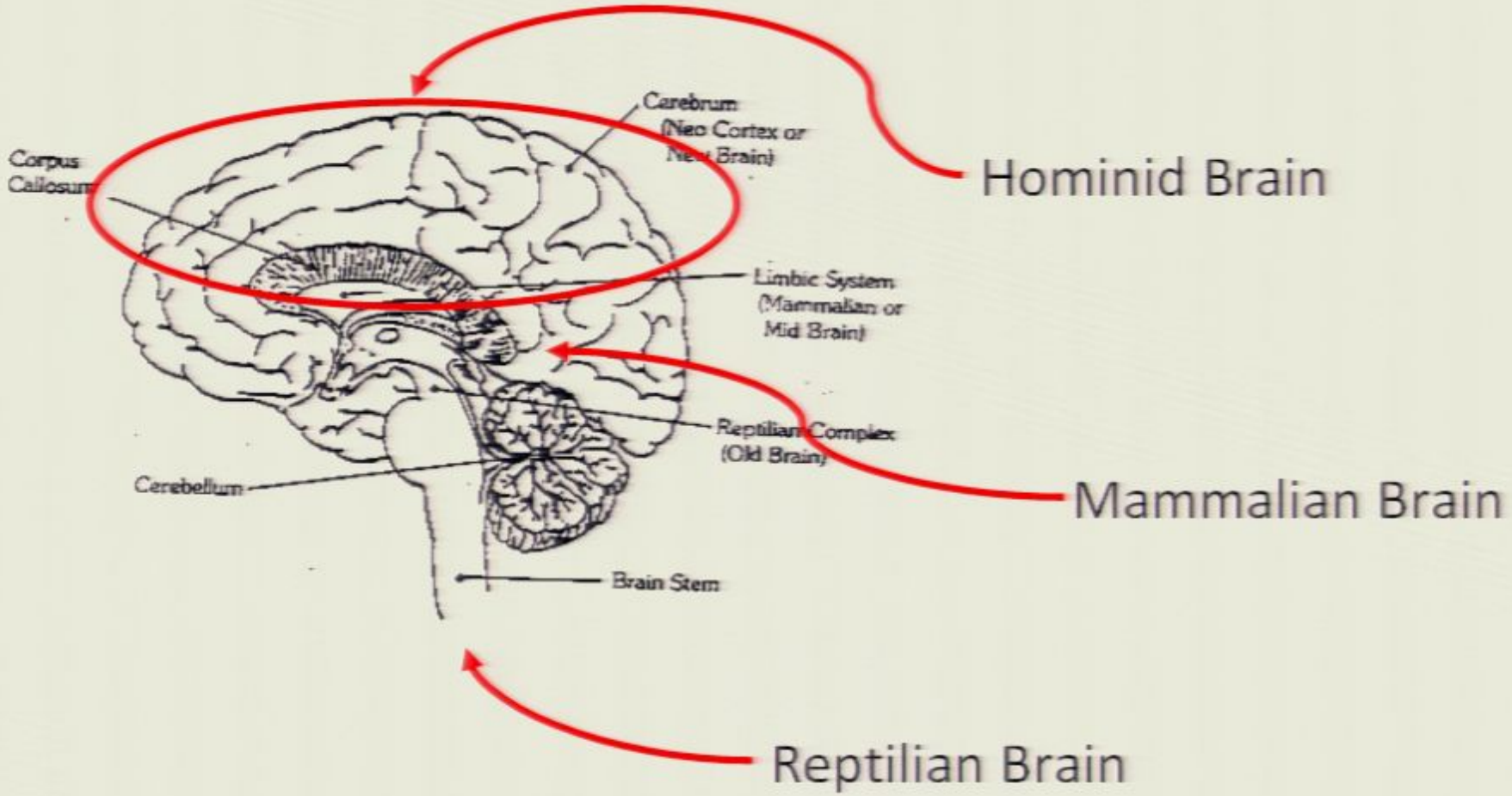

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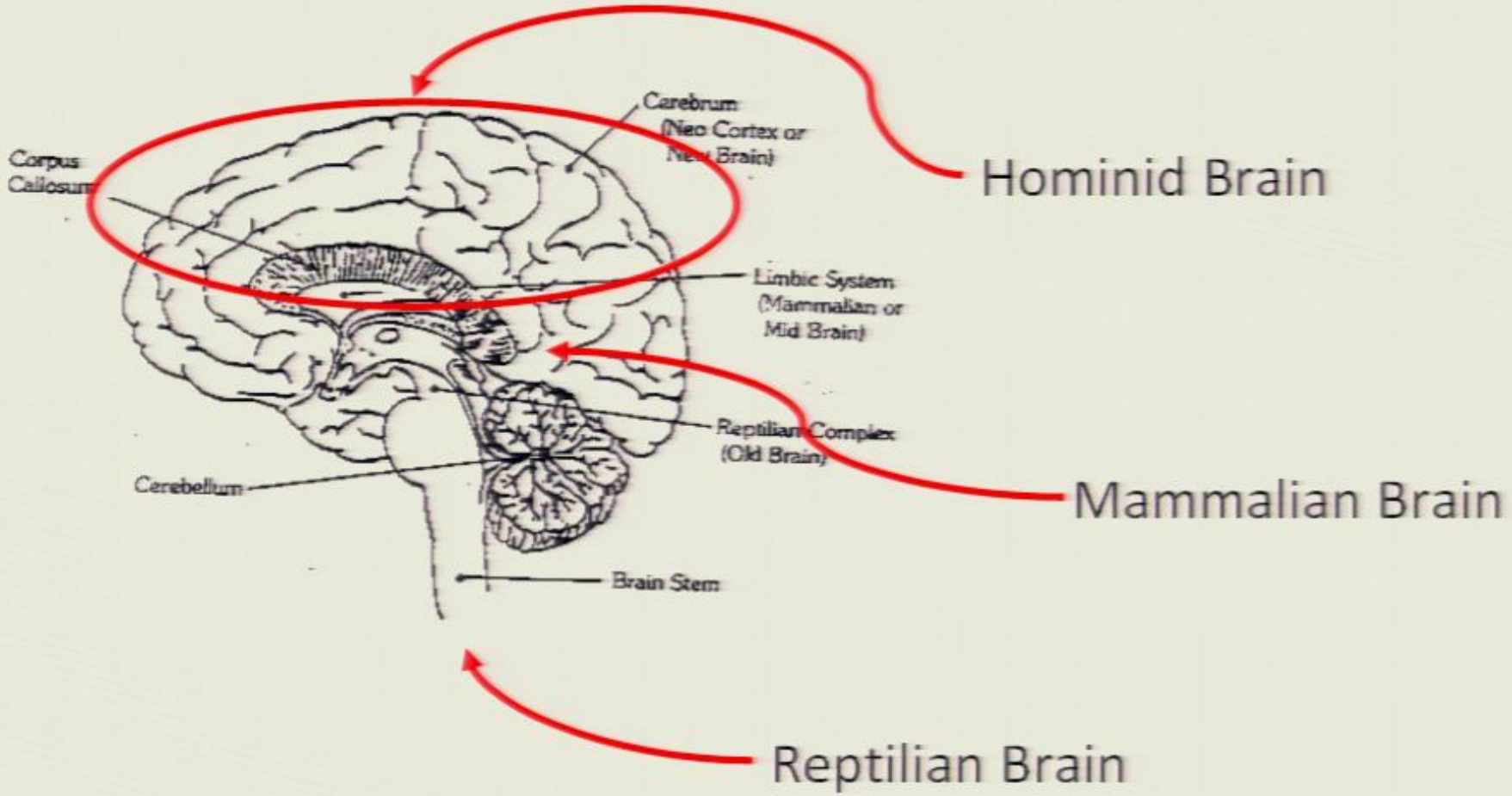

