A Complex System View on the Financial and Economic Crisis

DIDIER SORNETTE

Markets Stock Crash Why

Critical Events in Complex Financial Systems

Princeton University Press (2003)
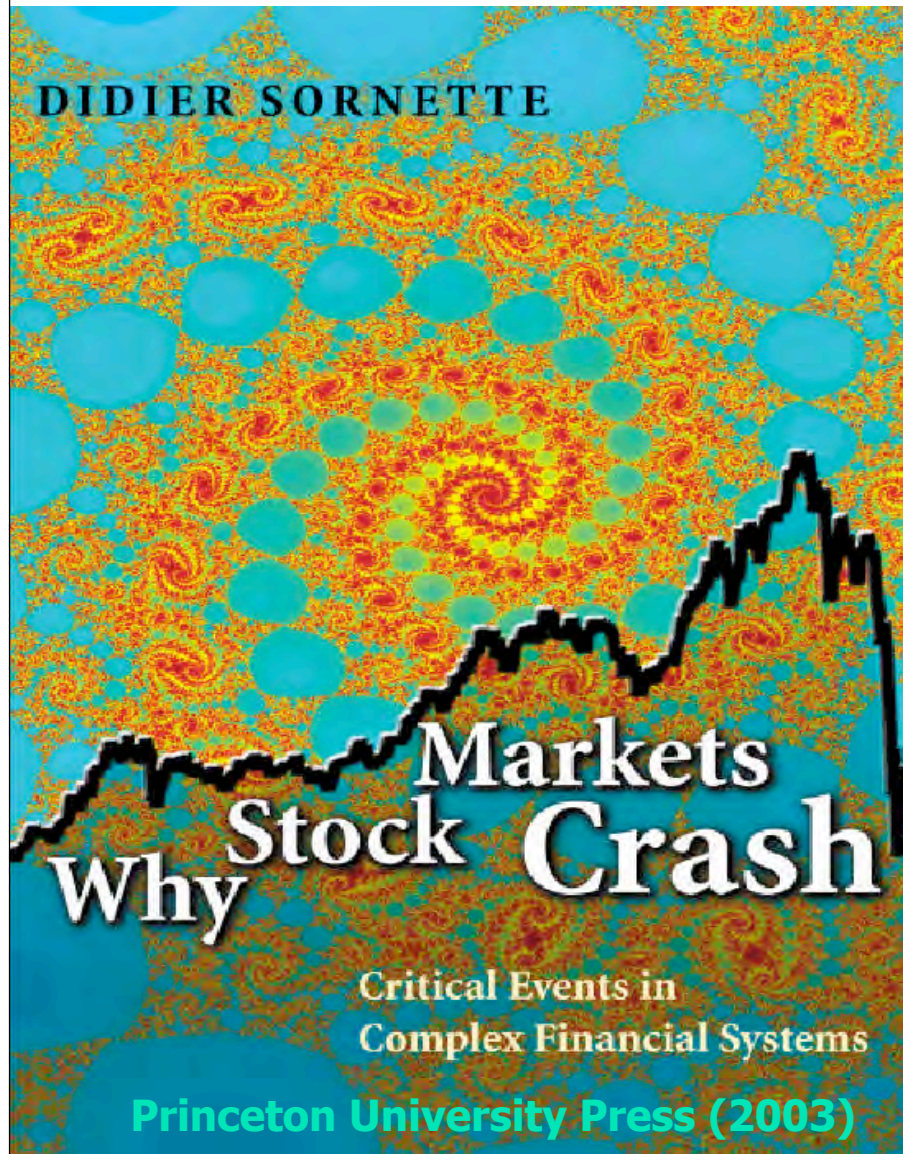
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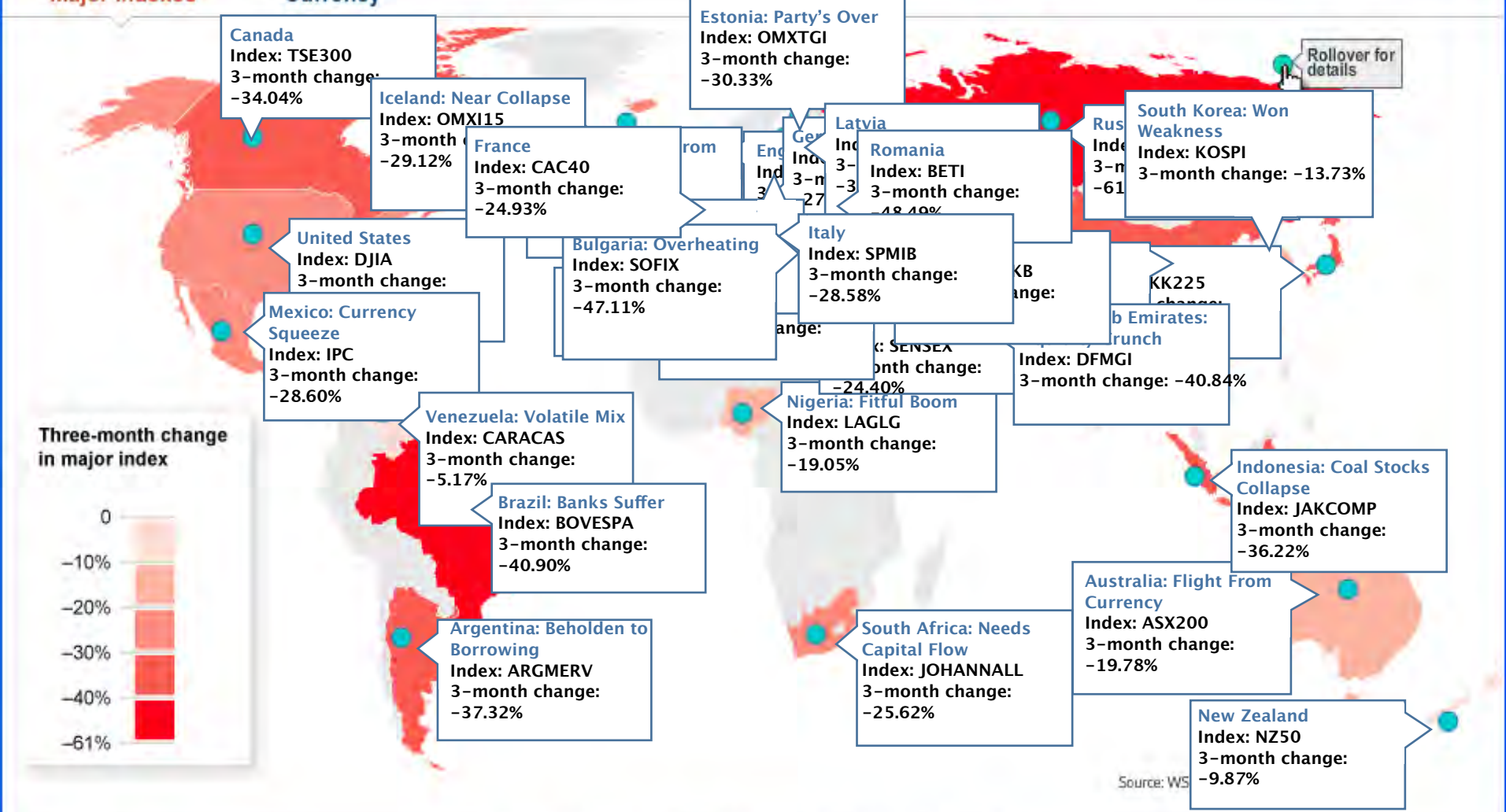A. Huesler (ETH Zurich)
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THE WALL STREET JOURNAL.

# Tumbling Stocks, Plunging Currencies   October 2008

In the tightly interwoven global financial system, countries large and small have been affected by the dramatic slow-down in economic growth. **Click on a country below to see how its major stock index and its currency have fared in the last three months.**

Major Indexes   **Currency**

Rollover for details

Canada
Index: TSE300
3-month change:
−34.04%

Iceland: Near Collapse
Index: OMXI15
3-month change:
−29.12%

France
Index: CAC40
3-month change:
−24.93%

Estonia: Party's Over
Index: OMXTGI
3-month change:
−30.33%

...rom

Eng...
Ind...
3...

Ge...

Latvia
Ind...
3−
−27...

Romania
Index: BETI
3-month change:
−48.49%

Rus...
Ind...
3−n...
−61...

South Korea: Won Weakness
Index: KOSPI
3-month change: −13.73%

United States
Index: DJIA
3-month change:

Bulgaria: Overheating
Index: SOFIX
3-month change:
−47.11%

Italy
Index: SPMIB
3-month change:
−28.58%

...KB
...ange:

...KK225
...change:

Mexico: Currency Squeeze
Index: IPC
3-month change:
−28.60%

...ange:

...: SENSEX
...onth change:
−24.40%

b Emirates: ...runch
Index: DFMGI
3-month change: −40.84%

Venezuela: Volatile Mix
Index: CARACAS
3-month change:
−5.17%

Nigeria: Fitful Boom
Index: LAGLG
3-month change:
−19.05%

Brazil: Banks Suffer
Index: BOVESPA
3-month change:
−40.90%

Indonesia: Coal Stocks Collapse
Index: JAKCOMP
3-month change:
−36.22%

Three-month change in major index

0

−10%

−20%

−30%

−40%

−61%

Argentina: Beholden to Borrowing
Index: ARGMERV
3-month change:
−37.32%

South Africa: Needs Capital Flow
Index: JOHANNALL
3-month change:
−25.62%

Australia: Flight From Currency
Index: ASX200
3-month change:
−19.78%

New Zealand
Index: NZ50
3-month change:
−9.87%

Source: WS...

Non-Borrowed Reserves of Depository Institutions (BOGNONBR)
Source: Board of Governors of the Federal Reserve System
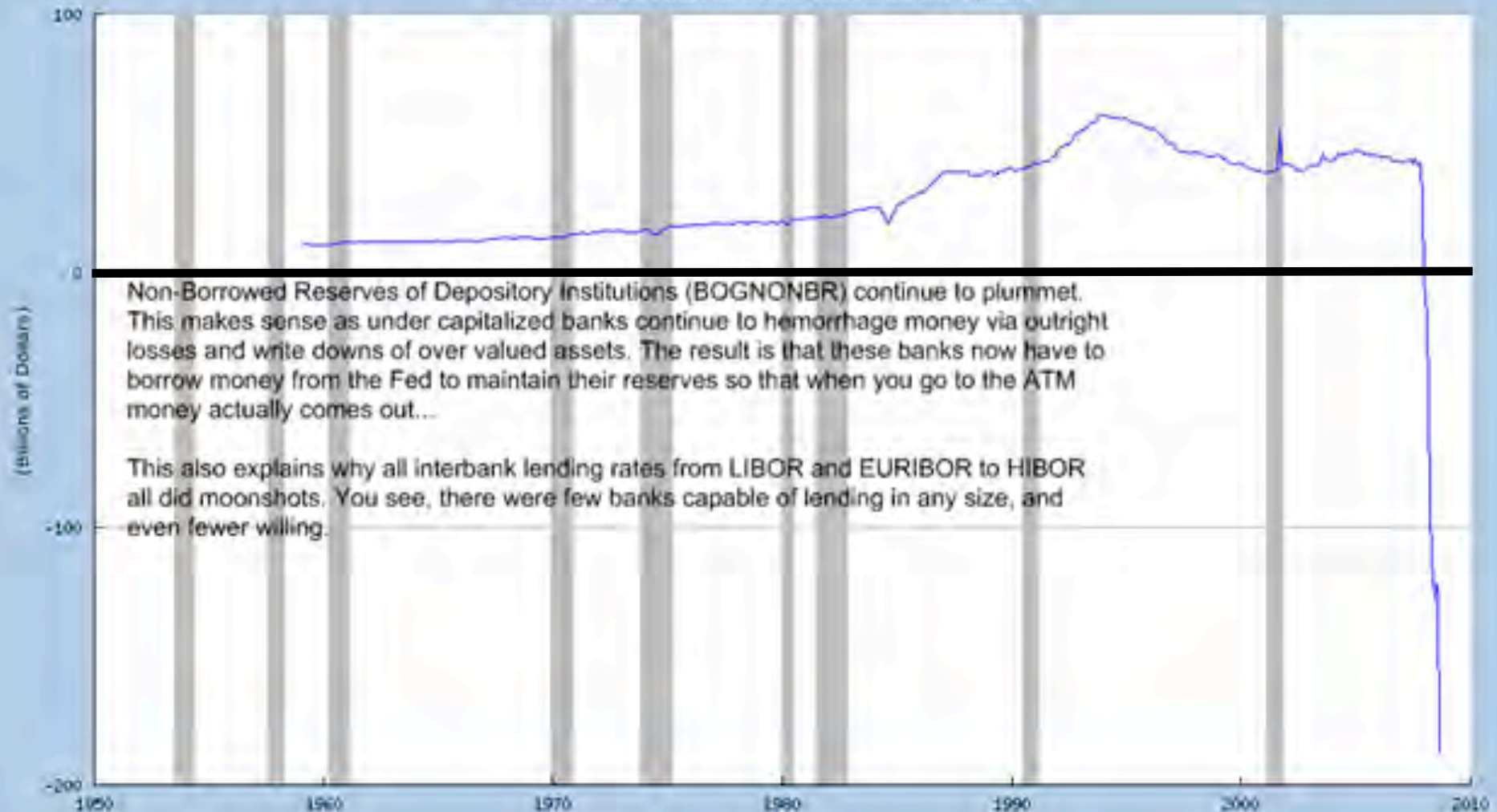
Non-Borrowed Reserves of Depository Institutions (BOGNONBR) continue to plummet.
This makes sense as under capitalized banks continue to hemorrhage money via outright
losses and write downs of over valued assets. The result is that these banks now have to
borrow money from the Fed to maintain their reserves so that when you go to the ATM
money actually comes out...

This also explains why all interbank lending rates from LIBOR and EURIBOR to HIBOR
all did moonshots. You see, there were few banks capable of lending in any size, and
even fewer willing.

Shaded areas indicate US recessions as determined by the NBER.
2009 Federal Reserve Bank of St. Louis: research.stlouisfed.org

The Disappearing Money Multiplier

M1 Money Multiplier (MULT)
Source: Federal Reserve Bank of St. Louis

2009 Federal Reserve Bank of St. Louis: research.stlouisfed.org
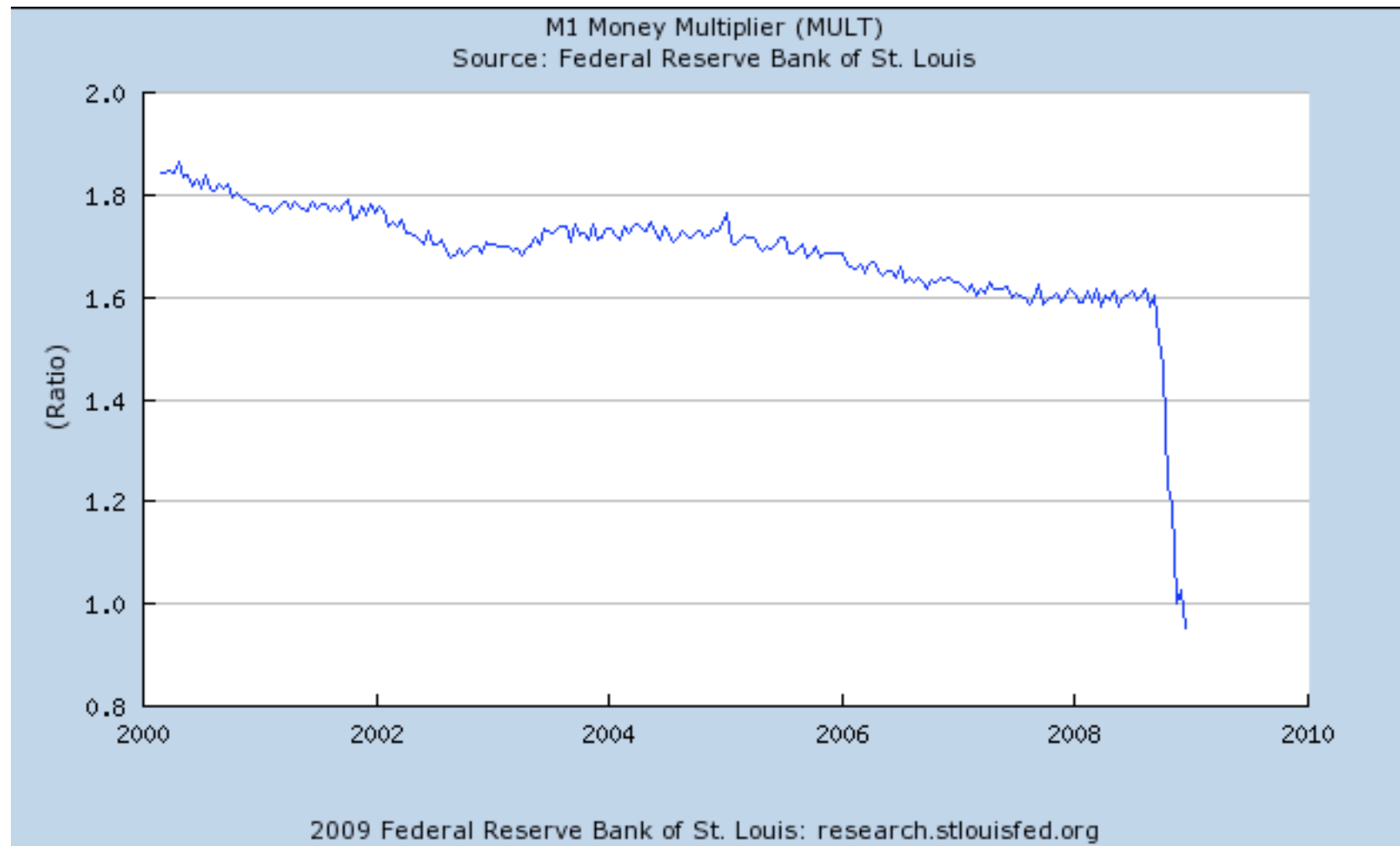
Econ prof Bill Seyfried of Rollins College:

The M1 money multiplier just slipped below 1. So each $1 increase in reserves (monetary base) results in the money supply increasing by $0.95 (OK, so banks have substantially increased their holding of excess reserves while the M1 money supply hasn't changed by much).

4

Standard claim: The current financial crisis in the United States has its roots in falling real estate values. It is based on a number of studies that have shown a strong link between house price depreciation and defaults on residential mortgages (Doms, Furlong, and Krainer 2007).

Real estate loans and MBS as a percent of total assets, by bank size

Percent

Source: Bank Call Reports.
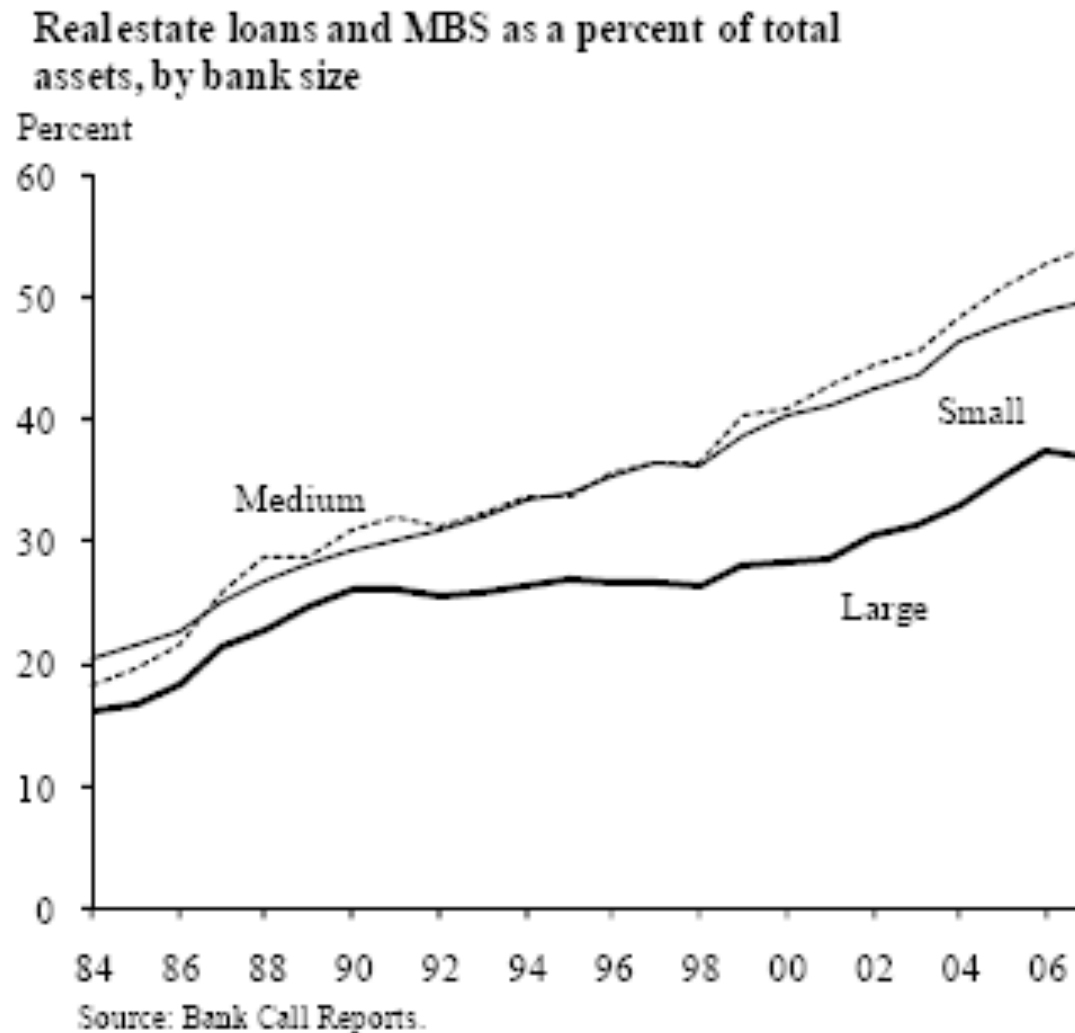
Another view:
Causes of current crisis and trust in the stock market

Respondents were asked, "According to you, what is the MAIN cause of the current crisis?"

● Trust in the stock market
■ Main causes of current crisis

Trust values: 2.6, 2.41, 1.97, 2.10

Main causes: 6.7%, 11.2%, 31.6%, 50.5%

Categories: Global imbalance, Excessive government intervention, Lack of oversight or regulation, Managers' greed and poor corporate governance

1 means "I do not trust at all"

5 means "I trust completely."

http://financialtrustindex.org/

Source: Paola Sapienza and Luigi Zingales

- Corporate governance problem: Banks have failed in their fiduciary duties

- Bad quantitative risk models in banks (Basel II)

- Rating agencies

The illusionary "PERPETUAL MONEY MACHINE"
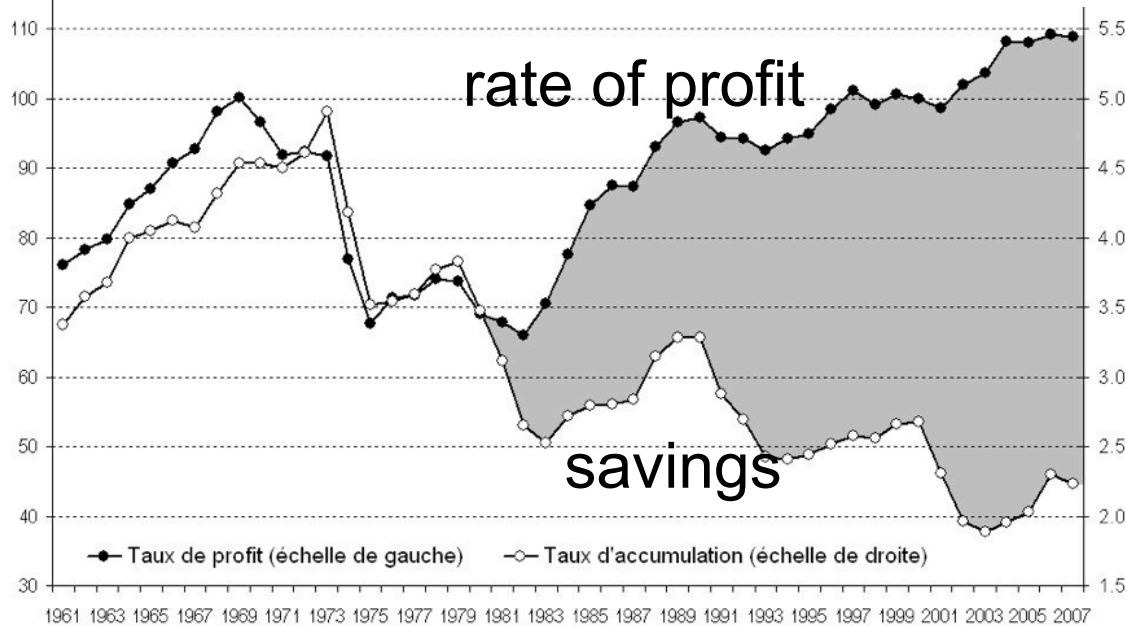
Rate of profit and rate of accumulation: The United States + European Union + Japan
* Rate of accumulation = rate of growth rate of the net volume of capital * Rate of profit = profit/capital (base: 100 in 2000)

Sources and data of the graphs: http://hussonet.free.fr/toxicap.xls
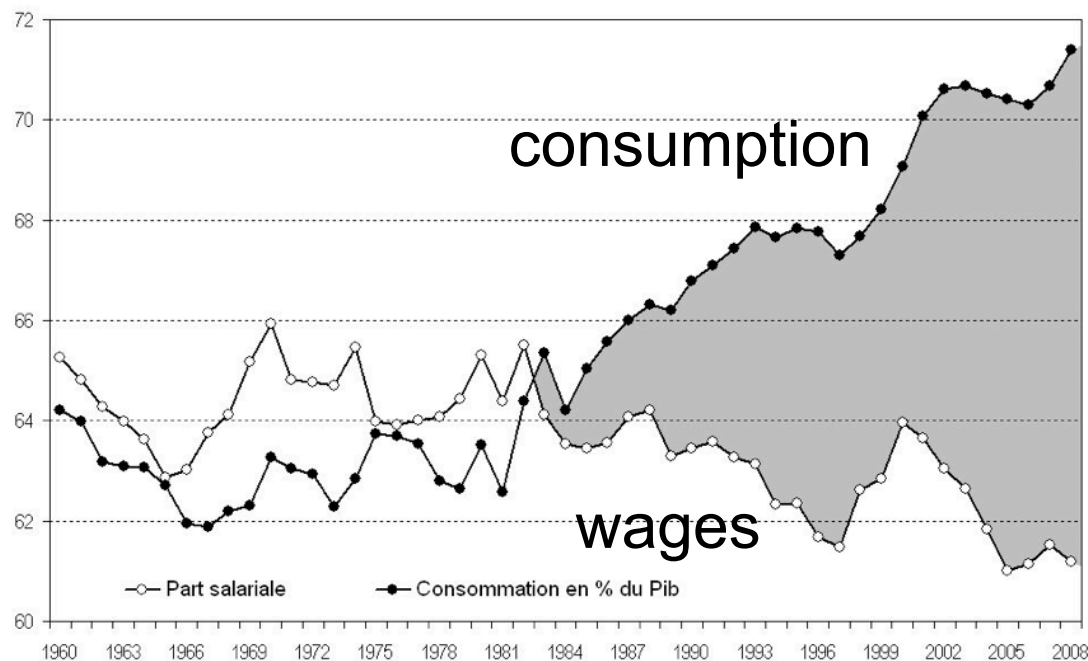
Thee gap widens between the share of wages and the share of consumption (gray zones), so as to compensate for the difference between profit and accumulation. FINANCE allows increasing debt and virtual wealth growh... which can only be transitory (even if very long).

United States Share of wages and of private consumption in Gross Domestic Product (GDP)
Source of data and graphics: http://hussonet.free.fr/toxicap.xls

The illusionary "PERPETUAL MONEY MACHINE"

Dow Jones

Household Wealth

Krach de 1987

Guerre d'Irak

Crise russe

Bulle Internet

subprimes

— Indice Dow Jones (échelle de gauche)
— Richesse des ménages (échelle de droite)
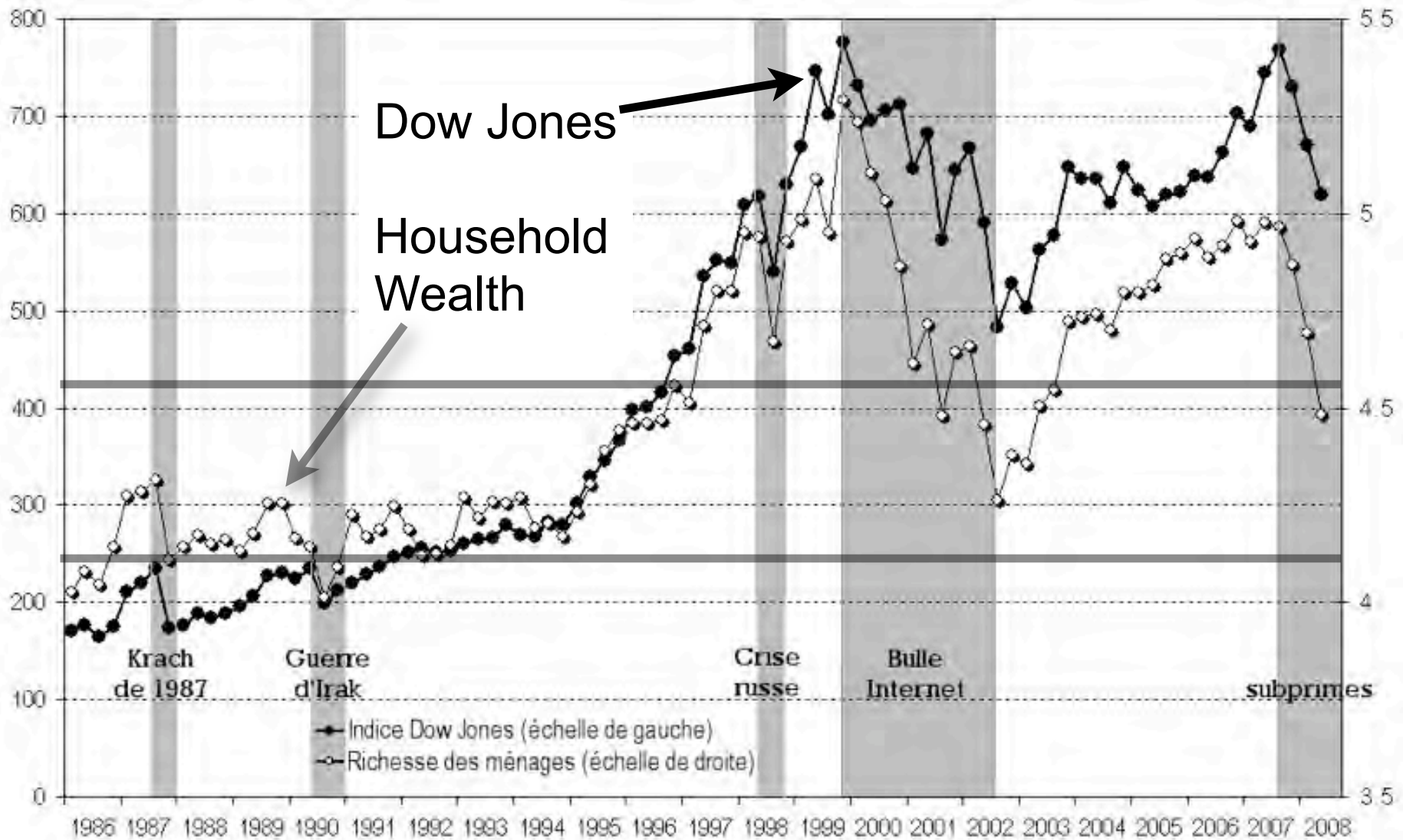
1: The Stock Exchange and household wealth in the United States

▶ The Dow Jones index at current prices (base: 100 in 1960)
▶ Net wealth of households as a multiple of their current income Sources and data for the graphs: http://hussonet.free.fr/toxicap.xls

source: Michel Husson

The illusionary "PERPETUAL MONEY MACHINE"

- An economy which grows at 2 or 3 per cent cannot provide a universal profit of 15 per cent, as some managers of equities claim and many investors dream of.

- As long as the incomes drawn from financial assets are re-invested, the fortunes increase independently of any material link with the real sphere and the variation can potentially become infinite.

- Financial assets represent the right to a share of the surplus value that is produced. As long as this right is not exercised, it remains virtual. But as soon as anyone exercises it, they discover that it is subject to the law of value, which means, quite simply, that you cannot distribute more real wealth than is produced.

A 15y History of the 2008- crisis

- The ITC "new economy" bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007) and stock market bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008) Consequences (deep loss of trust, systemic instability)
- Solution?

Various Bubbles and Crashes

price

Each bubble has been rescaled vertically and translated
to end at the time of the crash

IBM 1999

Nasdaq 2000

Hong-Kong 1997

DJ 1929

S&P500 1987

$/DEM 1985

S&P 500 1998

time
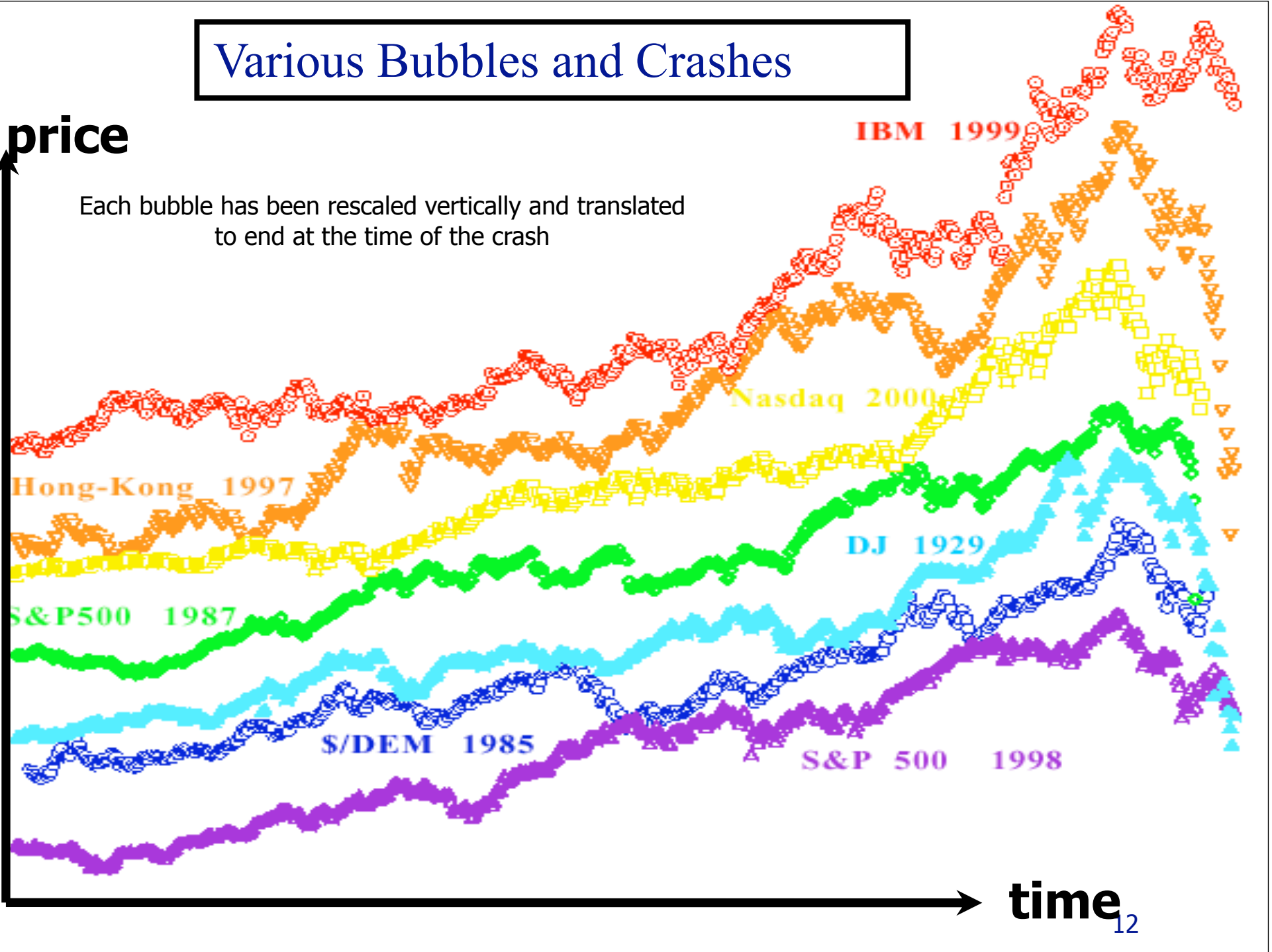
What is the cause of the crash?