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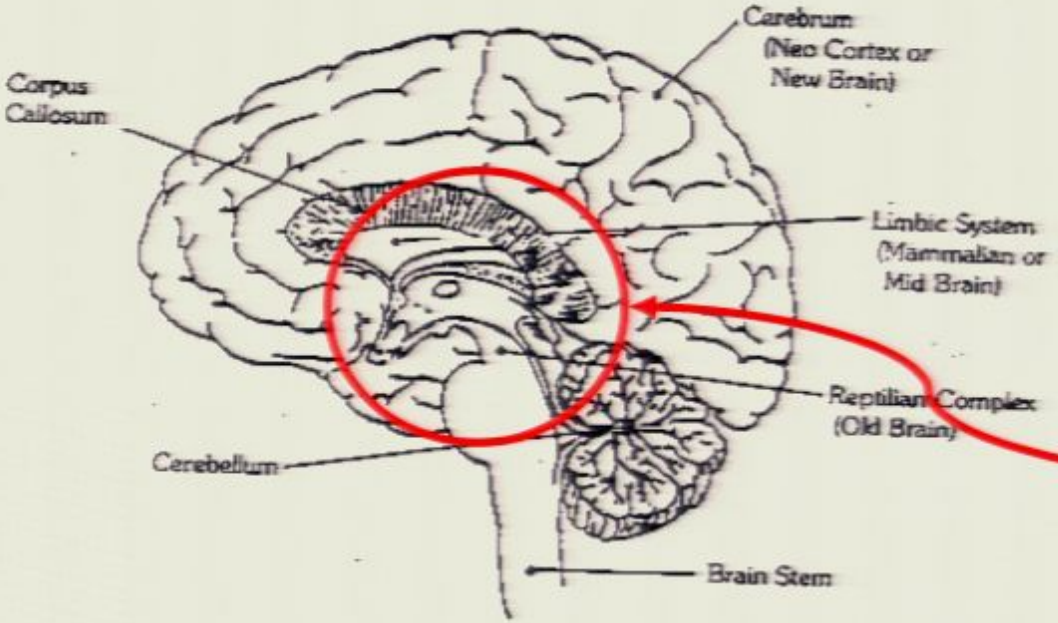
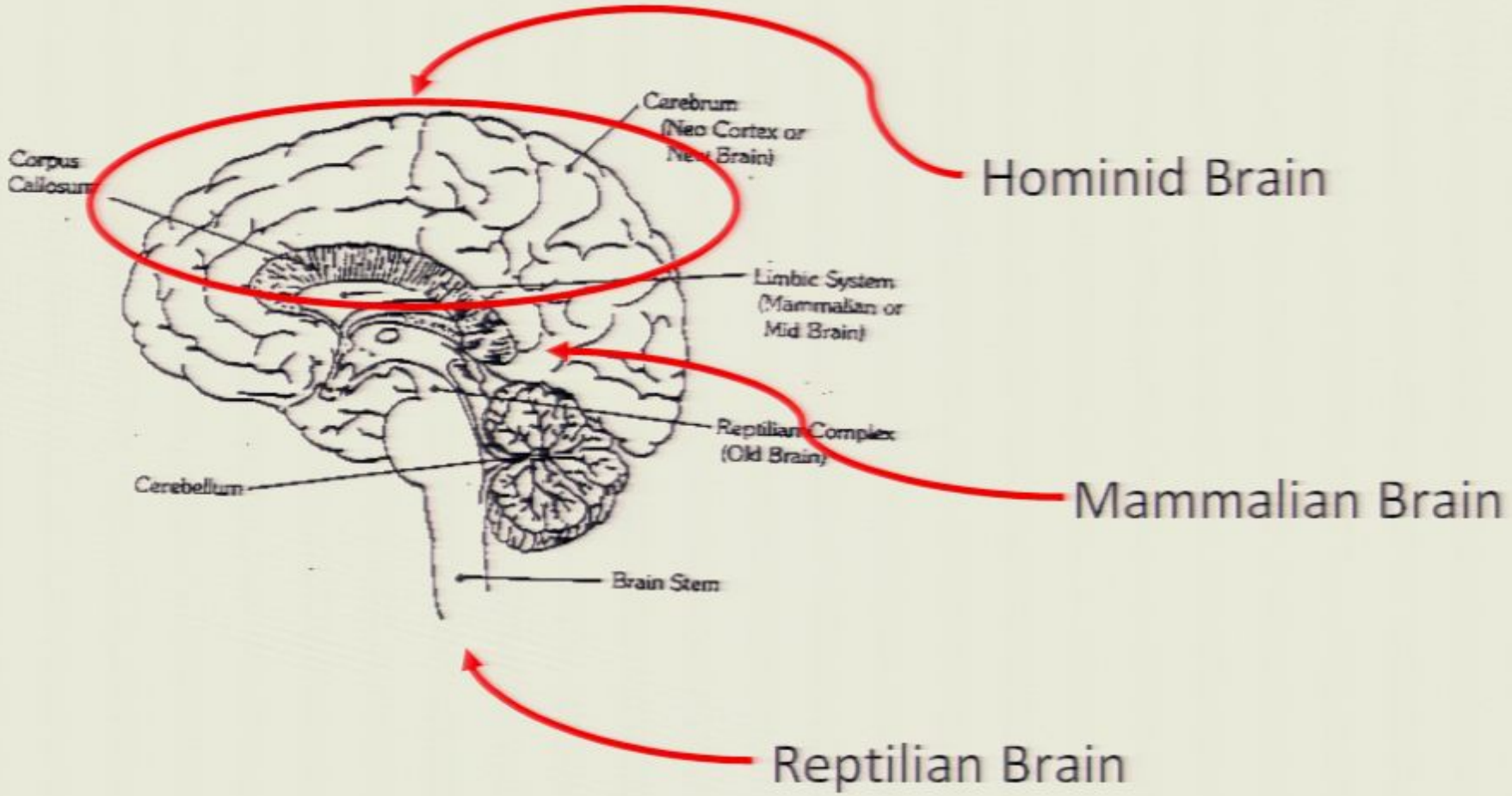


Mammalian Brain

Reptilian Brain

The Triune Model of the 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

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Say the colors of the following word:

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Say the colors of the following word:

RED	GREEN	BLUE	YELLOW	ORANGE
BLUE	BROWN	RED	GREEN	PURPLE
PINK	BLACK	BLUE	YELLOW	GREEN

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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
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- Agents Do Not Have Rational Expectations
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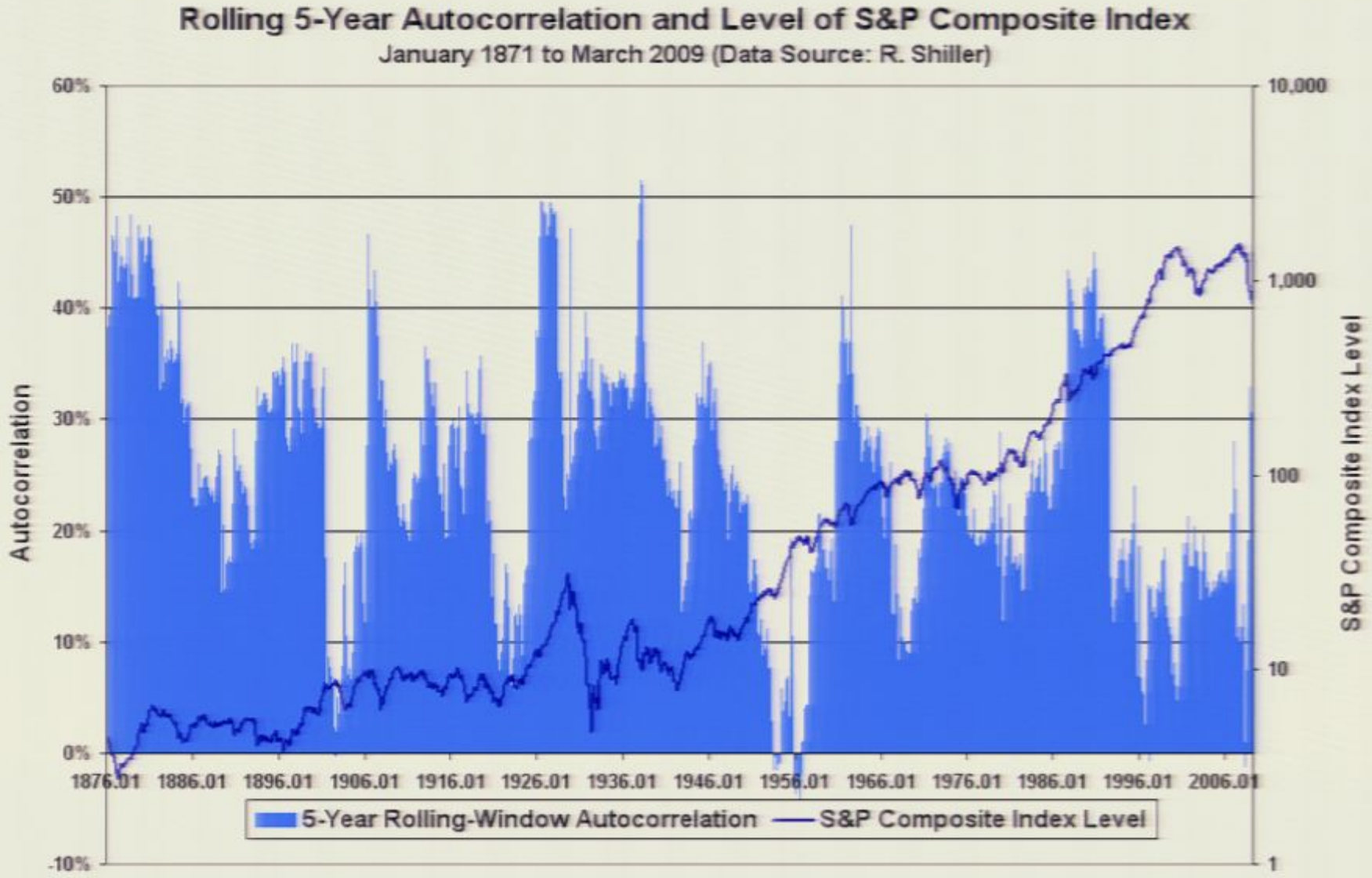
The Adaptive Markets Hypothesis

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



Adaptive Markets At Work

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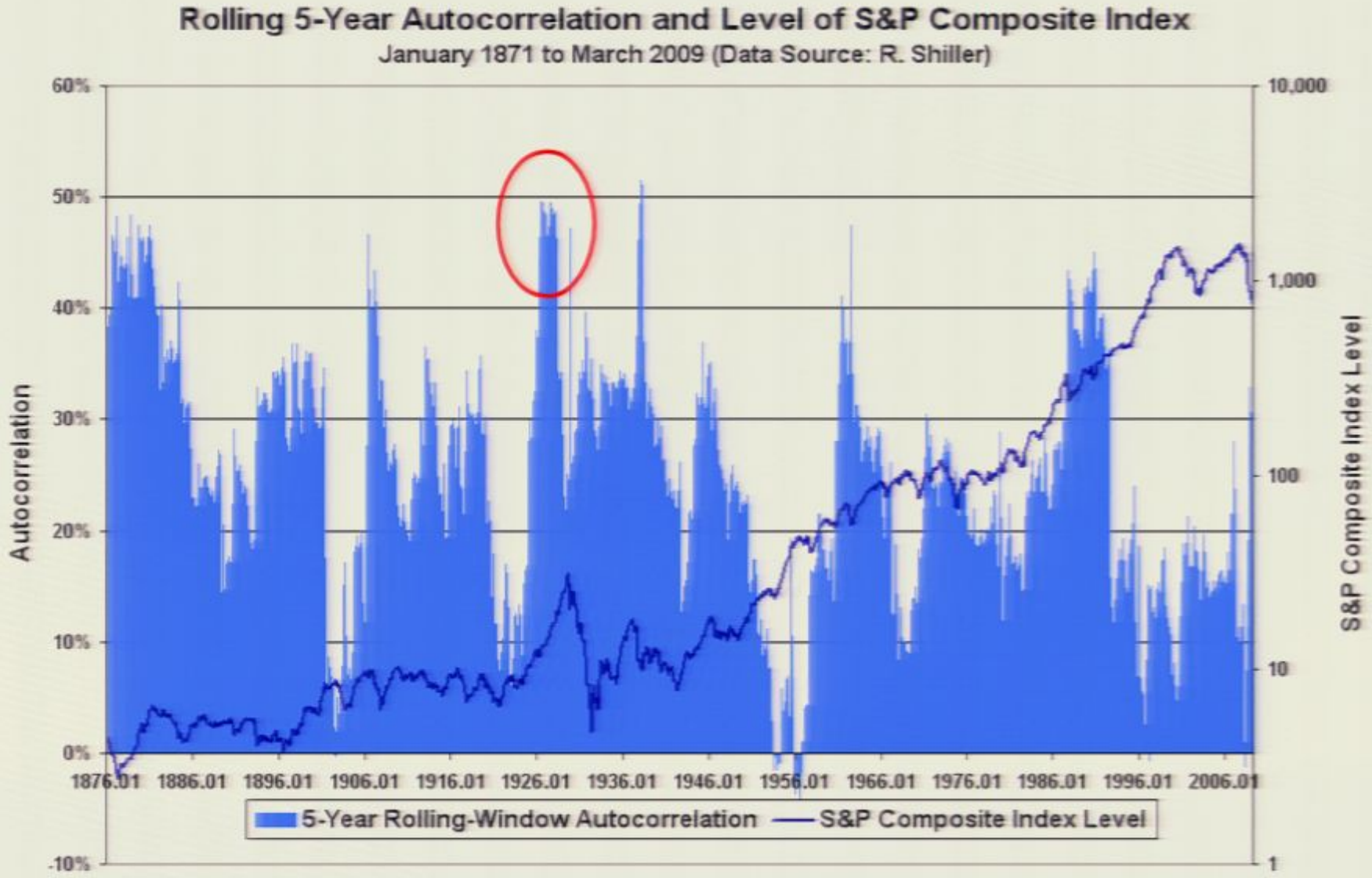