✓ Proximate causes: many possibilities

✓ Fundamental cause: maturation towards an instability

An instability is characterized by

- large or diverging susceptibility to external perturbations or influences
- exponential growth of random perturbations leading to a change of regime, or selection of a new attractor of the dynamics.

Mechanisms for positive feedbacks in the stock market

- **Technical and rational mechanisms**
    1. Option hedging
    2. Insurance portfolio strategies
    3. Trend following investment strategies
    4. Asymmetric information on hedging strategies

- **Behavioral mechanisms:**
    1. Breakdown of "psychological Galilean invariance"
    2. Imitation(many persons)
        a) It is rational to imitate
        b) It is the highest cognitive task to imitate
        c) We mostly learn by imitation
        d) The concept of "CONVENTION" (Orléan)

Imitation

-Imitation is considered an efficient mechanism of social learning.

- Experiments in developmental psychology suggest that infants use imitation to get to know persons, possibly applying a 'like-me' test ('persons which I can imitate and which imitate me').

- Imitation is among the most complex forms of learning. It is found in highly socially living species which show, from a human observer point of view, 'intelligent' behavior and signs for the evolution of traditions and culture (humans and chimpanzees, whales and dolphins, parrots).

- In non-natural agents as robots, tool for easing the programming of complex tasks or endowing groups of robots with the ability to share skills without the intervention of a programmer. Imitation plays an important role in the more general context of interaction and collaboration between software agents and human users.

Thy Neighbor's Portfolio: Word-of-Mouth Effects in the Holdings and Trades of Money Managers

HARRISON HONG, JEFFREY D. KUBIK, and JEREMY C. STEIN*

A mutual fund manager is more likely to buy (or sell) a particular stock in any quarter if other managers in the same city are buying (or selling) that same stock. This pattern shows up even when the fund manager and the stock in question are located far apart, so it is distinct from anything having to do with local preference. The evidence can be interpreted in terms of an epidemic model in which investors spread information about stocks to one another by word of mouth.

A fundamental observation about human society is that people who communicate regularly with one another think similarly. There is at any place and in any time a *Zeitgeist*, a spirit of the times.... Word-of-mouth transmission of ideas appears to be an important contributor to day-to-day or hour-to-hour stock market fluctuations. (pp. 148, 155)   Shiller (2000)

Humans Appear Hardwired To Learn By 'Over-Imitation'

ScienceDaily (Dec. 6, 2007) — Children learn by imitating adults--so much so that they will rethink how an object works if they observe an adult taking unnecessary steps when using that object, according to a new Yale study.

What is a bubble?

$$\frac{dp}{dt} = cp^d$$

$$p(t) = \left(\frac{c}{m}\right)^{-m} (t_c - t)^{-m}$$

$$m = 1/(d-1) > 0 \text{ and } t_c = t_0 + mp_0^{1-d}/c.$$

Our proposition: FASTER than exponential transient unsustainable growth of price

DISCRETE HIERARCHY
OF THE AGENT NETWORK

Presentation of three different mechanisms leading to discrete scale invariance, discrete hierarchies and log-periodic signatures

❑ Co-evolution of brain size and group size

(Why do we have a big Brain?)

=> Discrete hierarchy of group sizes

❑ Interplay between nonlinear positive and negative feedbacks and inertia

❑ Impulse-retracting market wave analysis

$$I(t) = A + B(t_c - t)^z + C(t_c - t)^z \cos(\omega \log(t_c - t) - \phi)$$
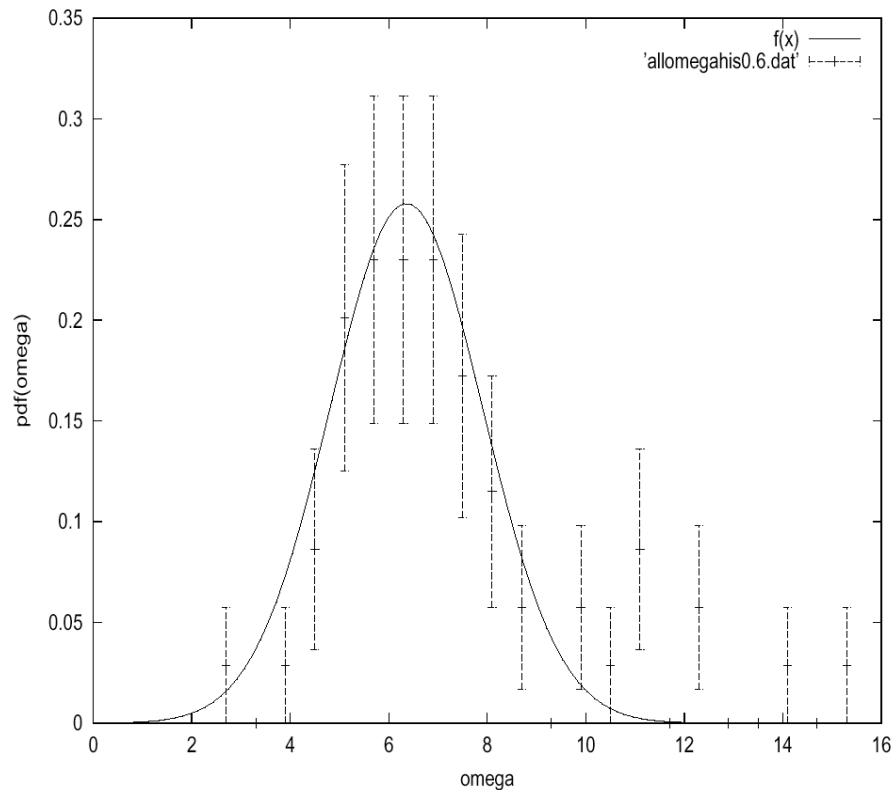
Figure 5: Empirical distribution of the log-periodic angular frequency ω in eq. (1) for over thirty case studies. The fit with a Gaussian distribution gives $\omega \approx 6.36 \pm 1.55$. The smaller peak centered on $11 - 12$ suggests the existence of a second discernable harmonics at $2\omega \approx 12$.

Figure 6: Empirical distribution of the exponent z of the power law in eq. (1) for over thirty case studies. The fit with a Gaussian distribution gives $\beta \approx 0.33 \pm 0.18$.

Demonstration of universal values of z and omega across many different bubbles at different epochs and different markets

A. Johansen and D. Sornette, Shocks, Crashes and Bubbles in Financial Markets, Brussels Economic Review (Cahiers economiques de Bruxelles), 49 (3/4), (2006)

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(a) Textbook example of a series of superexponential acceleration followed by crashes

Arrows show peaks followed by corrections of more than 15% in less than three weeks

(b) Hong-Kong

Red line is 13.8% per year: but
The market is never following the average
growth; it is either super-exponentially
accelerating or crashing

Patterns of price trajectory during 0.5-1 year before each peak: Log-periodic power law
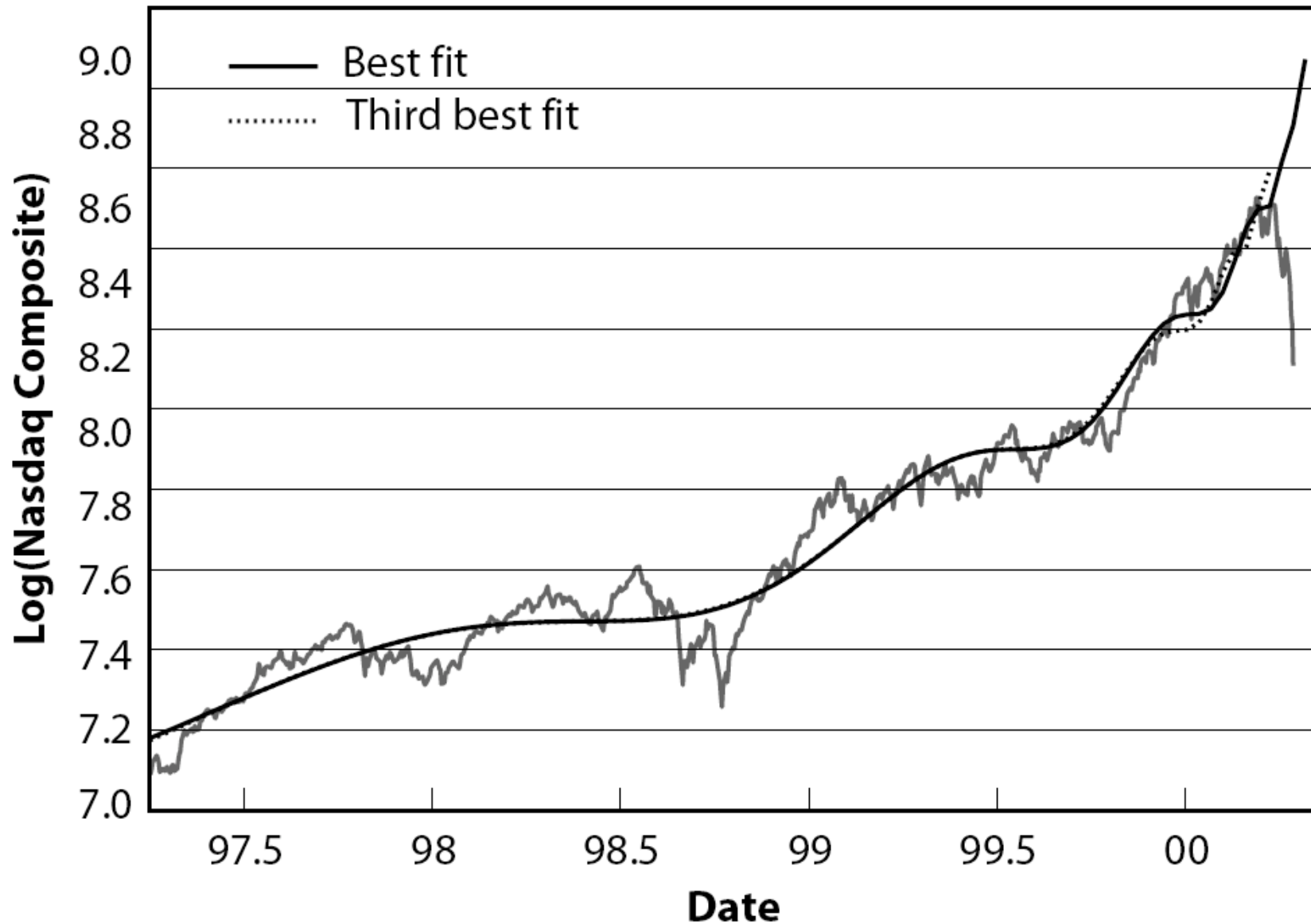
THE NASDAQ CRASH OF APRIL 2000

Internet stocks

The Internet stock index and non-Internet stock index which are equally weighted. Comparison of index levels of the Internet index and the non-Internet Stock index, and the Nasdaq composite index for the period 1/2/1998-12/31/2002. The two indexes are scaled to be 100 on 1/2/1998.

non-Internet stocks

Non-Internet Stock Price Index
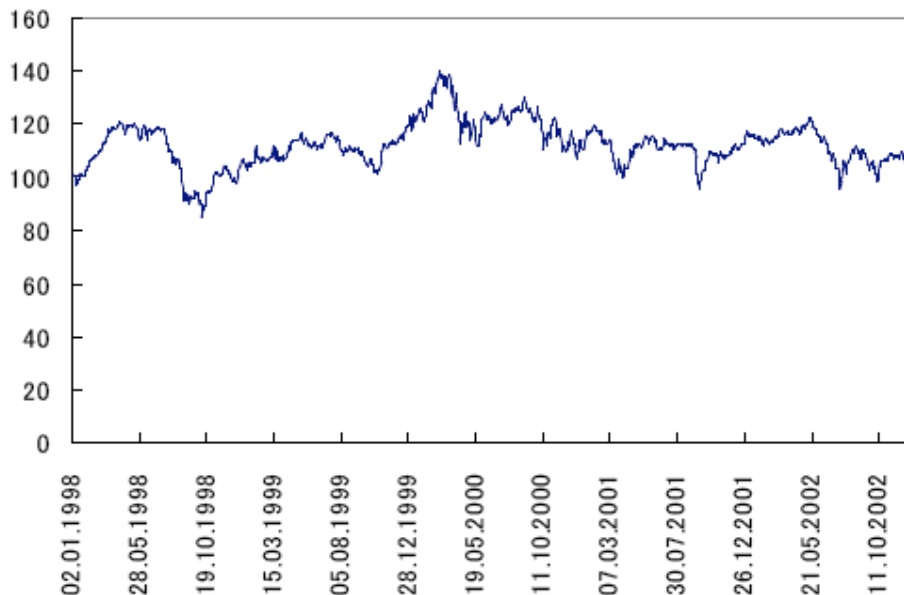
THE NASDAQ CRASH OF APRIL 2000

"New Economy": ICT

THE NASDAQ CRASH OF APRIL 2000
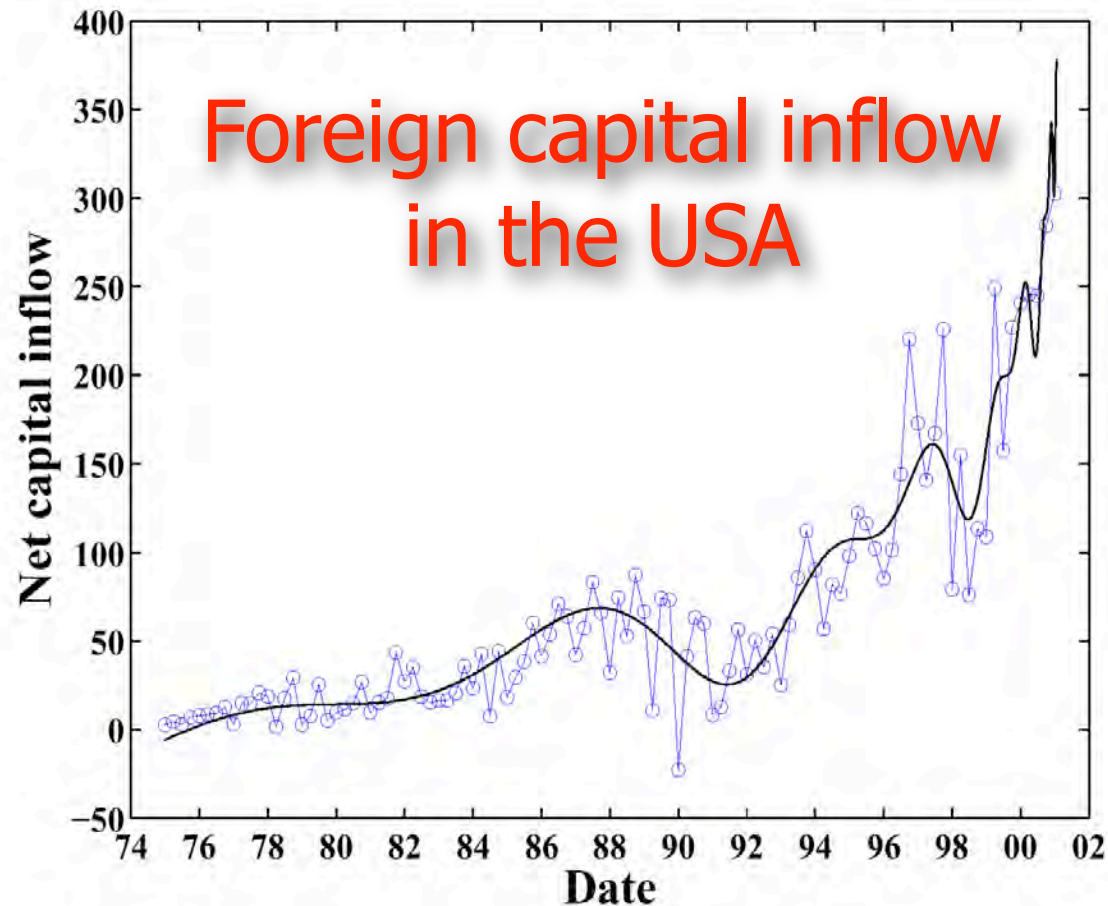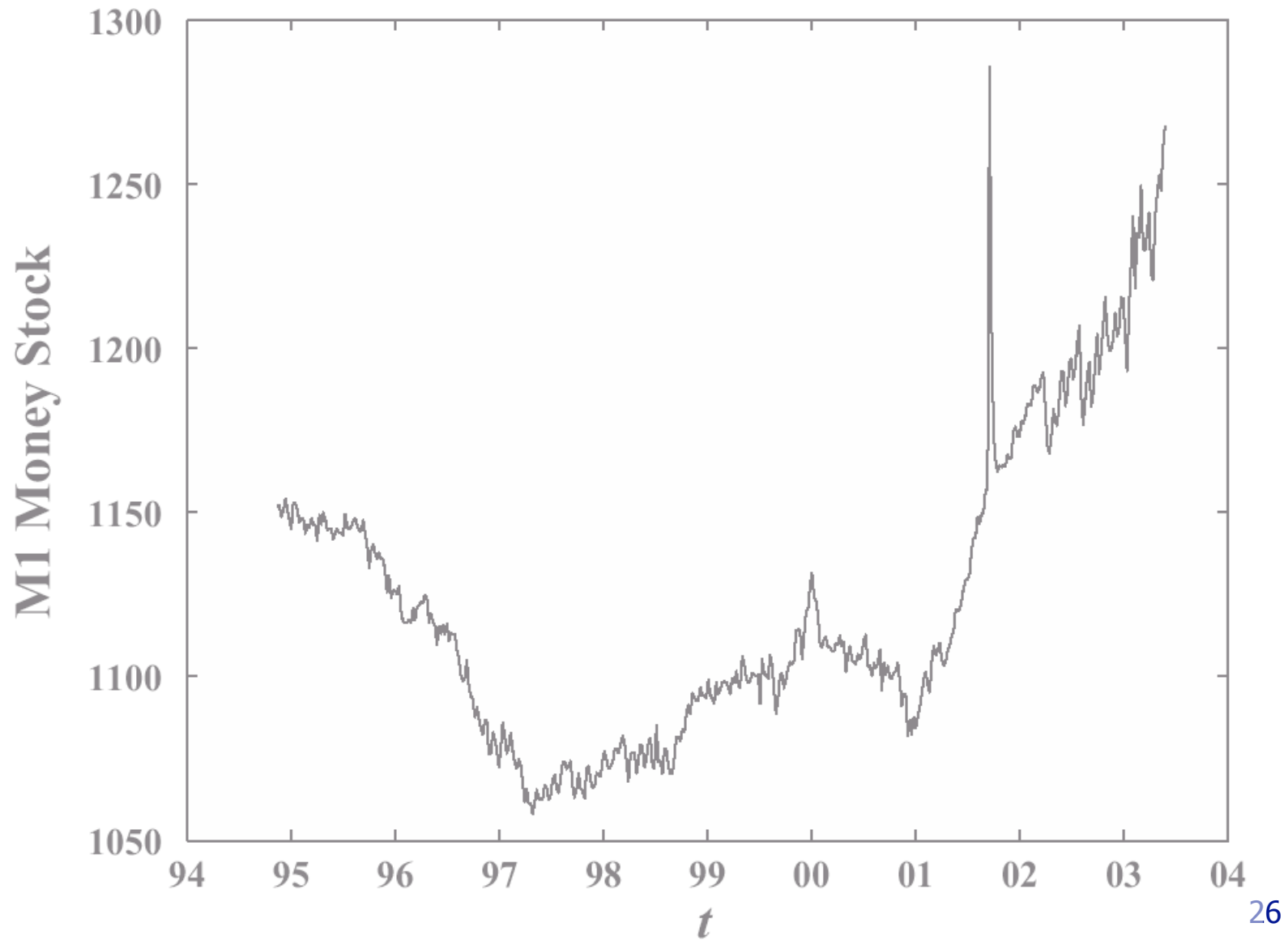