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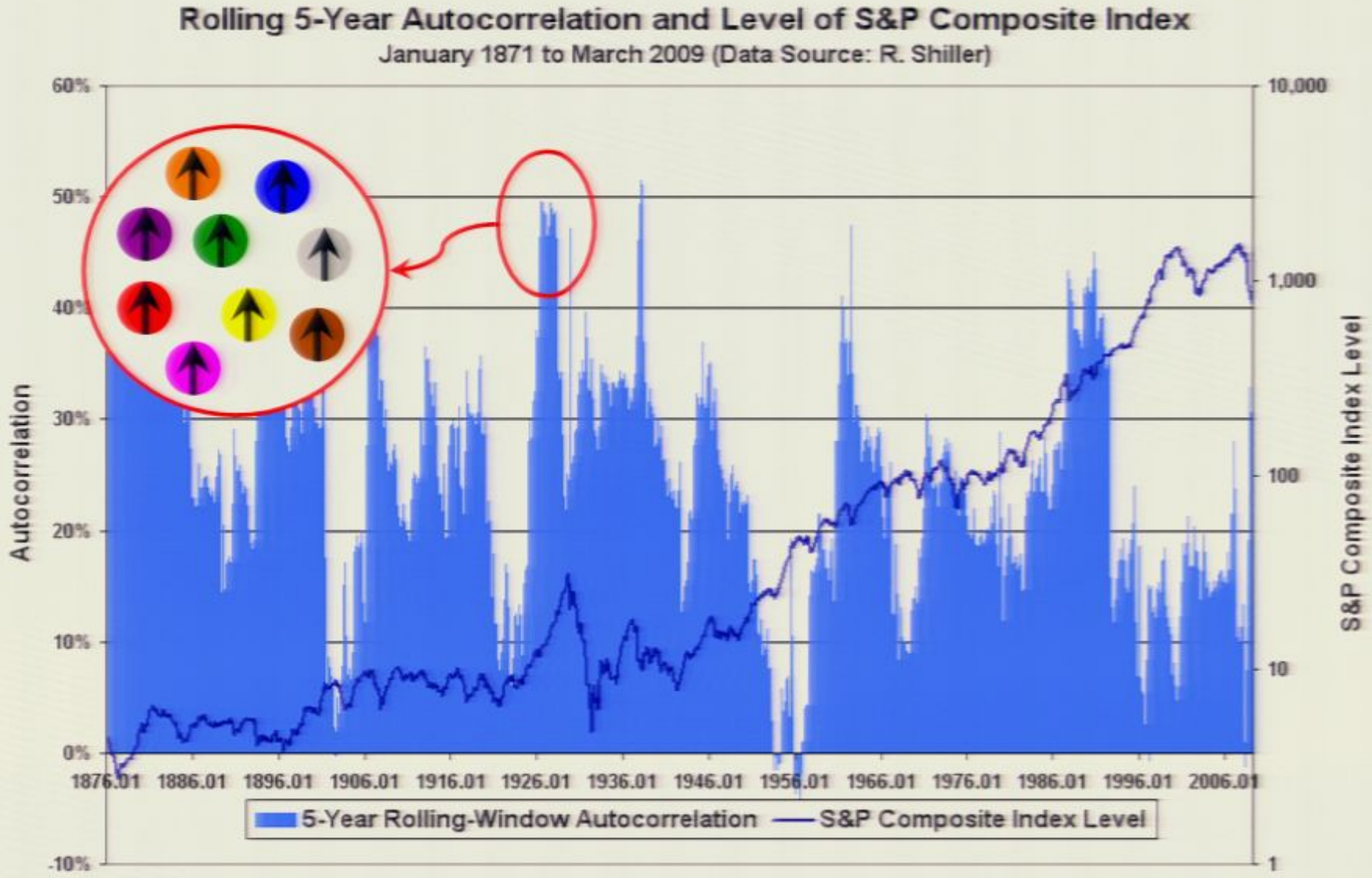

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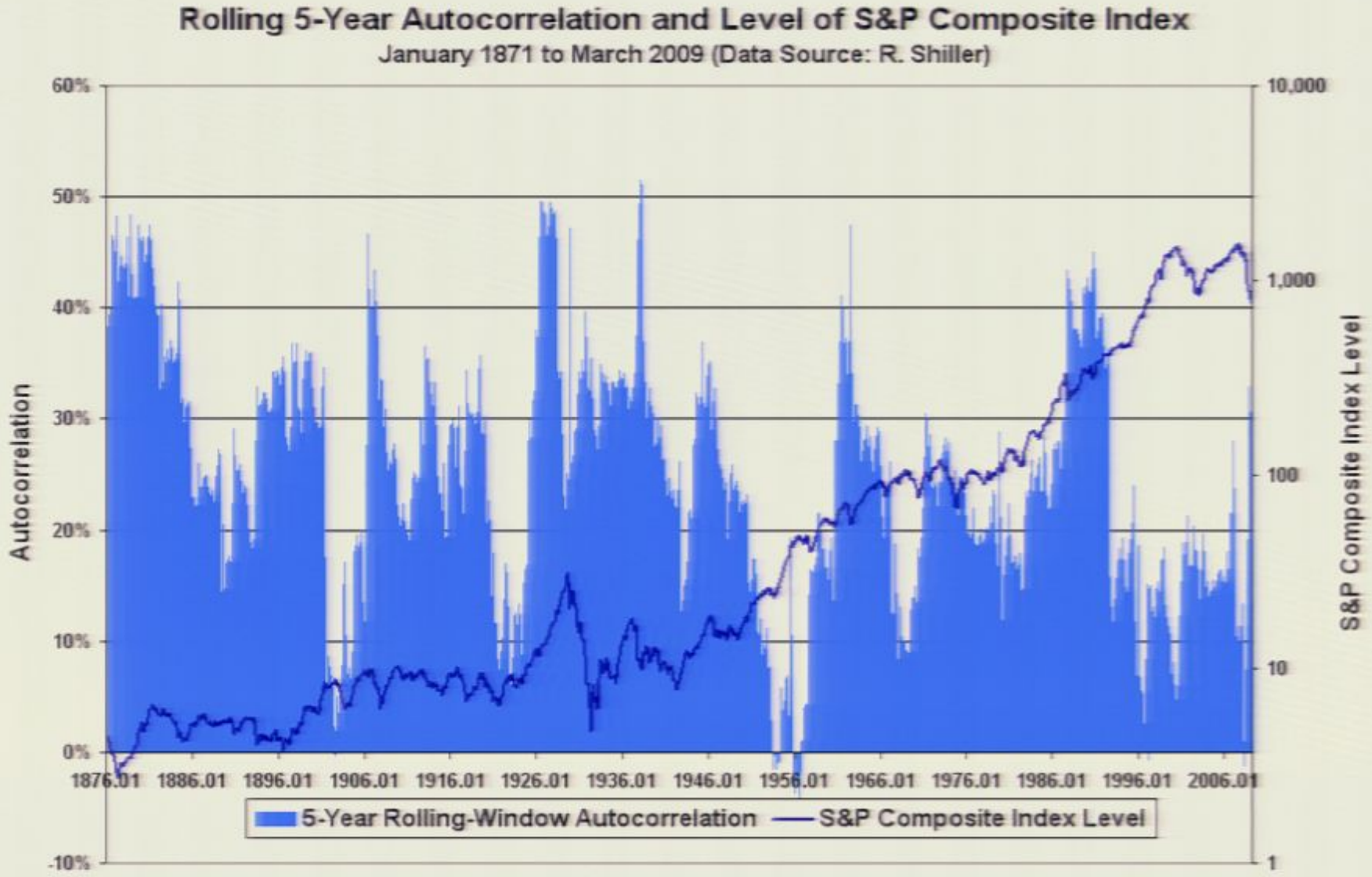

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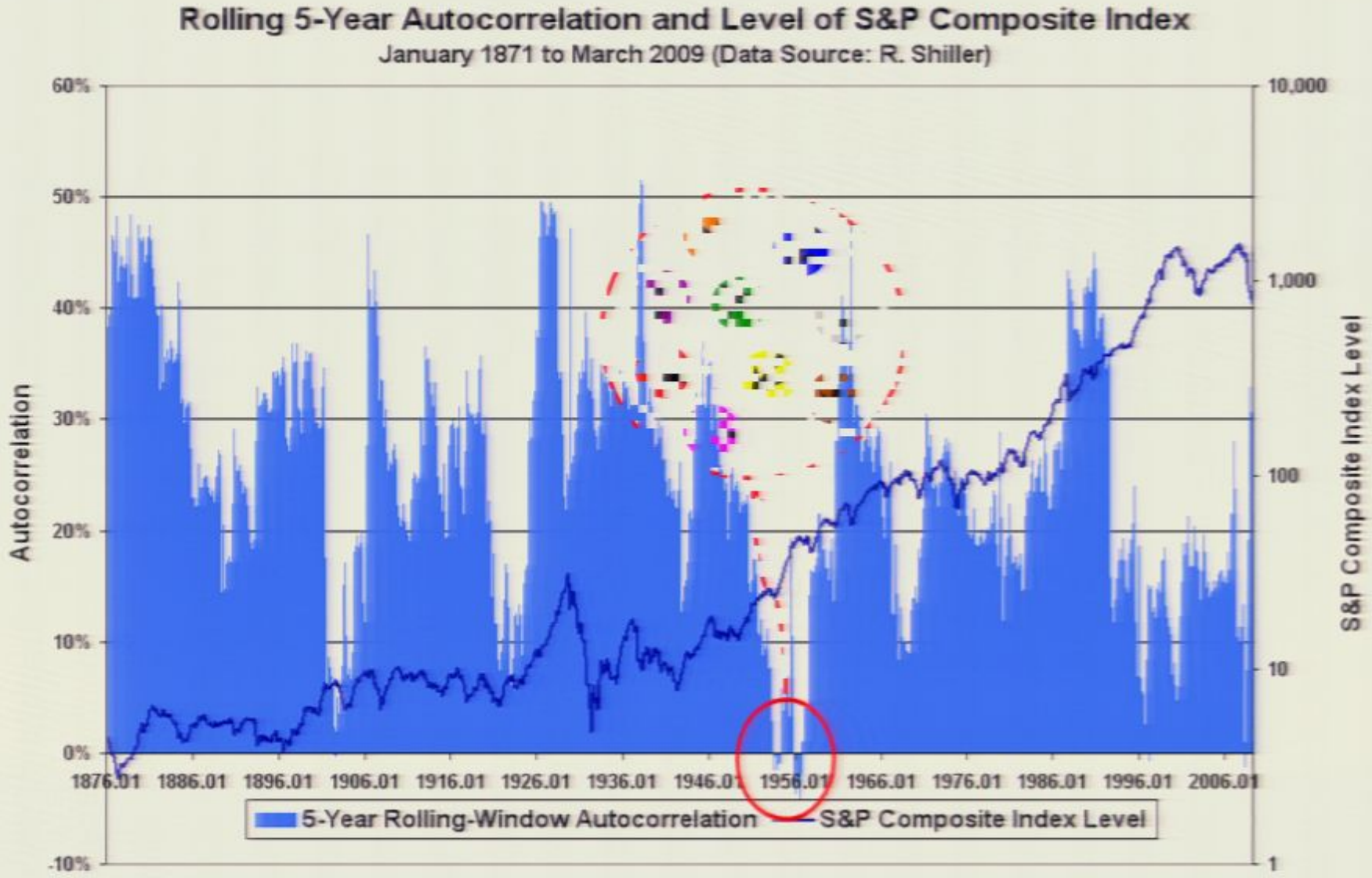

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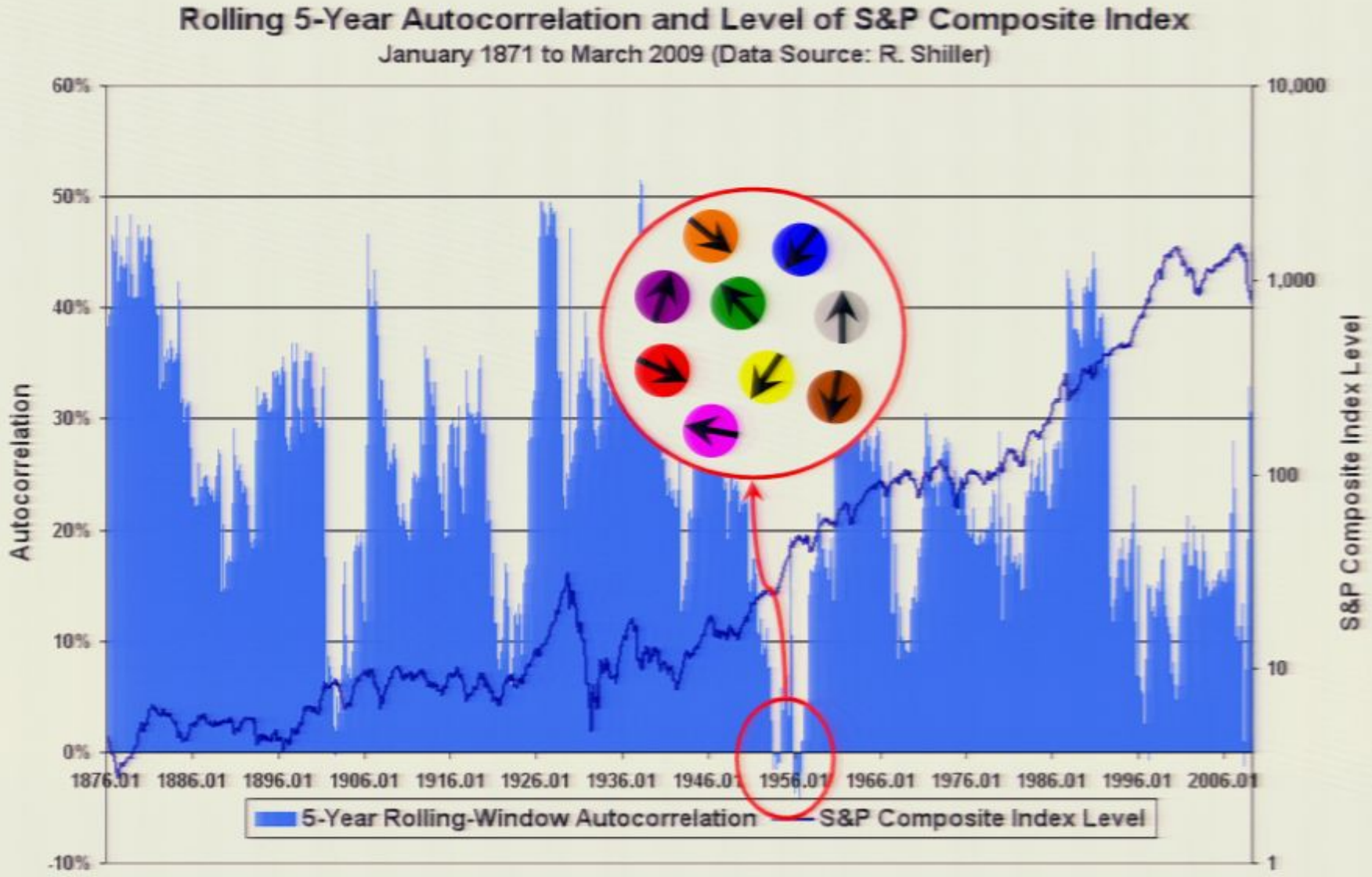