Foreign capital inflow
in the USA

Fig. 2. Fit of the time evolution of the foreign net capital inflow $I(t)$ in the USA from 1975 till the first quarter of 2001 when it reached its maximum, by a second-order Weierstrass-type function given by expression (1). The predicted critical time is $t_c = 2001/03/12$, the power-law exponent is $m = 0.01$, and the angular log-frequency is $\omega = 4.9$. The fitted linear parameters are $A = 7355$, $B = -6719$, $C_1 = 21.5$ and $C_2 = 16.2$. The r.m.s. of the residuals of the fit is 22.810.
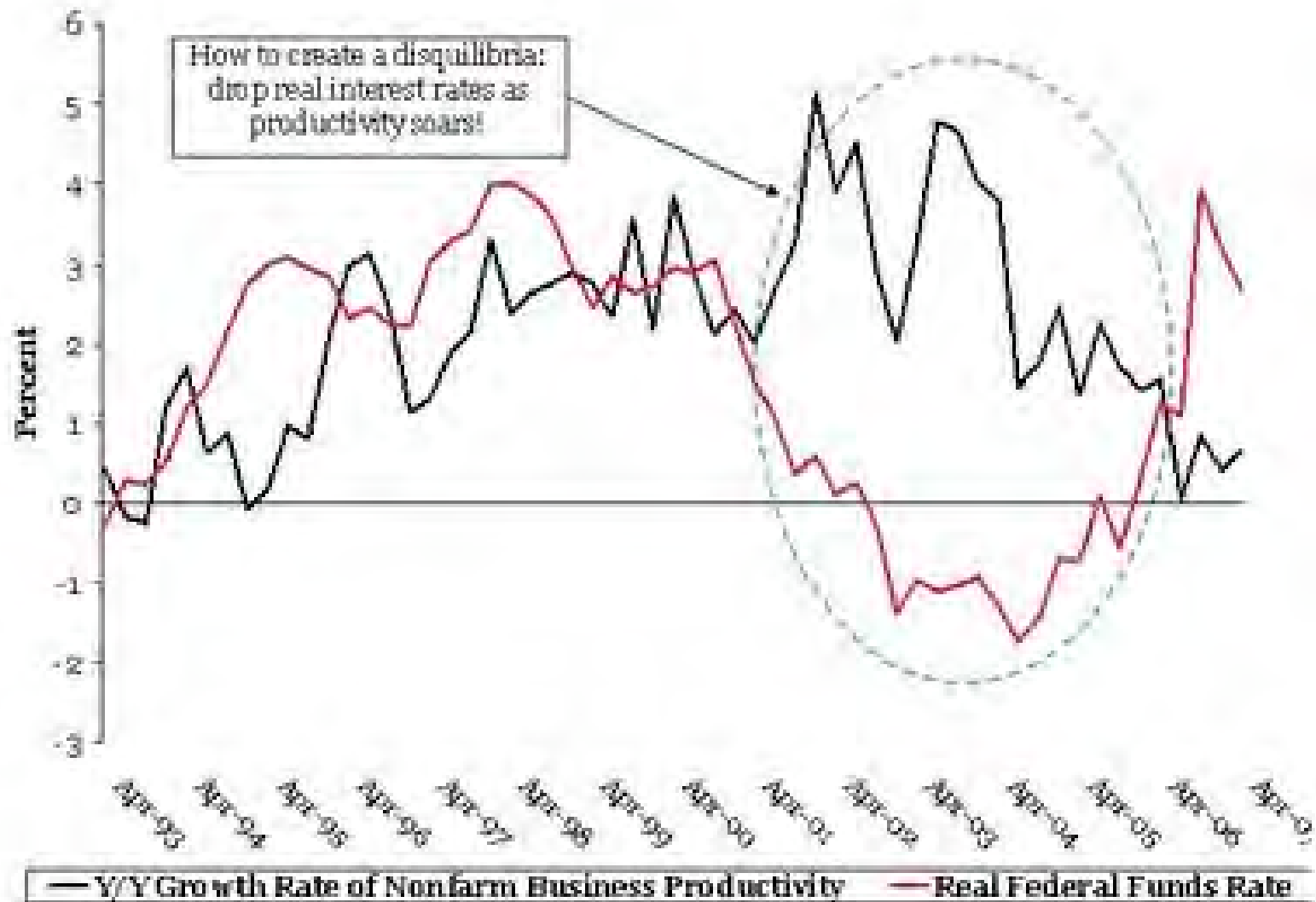
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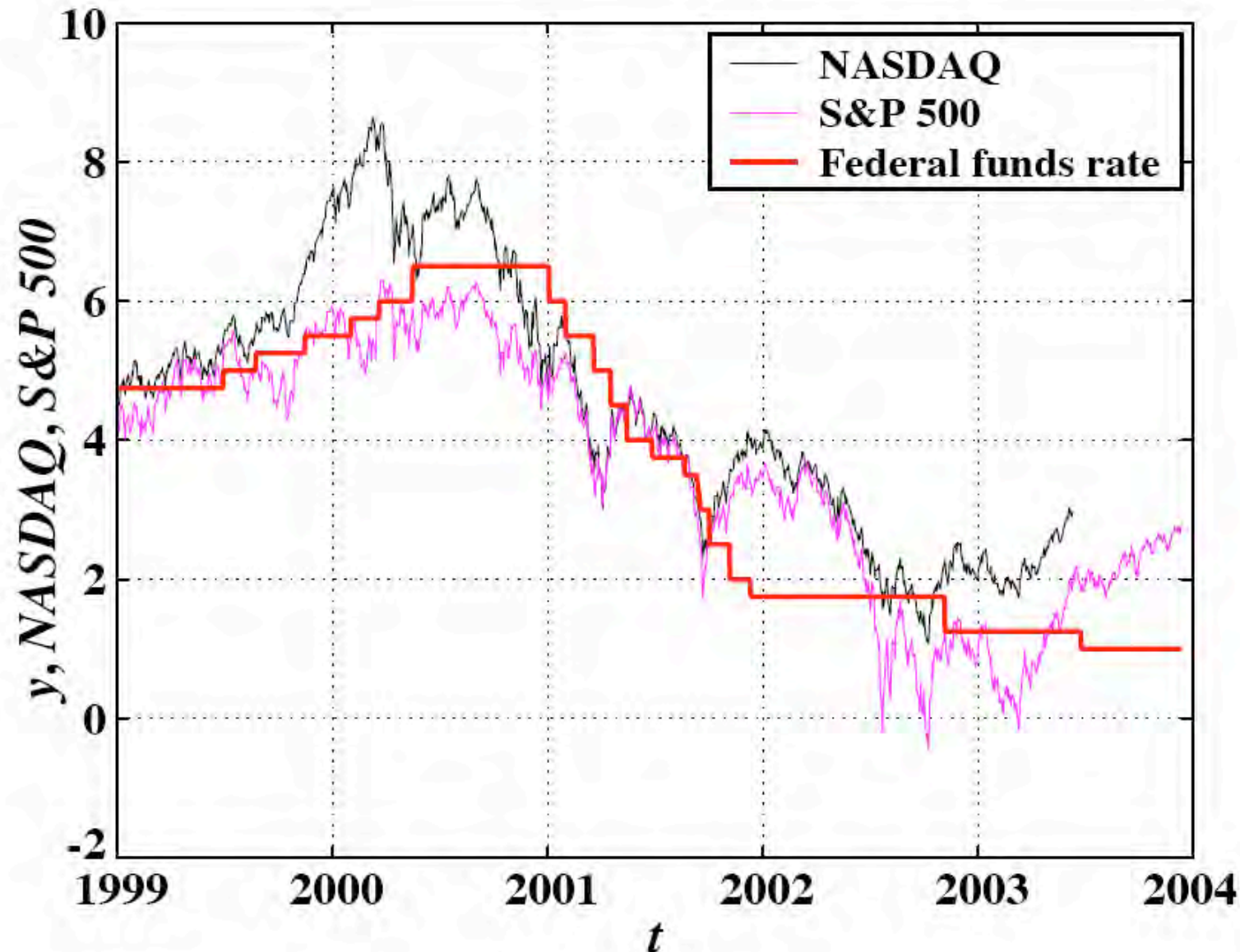- Consequences (deep loss of trust, systemic instability)
- Solutions?
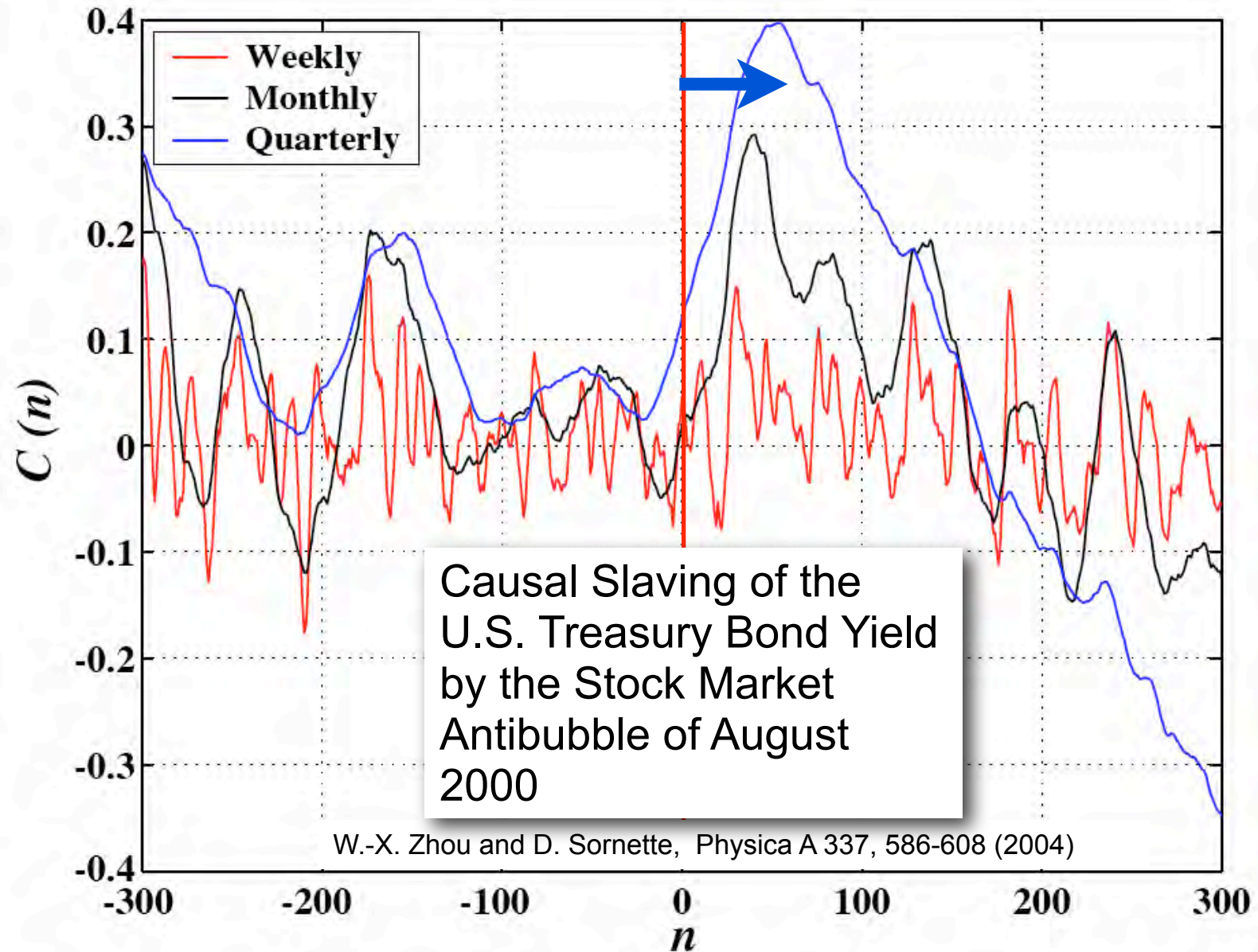
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Growth of Money supply (M1)

No, Greenspan Was Not Right

How to create a disequilibria: drop real interest rates as productivity soars!

Legend: Y/Y Growth Rate of Nonfarm Business Productivity — Real Federal Funds Rate

"SLAVING OF THE FED TO THE STOCK MARKET

Comparison of the Federal funds rate, the S&P 500 Index x(t), and the NASDAQ composite z(t), from 1999 to mid-2003. To allow a illustrative visual comparison, the indices have been translated and scaled as follows: $x \rightarrow 5x - 34$ and $z \rightarrow 10z - 67$.

Causal Slaving of the U.S. Treasury Bond Yield by the Stock Market Antibubble of August 2000

W.-X. Zhou and D. Sornette, Physica A 337, 586-608 (2004)

Cross-correlation coefficient C(n) between the increments of the logarithm of the S&P 500 Index and the increments of the Federal funds rate as a function of time lag n in days. The three curves corresponds to three different time steps used to calculate the increments: weekly, monthly and quarterly. A positive lag n corresponds to having the Federal funds rate posterior to the stock market.

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Real-estate bubbles

Percentage change in real housing prices 2002–2006

Sources: Shiller; BIS.
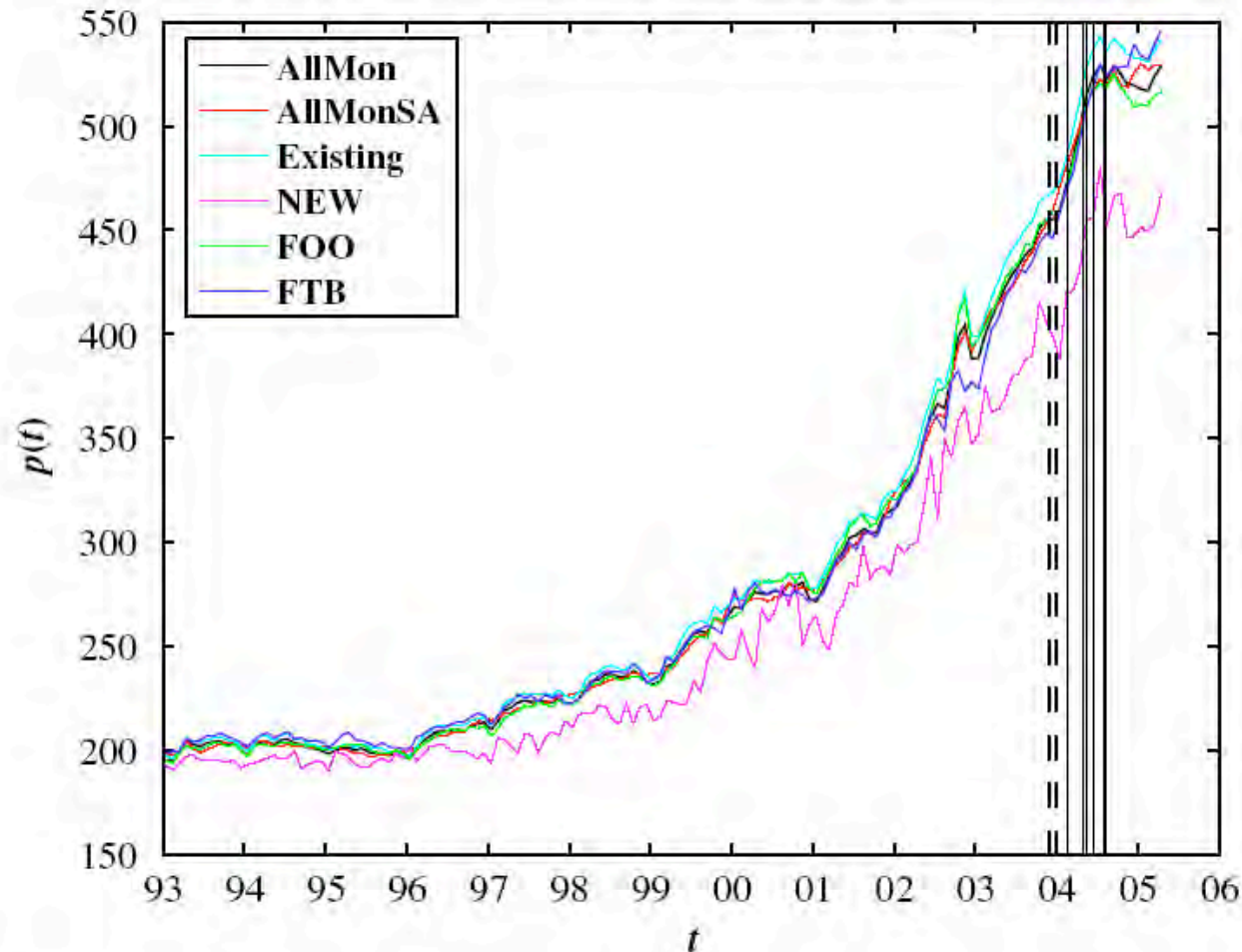
31

Real-estate in the UK

Fig. 1. (Color online) Plot of the UK Halifax house price indices from 1993 to April 2005 (the latest available quote at the time of writing). The two groups of vertical lines correspond to the two predicted turning points reported in Tables 2 and 3 of [1]: end of 2003 and mid-2004. The former (resp. later) was based on the use of formula (2) (resp. (3)). These predictions were performed in February 2003.

W.-X. Zhou, D. Sornette, 2000–2003 real estate bubble in the UK but not in the USA, Physica A 329 (2003) 249–263.
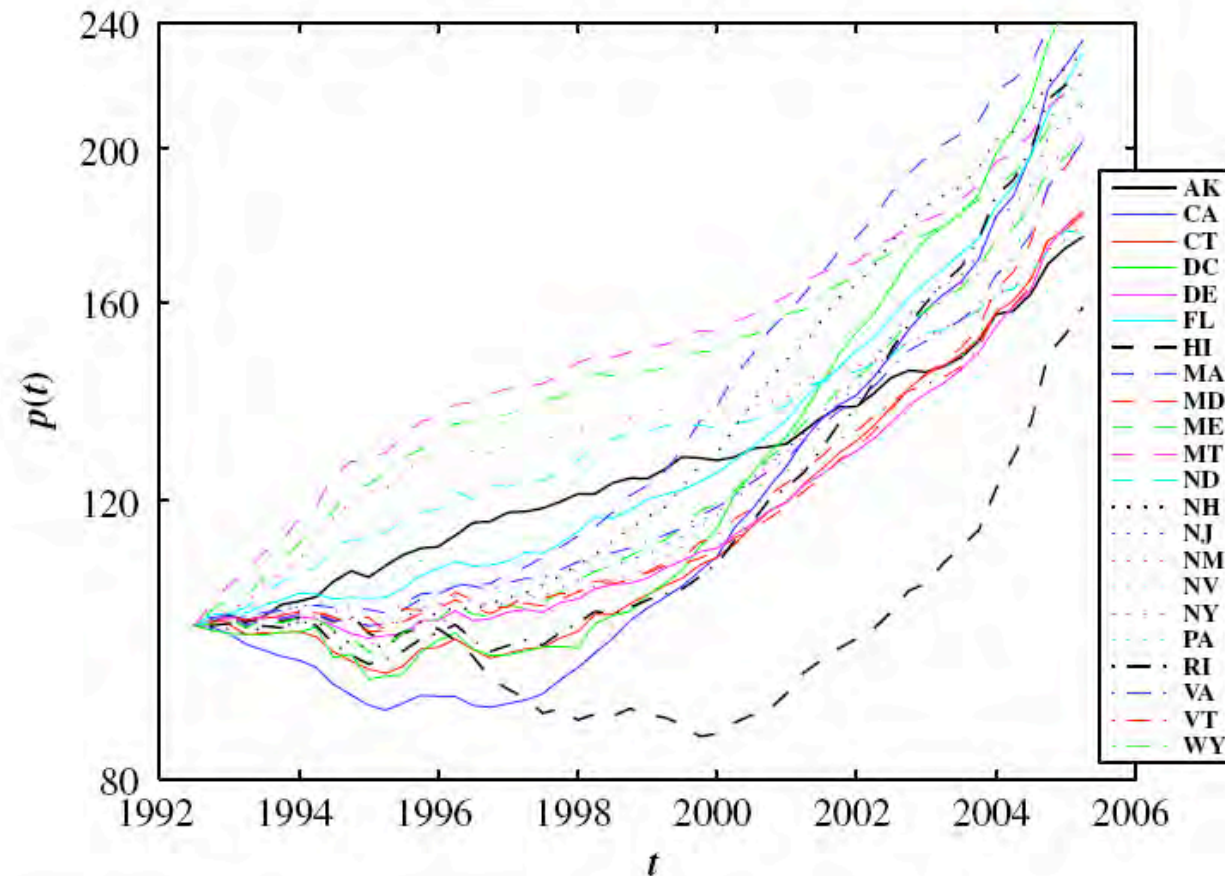
Real-estate in the USA

Fig. 5. (Color online) Quarterly average HPI in the 21 states and in the District of Columbia (DC) exhibiting a clear upward faster-than-exponential growth. For better representation, we have normalized the house price indices for the second quarter of 1992 to 100 in all 22 cases. The corresponding states are given in the legend.

717 VERNON WY
BURLINGAME, CA 94010

(2005)

2 Bedrooms, **1** Bath(s)
**1,310** Estimated Sq. Ft.

Listing #: 620130

$1,049,000

And this with the median household income in San Mateo County of ~$70,000. With 20% down, the mortgage
for a "starter" $1M house would be 11-12 times the median income. Even if one were "buying up" to one of these houses,
say, with equity of 50%, the mortgage/median income ratio would be 7:1!!!

From late '02 and early '03 to date--the bubbliest phase--the value of the property below is estimated to have more than DOUBLED,
 peaking at an estimated $1.16M in summer-fall '05, an annualized increase in value of ~14% from '96. However, before the one
order of magnitude of exponential growth of the bubble commenced in late '02, the rate of growth of the value of this property
was ~6.9%/yr. Were the value to regress to the pre-bubble trend, the estimated value would be $620,000-$820,000 over the
course of the next 4 years or a 30% to 40-45% nominal decline and -11% to -18%/yr. in real terms (at the trend 2.7% CPI).
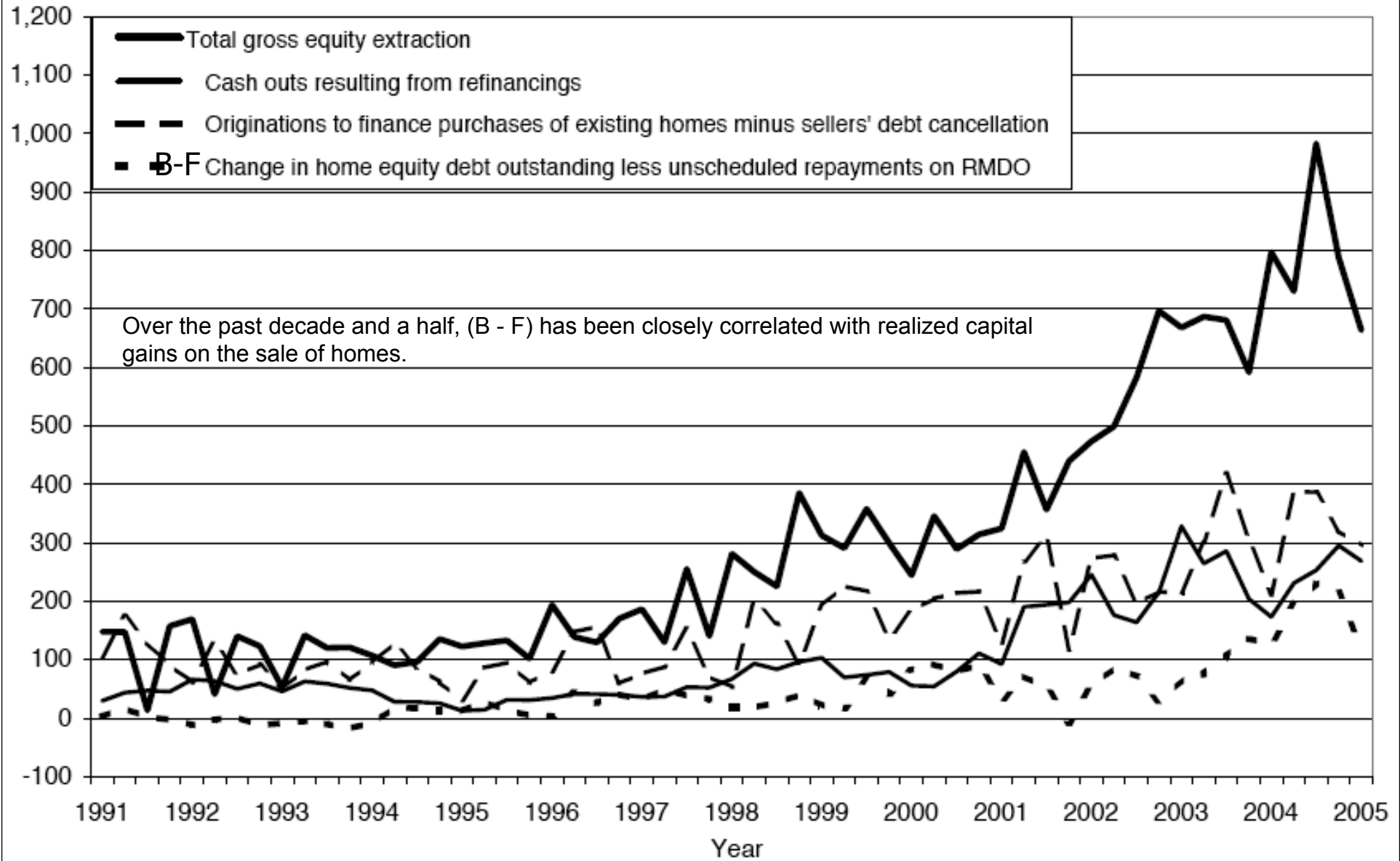
Our study in 2005 identifies the bubble states
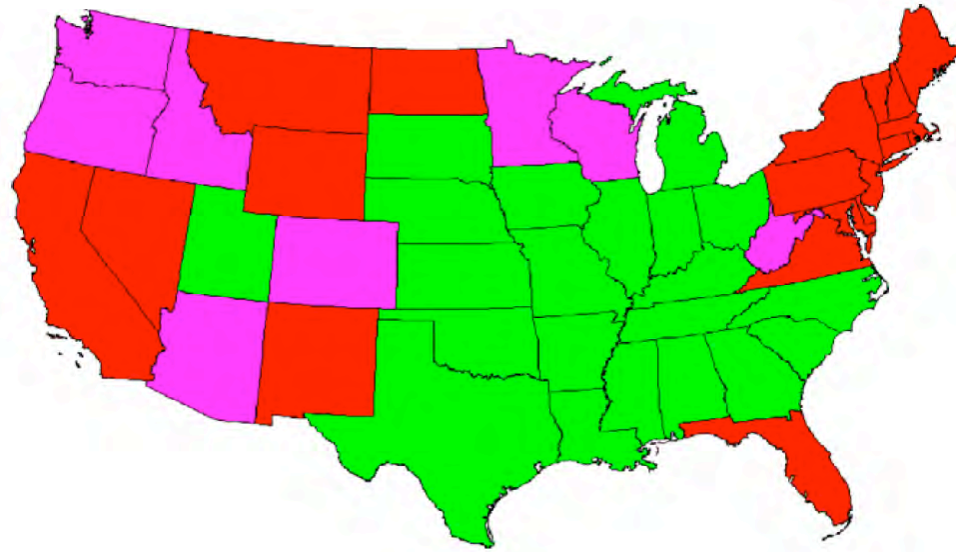
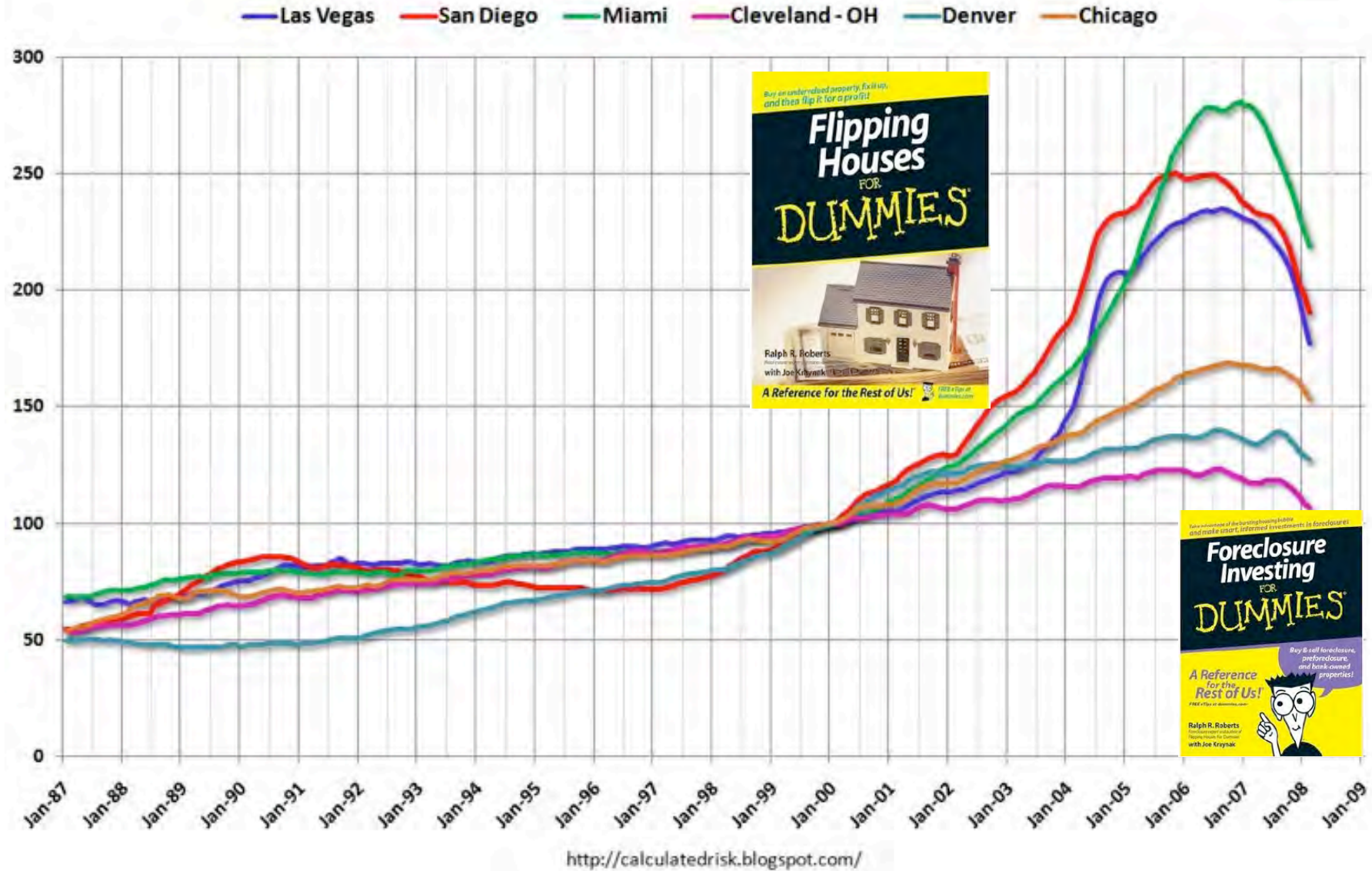Local bubbles (Froths) of Housing Markets in US, 1998-2006

Inflation-Adjusted Home-Price Appreciation, 1998–2006
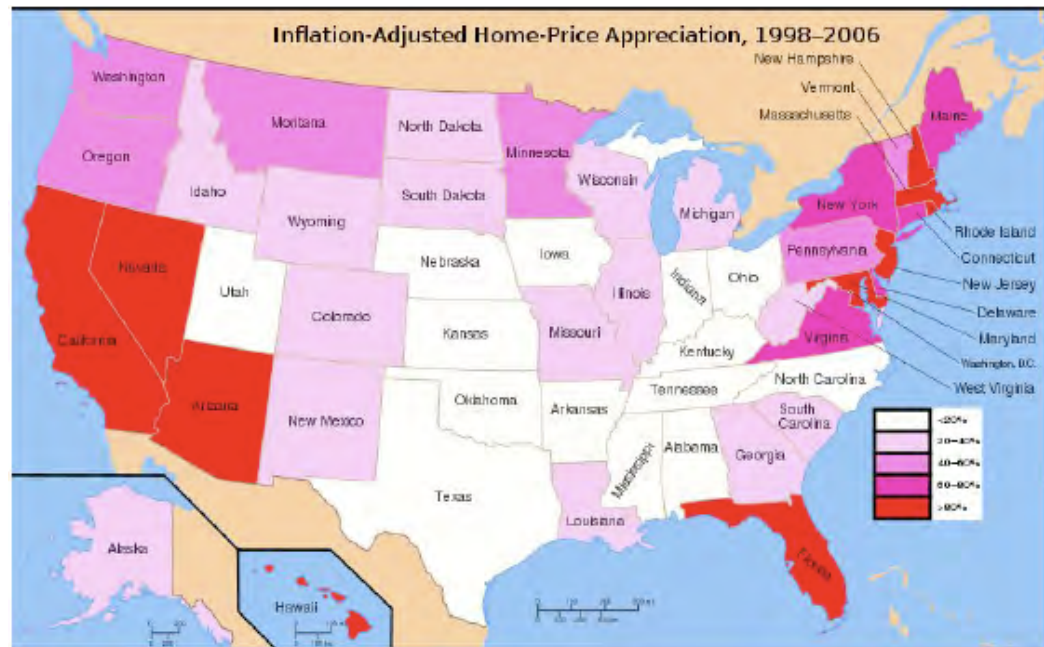
The Components of Gross Equity Extraction
(1991:Q1-2005:Q1, seasonally adjusted annual rate)

Billions of dollars

Legend:
- Total gross equity extraction
- Cash outs resulting from refinancings
- Originations to finance purchases of existing homes minus sellers' debt cancellation
- B-F Change in home equity debt outstanding less unscheduled repayments on RMDO

Over the past decade and a half, (B - F) has been closely correlated with realized capital gains on the sale of homes.