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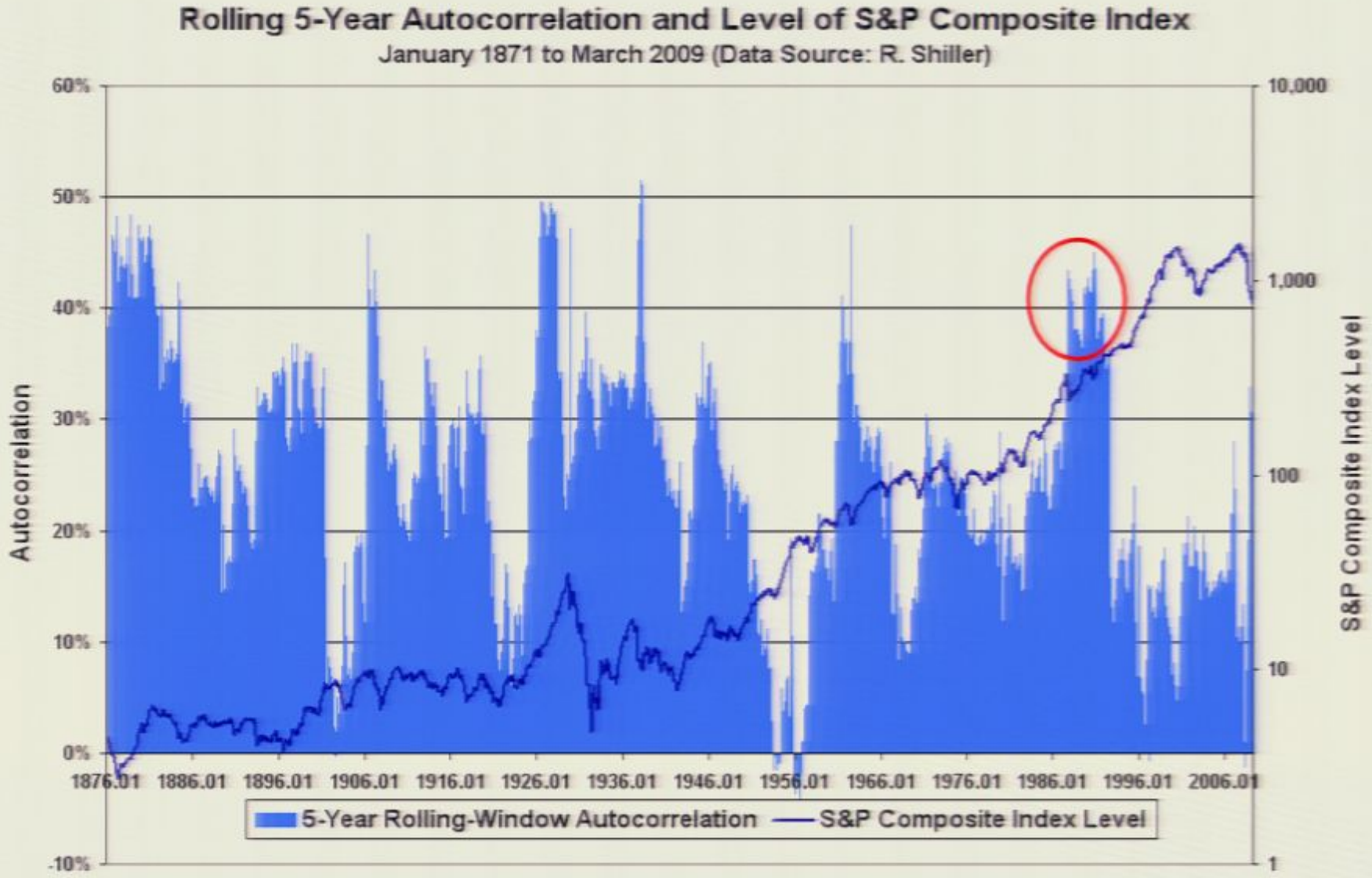

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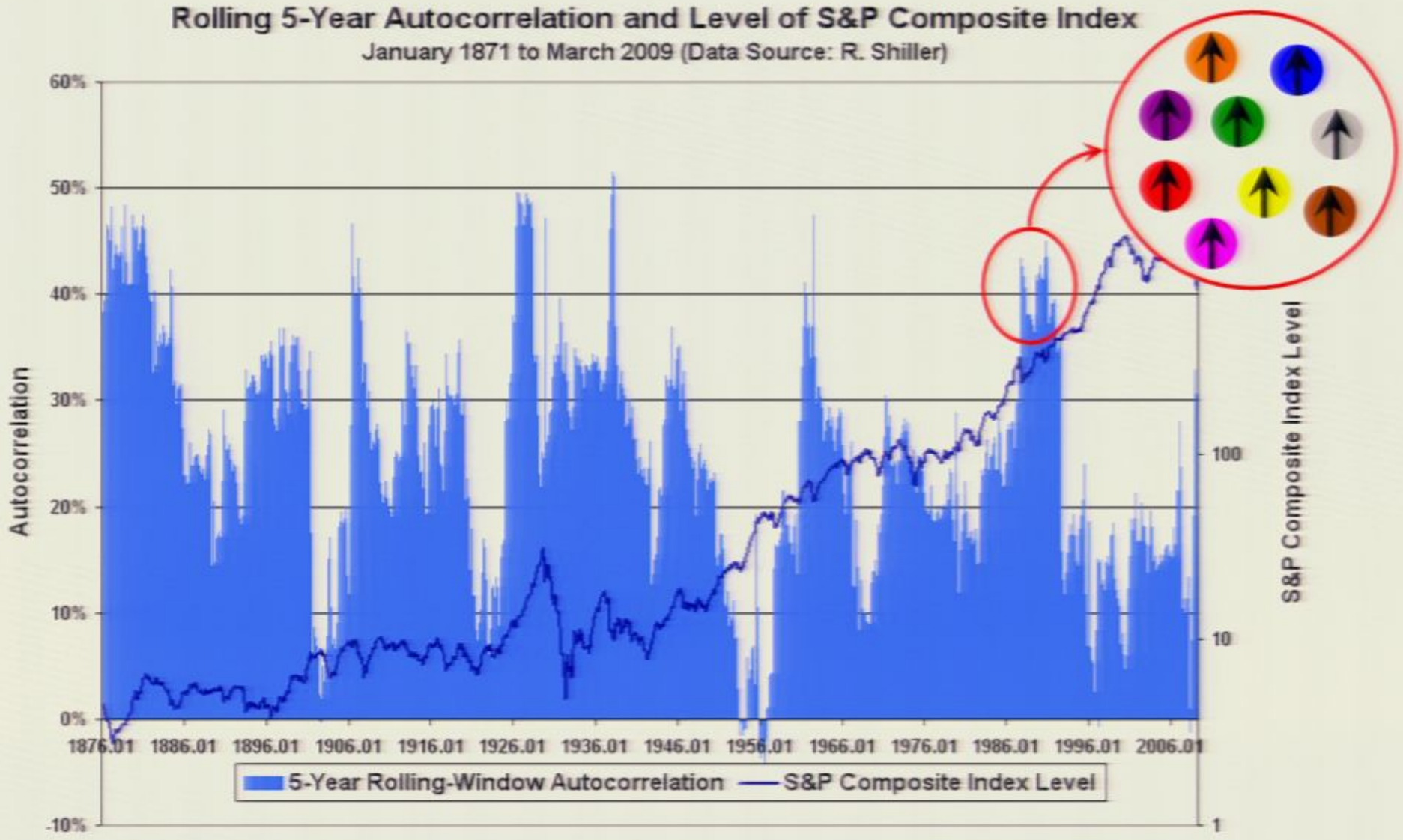