Year

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Alan Greenspan and James Kennedy (Nov. 2005)

Case-Shiller Home Price Indices, Selected Cities

Legend: Las Vegas, San Diego, Miami, Cleveland - OH, Denver, Chicago
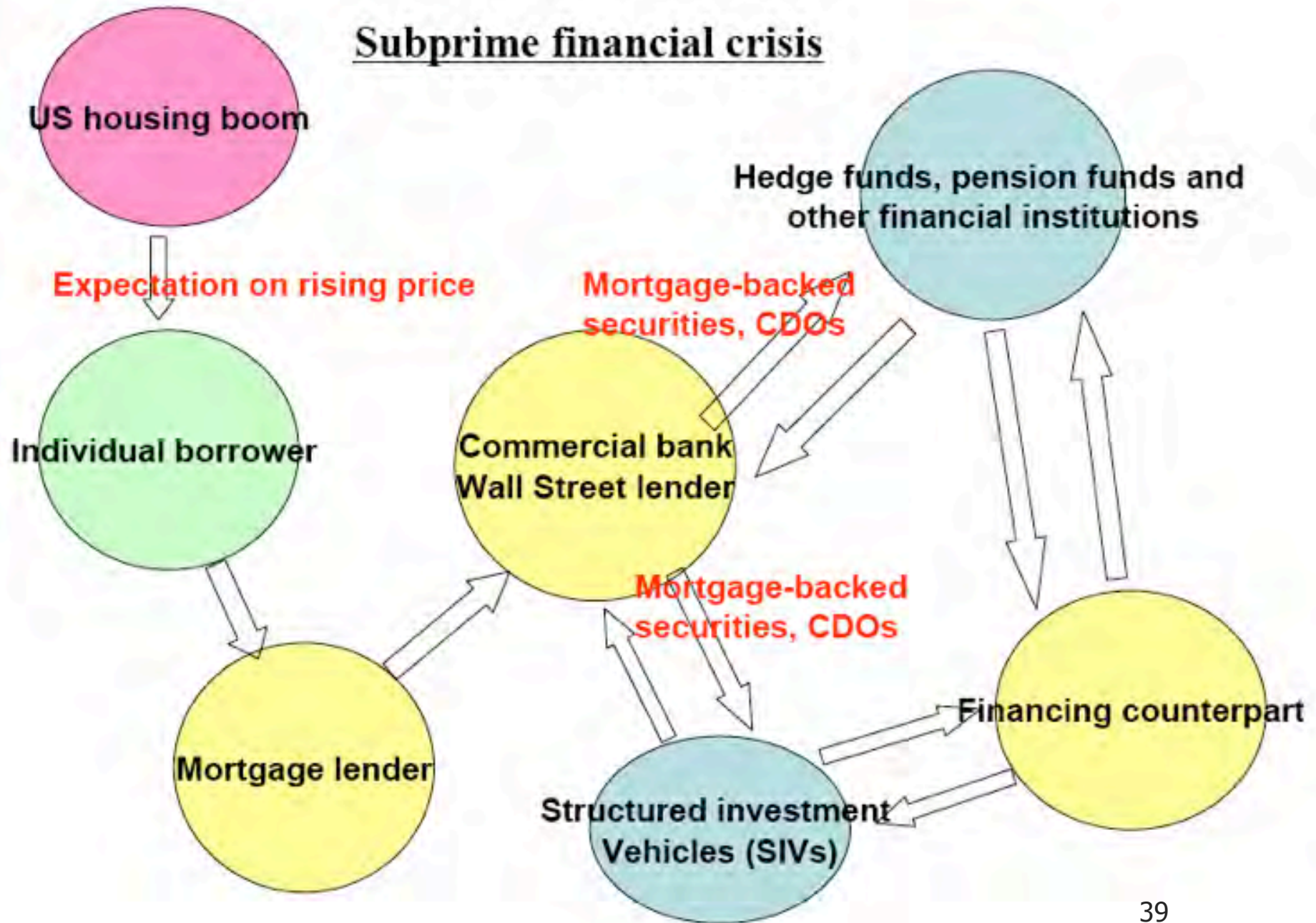
http://calculatedrisk.blogspot.com/

This graph shows the year-over-year price changes for the Case-Shiller composite 10 and 20 indices (through February), and the Case-Shiller and OFHEO National price indices (through Q4 2007).
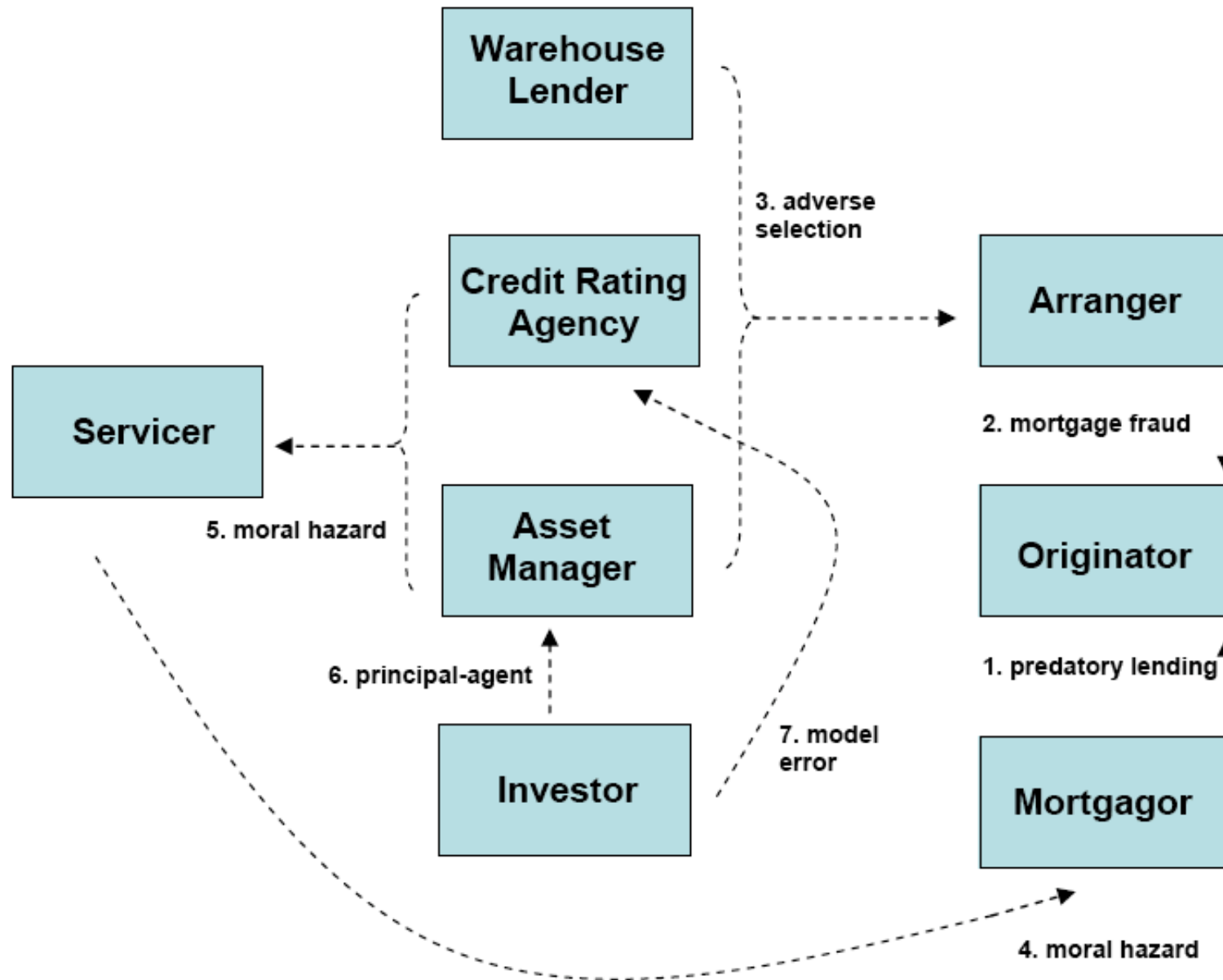
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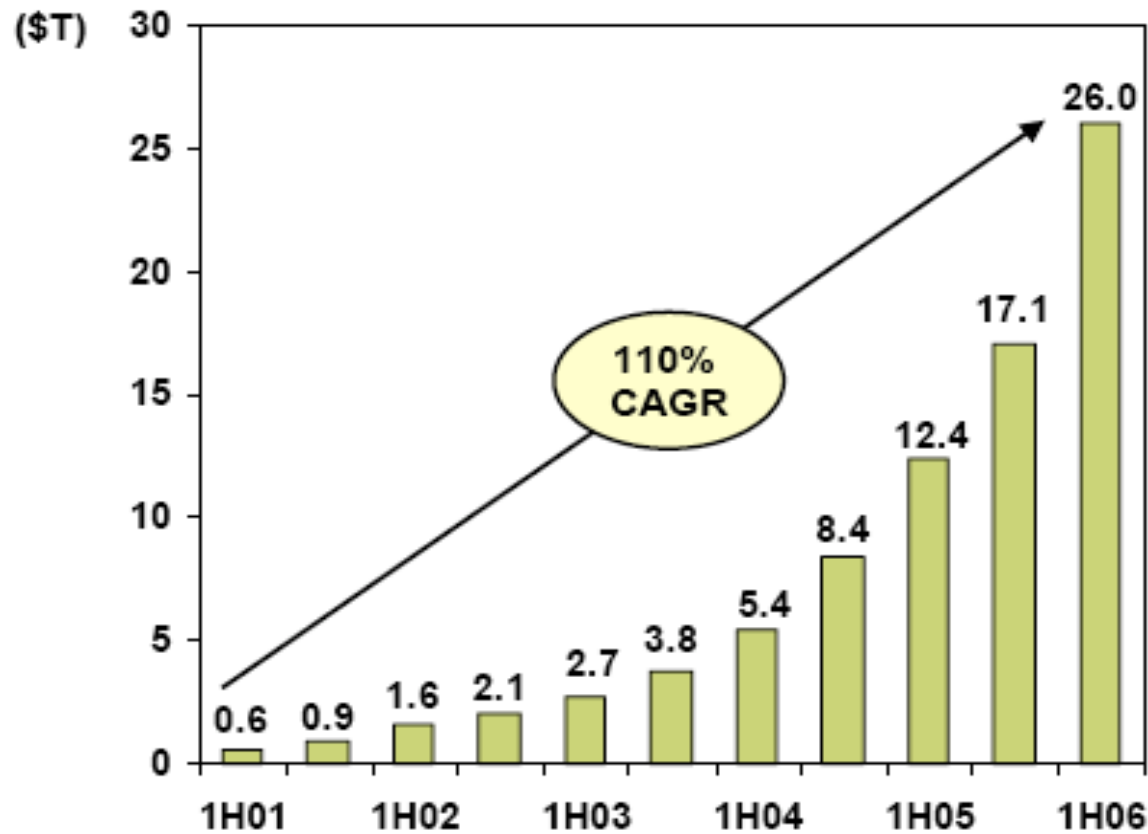- Solutions?

Subprime financial crisis

US housing boom

Hedge funds, pension funds and other financial institutions

Expectation on rising price

Mortgage-backed securities, CDOs

Individual borrower

Commercial bank
Wall Street lender

Mortgage-backed securities, CDOs

Mortgage lender

Financing counterpart

Structured investment Vehicles (SIVs)

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Key Players and Frictions in Subprime Mortgage Credit Securitization

Warehouse Lender

Credit Rating Agency

Servicer

Asset Manager

Investor

Arranger

Originator

Mortgagor

3. adverse selection

2. mortgage fraud

5. moral hazard

6. principal-agent

7. model error

1. predatory lending

4. moral hazard

Securitization of non-financial assets (commodities, real-estate, credit)

Notional value of CDS

Period	Value ($T)
1H01	0.6
1H02	0.9
	1.6
	2.1
1H03	2.7
	3.8
1H04	5.4
	8.4
1H05	12.4
	17.1
1H06	26.0

110% CAGR

Average Subprime MBS Capital Structure*

AAA: 79.3%
AA: 6.6%
A: 5.4%
BBB: 4.3%
BB: 2.6%
OC: 1.9%
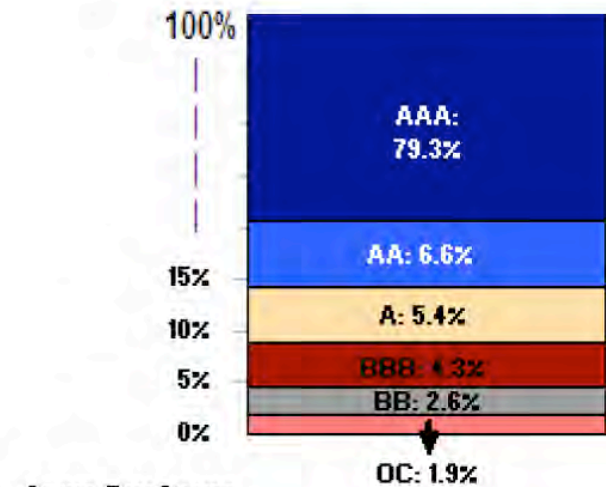
Source: Bear Stearns

Securitization of non-financial assets (commodities, real-estate, credit)
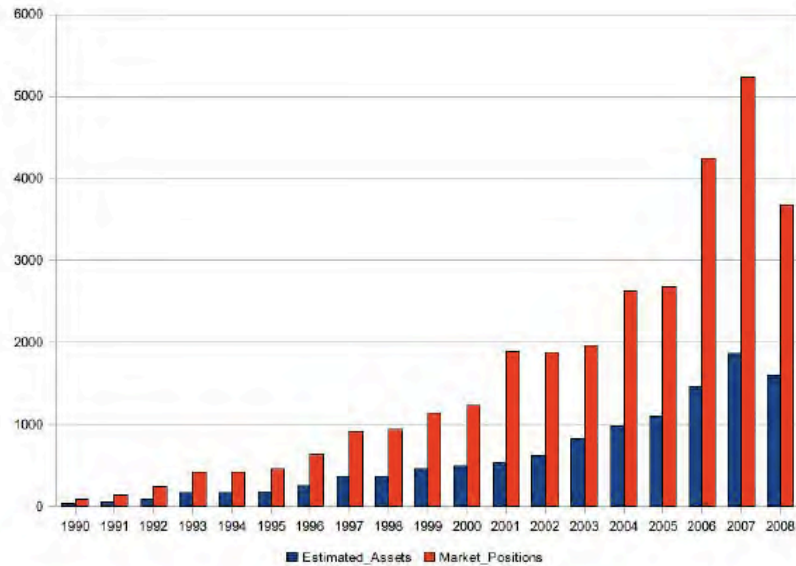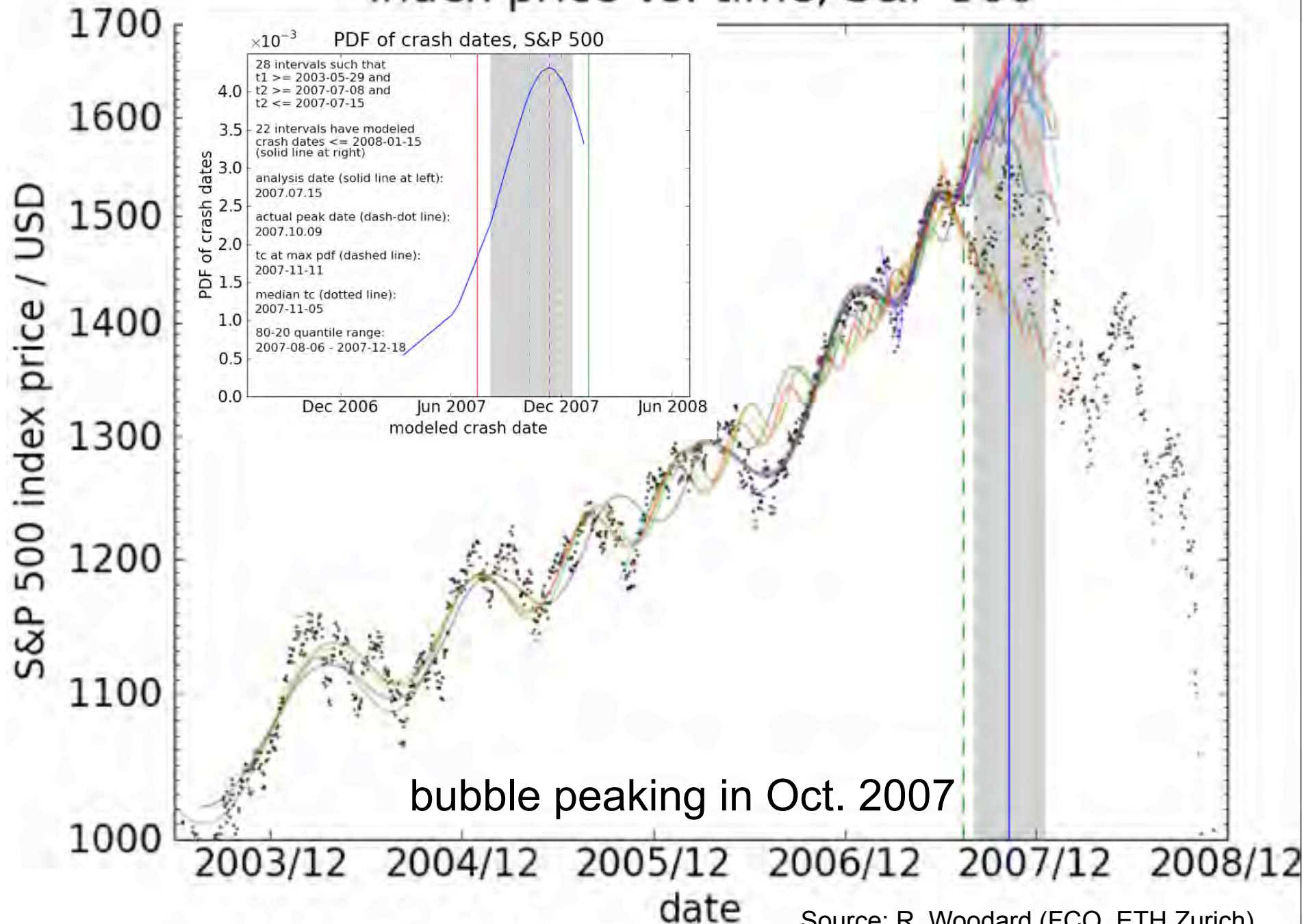

Estimated assets and market positions in the hedge-fund industry from 1990 to 2008
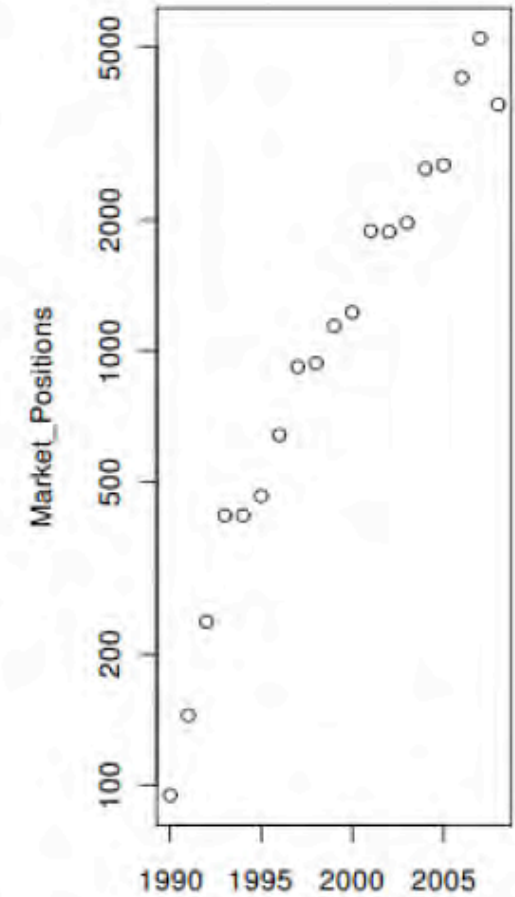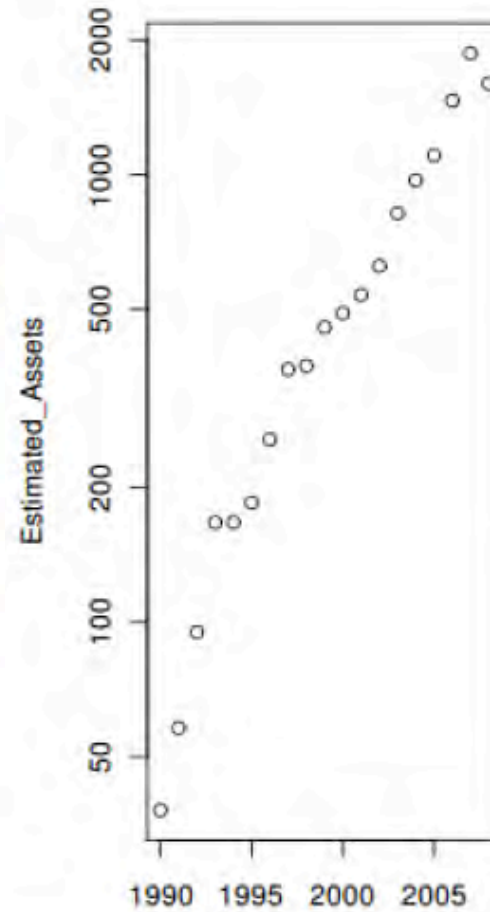
Source: A. Huesler and D. Sornette

Lo, A. W. Hedge funds, systemic risk, and the financial crisis of 2007- 2008: Written testimony for the house oversight committee hearing on hedge funds. Social Science Research Network Working Paper Series (November 2008).
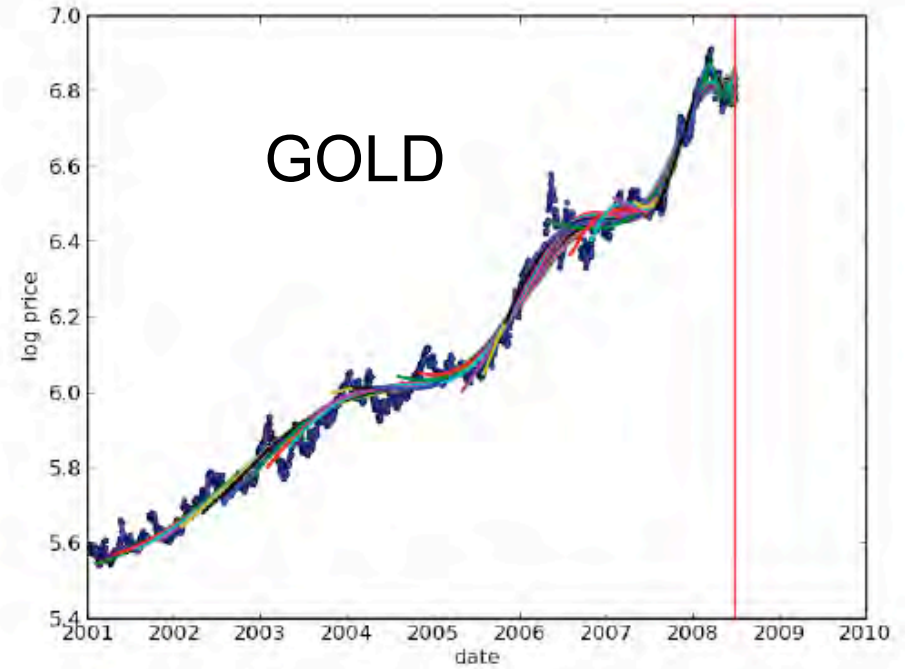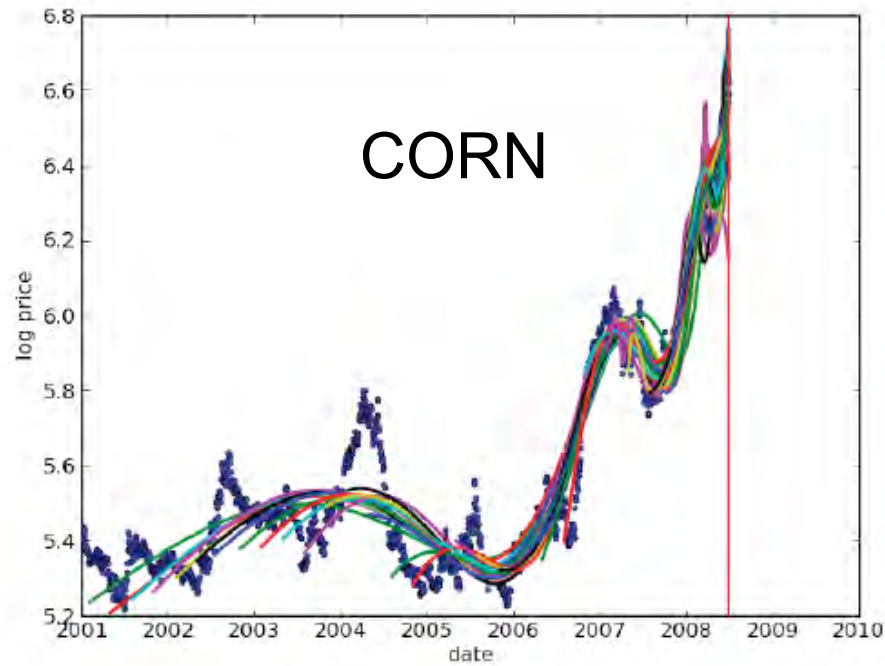
Index price vs. time, S&P 500

PDF of crash dates, S&P 500

$\times 10^{-3}$

28 intervals such that
t1 >= 2003-05-29 and
t2 >= 2007-07-08 and
t2 <= 2007-07-15

22 intervals have modeled
crash dates <= 2008-01-15
(solid line at right)

analysis date (solid line at left):
2007.07.15

actual peak date (dash-dot line):
2007.10.09

tc at max pdf (dashed line):
2007-11-11

median tc (dotted line):
2007-11-05

80-20 quantile range:
2007-08-06 - 2007-12-18

PDF of crash dates

modeled crash date

S&P 500 index price / USD

date

bubble peaking in Oct. 2007

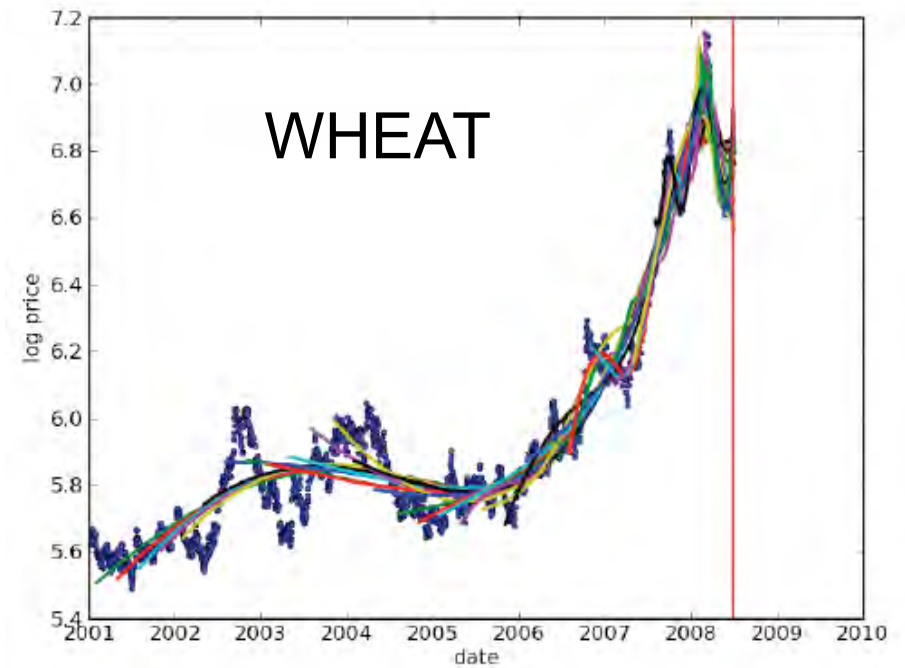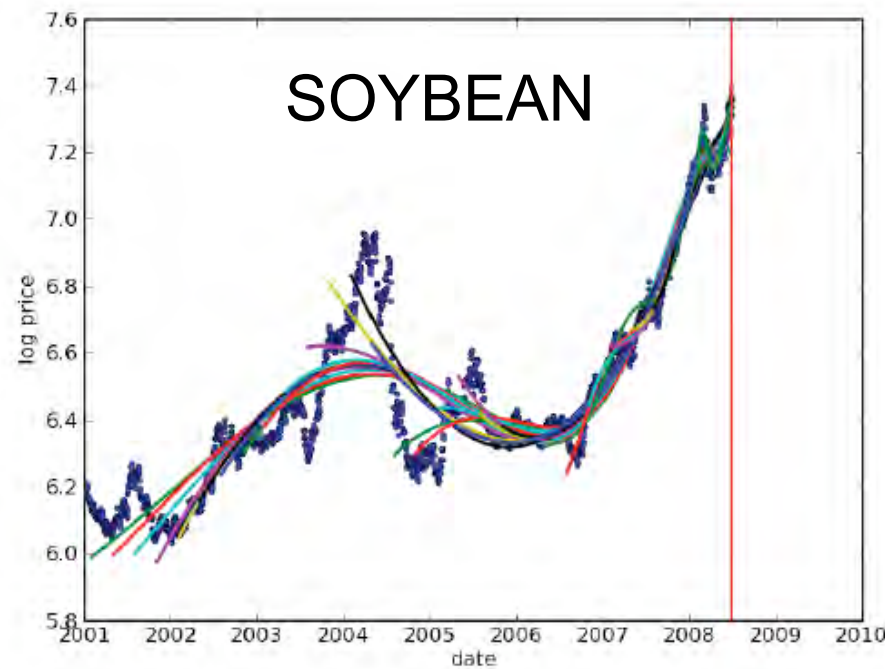Source: R. Woodard (FCO, ETH Zurich)

A 15y History of the 2008- crisis

- The ITC "new economy" bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007)
- **Commodities and Oil bubbles (2006-2008)**
- Consequences (deep loss of trust, systemic instability)
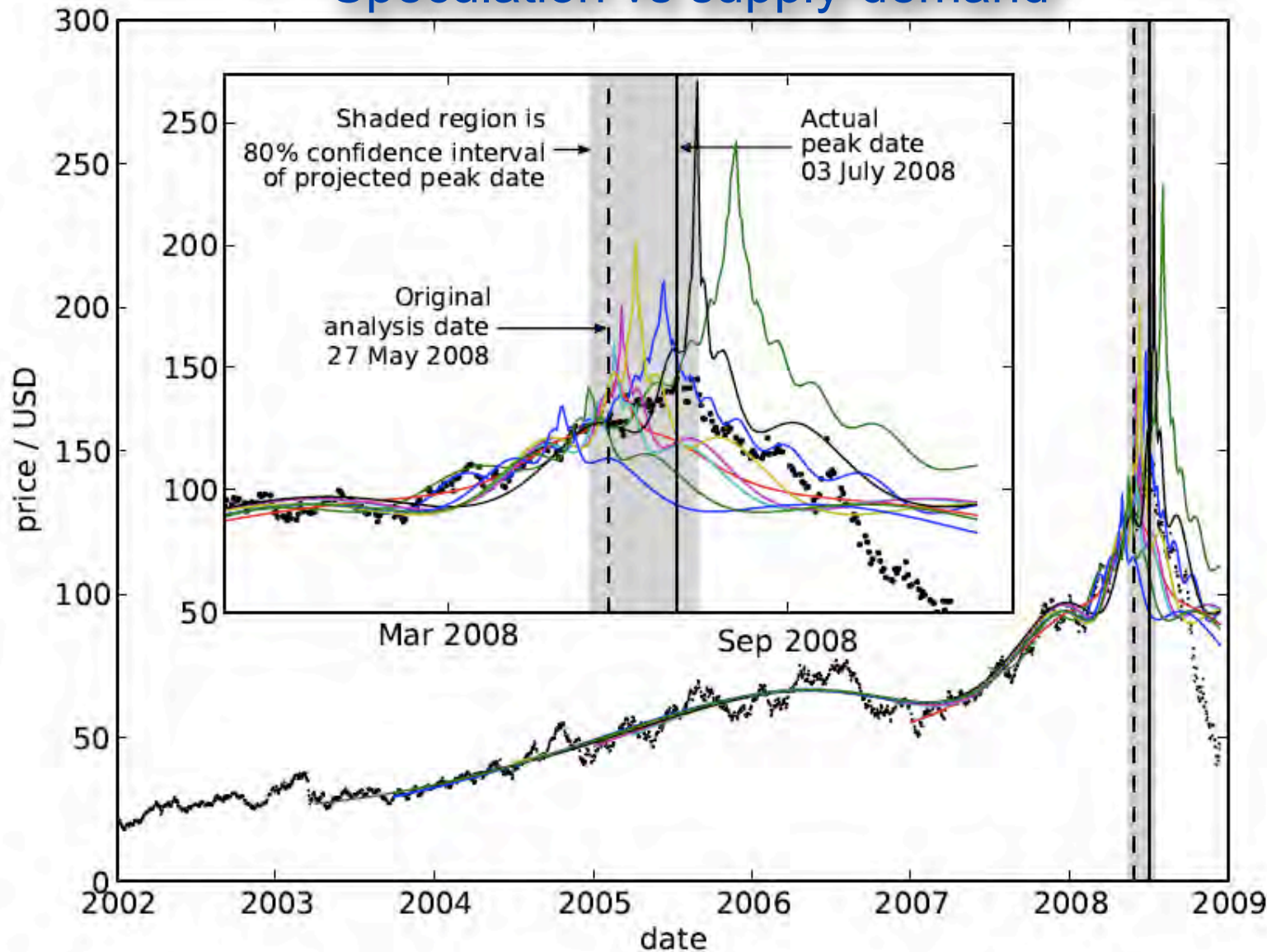- Solutions?

source: R. Woodard

R.Woodard and D.Sornette (2008)

2006-2008 Oil bubble
Speculation vs supply-demand

Shaded region is 80% confidence interval of projected peak date →

Original analysis date 27 May 2008

Actual peak date 03 July 2008

D. Sornette, R. Woodard and W.-X. Zhou, The 2006-2008 Oil Bubble and Beyond, Physica A 388, 1571-1576 (2009) (arXiv.org/abs/0806.1170)

Typical result of the calibration of the simple LPPL model to the oil price in US$ in shrinking windows with starting dates t_{start} moving up towards the common last date t_{last} = May 27, 2008.

In summary

Each excess is partially "solved" by the subsequent excess... leading to a succession of
-unsustainable wealth growth
-instabilities

The present crisis+recession is the consolidation after this series of unsustainable excesses.

One could conclude that the extraordinary severity of this crisis is not going to be solved by the same of implicit or explicit "bubble thinking".

"The problems that we have created cannot be solved at the level of thinking that created them." Albert Einstein

Recession-Plagued Nation Demands New Bubble To Invest In

(satirical american journal)

The Next Big Bubble?

These are the economic bubbles Americans would like to foolishly invest in to take their minds off the current fiscal crisis most.

- Carbides
- Some sort of fund
- Debt refinancing
- Postmodernism
- (No preference)
- Atmospherics
- Illegal immigration futures
- Freight—yeah, that sounds about right. "Freight"

Source: University of Chicago

A prominent finance expert asks Congress to help Americans rebuild their ficticious dreams.

Mr. Jenkins

"Every American family deserves a false sense of security," said Chris Reppto, a risk analyst for Citigroup in New York. "Once we have a bubble to provide a fragile foundation, we can begin building pyramid scheme on top of pyramid scheme, and before we know it, the financial situation will return to normal."