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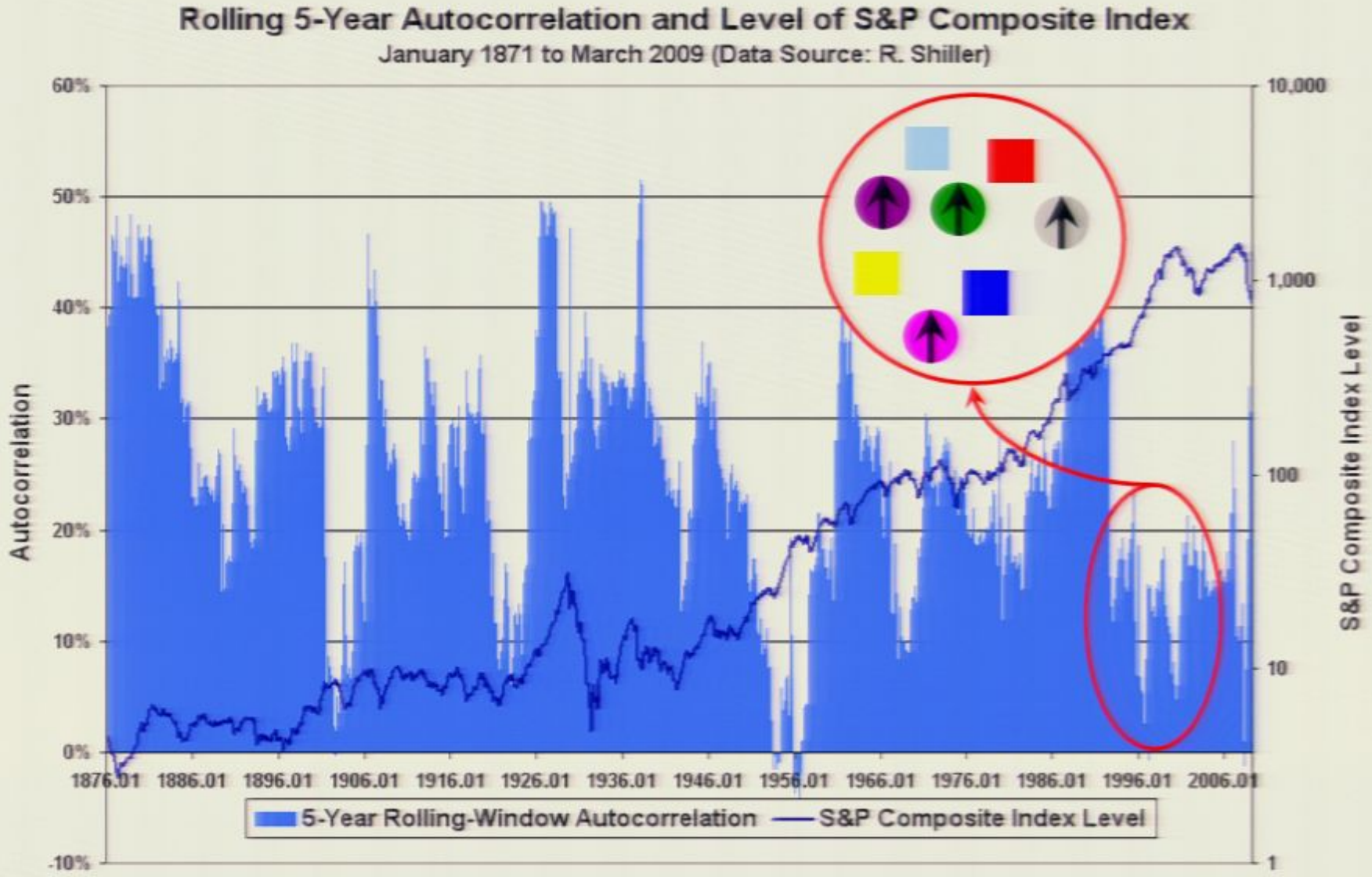

Where Do Heuristics Come From?

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Consider Getting Dressed:

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- 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

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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

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Is Human Behavior The Culprit?

Complexity, Tight Coupling, and Human Behavior

Perimeter



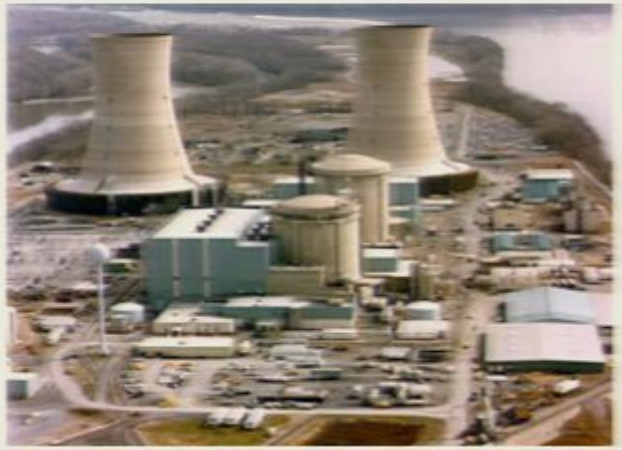



Complexity, Tight Coupling, and Human Behavior

Perimeter





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 GIMEIN

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

Andrew W. Lo of M.I.T. says he has found warning signs for the hedge fund industry.

F all the sectors of the financial universe, the hedge fund world is probably the most secretive and almost certainly the most alluring. Open only to institutions and the wealthy, hedge funds offer sophisticated models of risk, access to the smartest financial minds and the chance for outsized returns. According to Van Hedge Advisors, hedge fund assets have topped a trillion dollars.

The downside, unfortunately, is that occasionally the industry may be subject to catastrophic and unexpected losses. In 1998, many top hedge fund managers lost their shirts. Long Term Capital Management came close to collapse. Just last month, investors were reminded of exactly this kind of possibility with the apparent failure of a $1.8 billion Connecticut hedge fund managed by the Bayou Group.

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, and he says that another hedge fund industry shakeout is likely in the near future. Mr. Lo is not a company, AlphaSimplex, that manages a $400 million hedge fund — so he is not looking for a reason to say hedge funds are in trouble. But that is exactly what he's saying, backing it up with powerful data and a couple of unexpected theories.

Mr. Lo has been working on the economics of hedge funds since the mid-1990's, but he started thinking seriously about how to measure risk across the industry in 1998, when he was first approached by backers to start his own hedge fund; it opened in 2003. He knew that sophisticated investors would want lots of data about his fund's returns and about the risk level he would assume, so he started looking carefully at the return data provided by other funds.

Traditionally, economists have thought that big up-and-down fluctuations in returns indicated risky investments, so many hedge fund investors have hoped to see a pattern of smooth and even returns. But Mr. Lo quickly saw that lots of hedge funds were posting returns that were just too smooth to be realistic. Digging deeper, he found that funds with hard-to-appraise, illiquid investments — like real estate or esoteric interest rate swaps — showed returns that were particularly even. In those cases, he concluded, managers had no way to measure their fluctuations, and simply assumed that their value was going up steadily. The problem, unfortunately, is that those are exactly the kinds of investments that can be subject to big losses in a crisis. In 1998, investors overcreated en masse from such investments.

Now, in a paper to be published by the University of Chicago, Mr. Lo, working with his graduate students, has come to a disturbing conclusion: that smooth returns, far from proving that hedge funds are safe, may be a warning sign for the industry. (The paper is at http://web.mit.edu/alo/www/Papers/systemic2.pdf.)

That doesn't necessarily hold true for every individual fund, but as Mr. Lo shows in his paper, measuring the smoothness of returns gives economists a good way to estimate the level of relatively illiquid investments in the hedge fund world. The approach lets economists measure industry-wide liquidity risks without knowing the details of the investments — information that hedge funds just don't give out.

By Mr. Lo's measures, hedge fund investments are less liquid now than they have been in 20 years. His work shows that the same pattern of investing preceded the 1998 global hedge fund meltdown and the 1987 stock market crash.

But that's not the only reason for worry. He says that crises like that of 1998 may be more predictable than was previously thought — and that another crisis is likely.

The 1998 panic is generally thought to have been set off by the Russian government's default on its debt. But Mr. Lo points out that only a minuscule proportion of the world's hedge fund investments were in Russian government bonds.

In his paper, he shows that the catastrophic losses of 1998 were preceded by a noticeable series of months of mediocre performance. Mr. Lo argues that while a hedge fund crisis appears to be sudden and to be caused by unforeseen events, the breakdown is only the last stage of the problem. As more hedge funds compete for the same slice of the pie, he says, their managers feel that they have no choice but to "leverage up," juicing their returns by borrowing more money to make bigger investments.

That, in turn, makes the investments more prone to a sudden credit crisis. Hedge funds that are highly leveraged are vulnerable to having their lenders — banks and big brokerage firms — cut off credit when they think that their money may be at risk. And Mr. Lo thinks that lenders would do exactly that in an industrywide downturn. That would force hedge funds to close out their positions at the worst possible time — like kind of cycle that brought down Long Term Capital Management.

Here again, his data suggests that the current situation is serious. His research indicates that the industry may have already entered a period of lower returns that signal a prelude to crisis. He points to a downturn in April that hit virtually every category of hedge fund pursuing every kind of strategy.

"The concern that I and others have is that we're approaching the perfect financial storm where all the arrows line up in one direction," Mr. Lo said. The more money that is invested in hedge funds, he said, "the bigger the storm will be."

What might set off a crash is a matter of guesswork. Mr. Lo thinks that an oil-price increase to $100 a barrel, a level predicted by one Goldman Sachs analyst, could do it. Or, he said, a tightening of lending rules at Fannie Mae, the mortgage giant, could set off a "humongous unwinding" in credit markets. But Mr. Lo, who refers to some of his research as "measuring how strong the camel's back is and how much straw is already on it," thinks that the spark could be something much smaller.

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 in general to confront the risks: "He demonstrates simple models that generally show a winning payoff but occasionally really die."

So what should be done? Mr. Lo sees no way to eliminate the cyclical nature of hedge fund investing, but he says we can learn from the mistakes of funds that fail. He advocates the creation of a financial equivalent of the teams at the National Transportation Safety Board that swoop in to investigate airplane crashes.

The nightmare scenario for Mr. Lo would be a series of collapses of highly leveraged hedge funds that bring down the major banks or brokerage firms that lend to them. That's a possibility that the entire hedge fund industry — secretive and fractious though it is — has a huge interest in avoiding. □

THE NEW YORK TIMES, SUNDAY, SEPTEMBER 4, 2005

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

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ECONOMIC VIEW

MARK GIMEIN

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

Andrew W. Lo of M.I.T. says he has found warning signs for the hedge fund industry.

F all the sectors of the financial universe, the hedge fund world is probably the most secretive and almost certainly the most alluring. Open only to institutions and the wealthy, hedge funds offer sophisticated models of risk, access to the best financial minds and the chance for outsized returns. According to Van Hedge Advisors, hedge fund assets have topped a trillion dollars.

The downside, unfortunately, is that occasionally the industry may be subject to catastrophic and unexpected losses. In 1998, many top hedge fund managers lost their shirts. Long Term Capital Management came close to collapse. Just last month, investors were reminded of exactly this kind of possibility with the apparent failure of a $60 million Connecticut hedge fund managed by the Bayou Group.

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, and he says that another hedge fund industry shakeout is likely in the near future. Mr. Lo runs a company, AlphaSimplex, that manages a $400 million hedge fund — so he is not looking for a reason to say hedge funds are trouble. But that is exactly what he's saying, backing it up with powerful data and a couple of unexpected theories.

Mr. Lo has been working on the economics of hedge funds since the mid-1990's, but he started thinking seriously about how to measure risk across the industry in 1998, when he was first approached by backers to start his own hedge fund; it opened in 2003. He knew that sophisticated investors would want lots of data about his fund's returns and about the risk level he would assume, so he started looking carefully at the return data provided by other funds.

Traditionally, economists have thought that big up-and-down fluctuations in returns indicated risky investments, so many hedge fund investors have hoped to see a pattern of smooth and even returns. But Mr. Lo quickly saw that lots of hedge funds were posting returns that were just too smooth to be realistic. Digging deeper, he found that funds with hard-to-appraise, illiquid investments — like real-estate or esoteric interest rate swaps — showed returns that were particularly even. In those cases, he concluded, managers had no way to measure their fluctuations, and simply assumed that their value was going up steadily. The problem, unfortunately, is that those are exactly the kinds of investments that can be subject to big losses in a crisis. In 1998, investors retreated en masse from such investments.

Now, in a paper to be published by the University of Chicago, Mr. Lo, working with his graduate students, has come to a disturbing conclusion: that smooth returns, far from proving that hedge funds are safe, may be a warning sign for the industry. (The paper is at http://web.mit.edu/alo/www/Papers/systemic2.pdf.)

That doesn't necessarily hold true for every individual fund, but as Mr. Lo shows in his paper, measuring the smoothness of returns gives economists a good way to estimate the level of relatively illiquid investments in the hedge fund world. The approach lets economists measure industry-wide liquidity risks without knowing the details of the investments — information that hedge funds just don't give out.

By Mr. Lo's measures, hedge fund investments are less liquid now than they have been in 20 years. His work shows that the same pattern of investing preceded the 1998 global hedge fund meltdown and the 1987 stock market crash.

But that's not the only reason for worry. He says that crises like that of 1998 may be more predictable than was previously thought — and that another crisis is likely.

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That, in turn, makes the investments more prone to a sudden credit crisis. Hedge funds that are highly leveraged are vulnerable to having their lenders — banks and big brokerage firms — cut off credit when they think that their money may be at risk. And Mr. Lo thinks that lenders would do exactly that in an industrywide downturn. That would force hedge funds to close out their positions at the worst possible time — the kind of cycle that brought down Long Term Capital Management.

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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!