A 15y History of the 2008- crisis

- The ITC "new economy" bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008)
- **Consequences (deep loss of trust, systemic instability)**
- Solutions?

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Separation of financial and credit risks
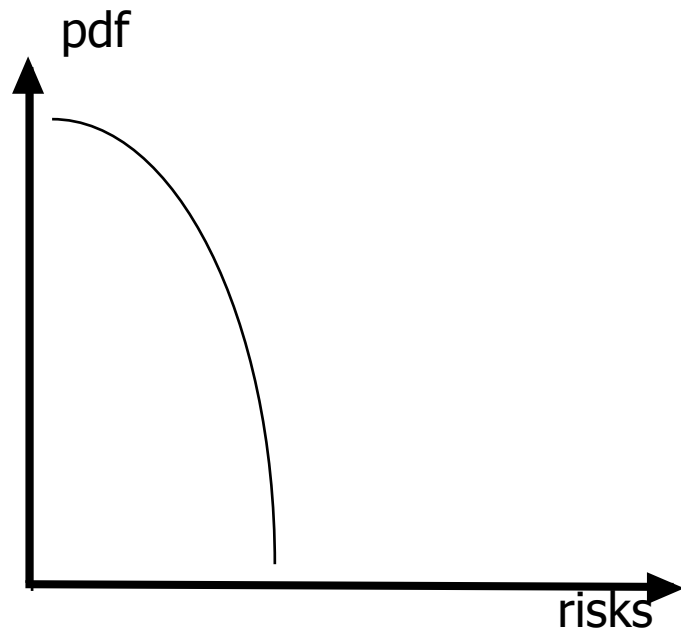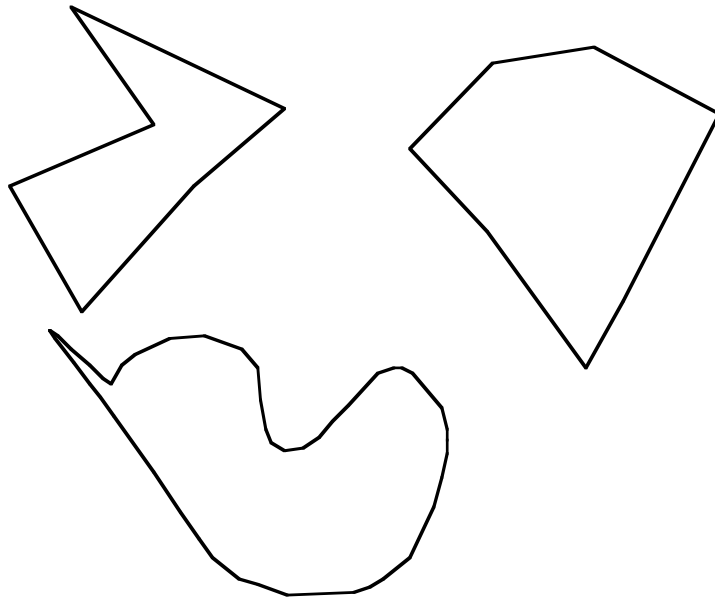
Securitization leads to larger inter-connectivity
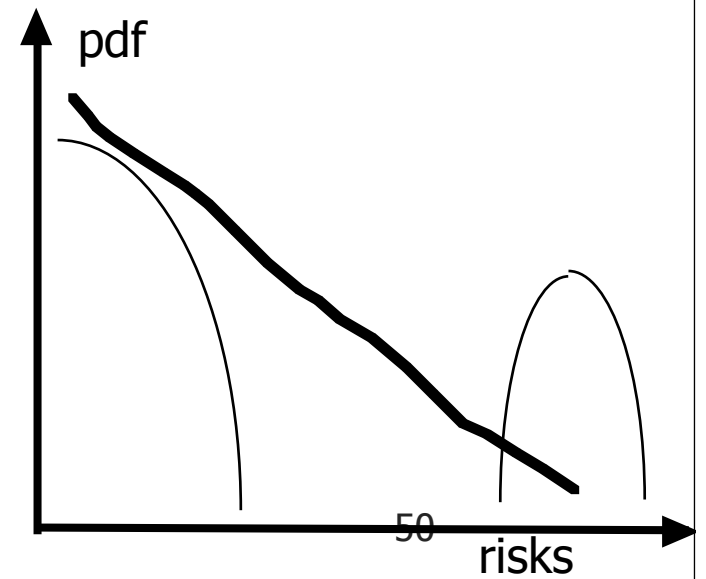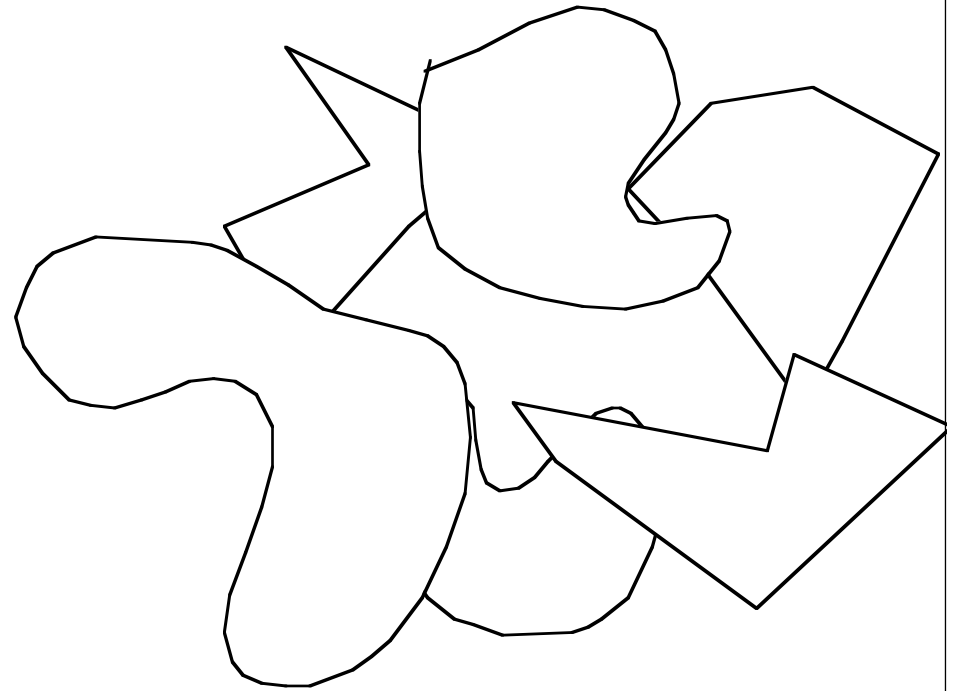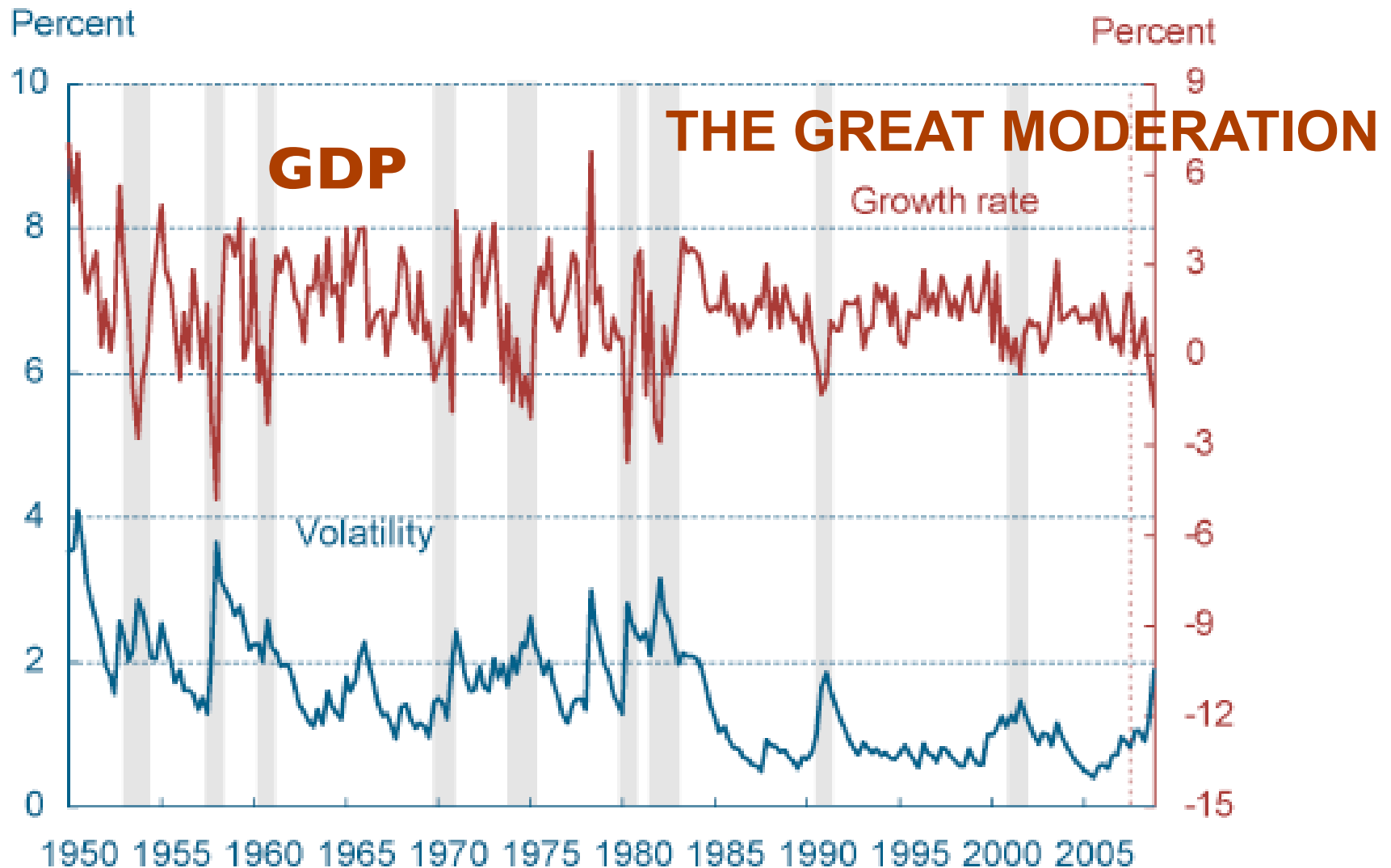
pdf

risks

pdf

50

risks

THE GREAT MODERATION

1992 to July 2007: Great Stability, a period of continuous growth, low inflation, and falling unemployment.

They were guided by and reinforced a wide consensus that economics had discovered the right way to manage the economy and that the UK and US were a good model of how to put it into effect.
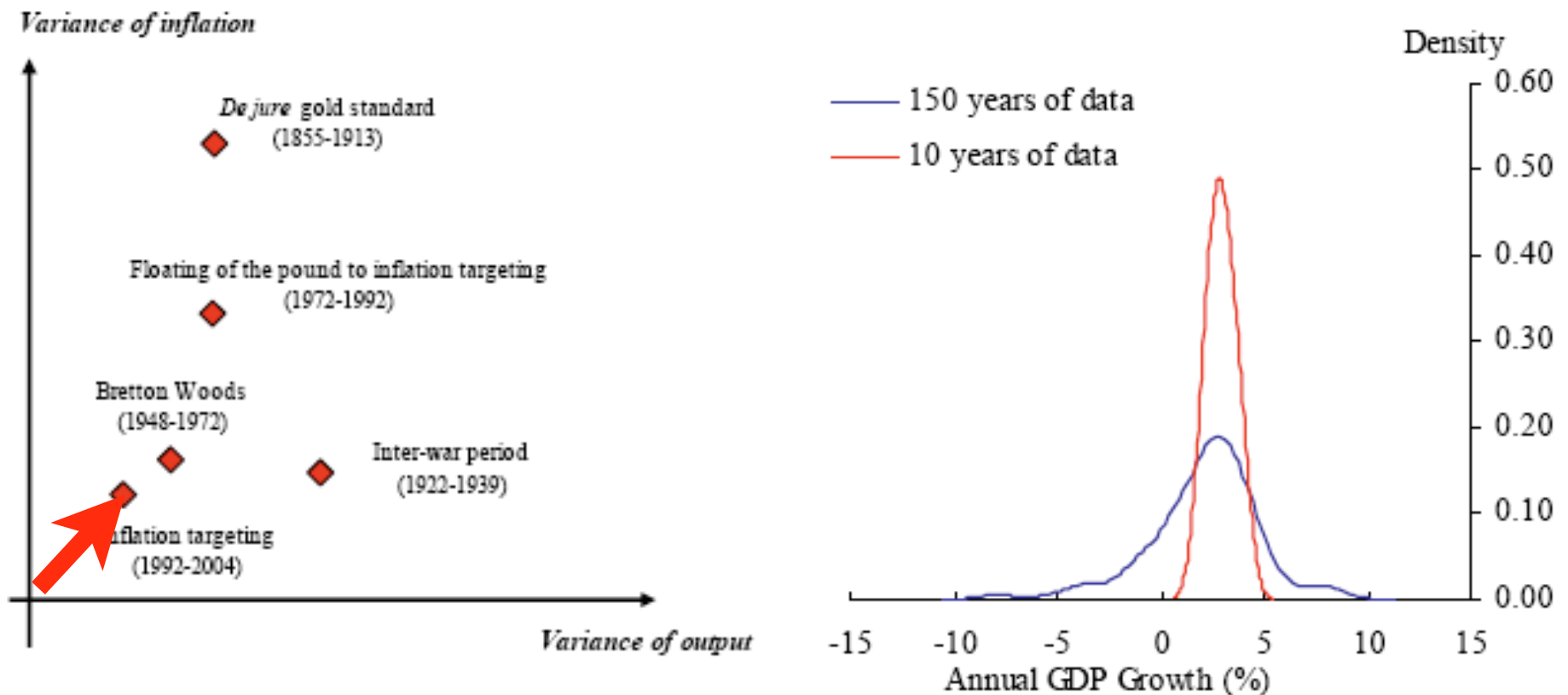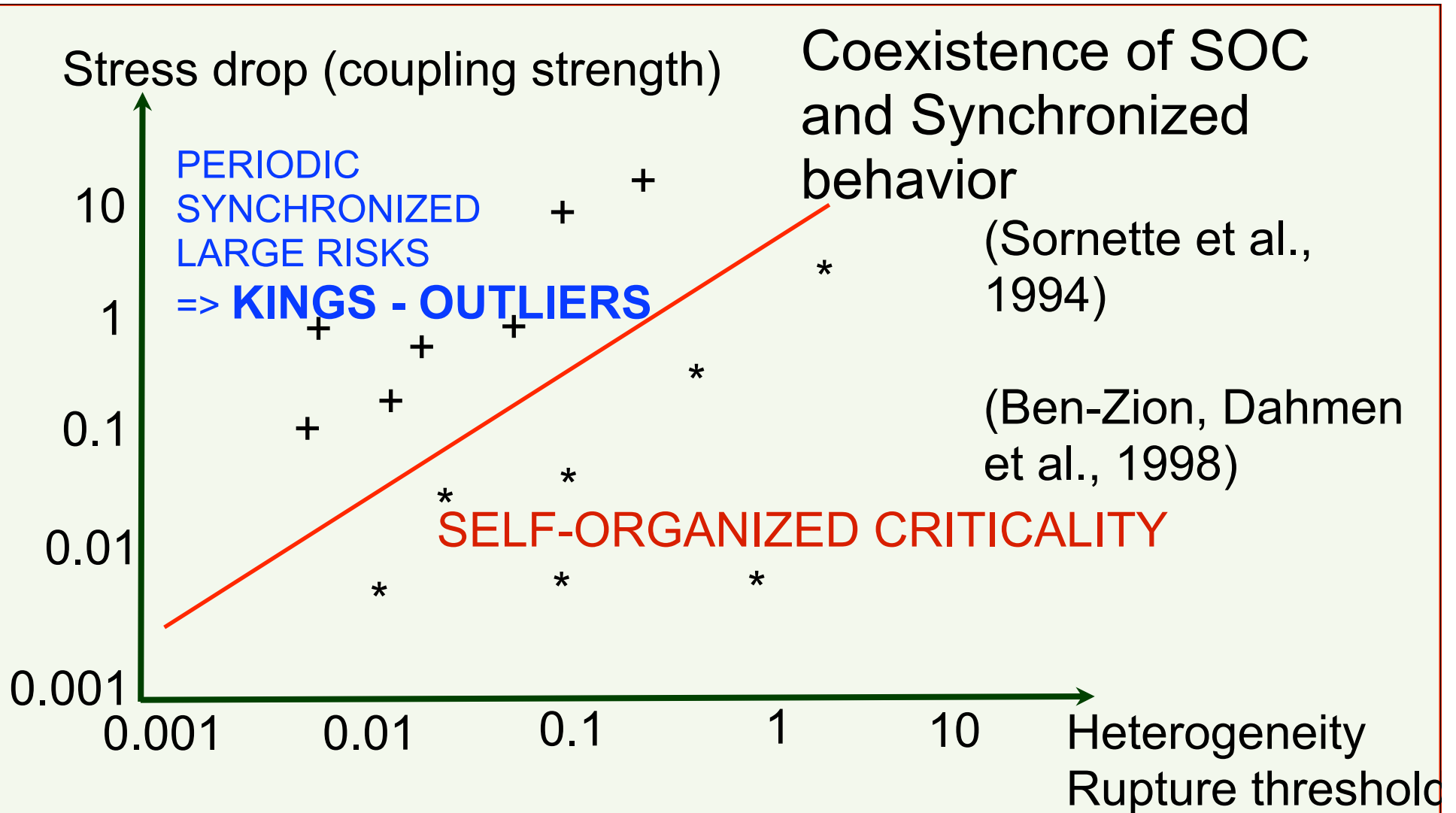
"Phase diagram" for the model in the space (heterogeneity, stress drop).
Crosses (+) correspond to systems which exhibit a periodic time evolution.
Stars * corresponds to systems that are self-organized critical, with a
Gutenberg-Richter earthquake size distribution and fault localization whose
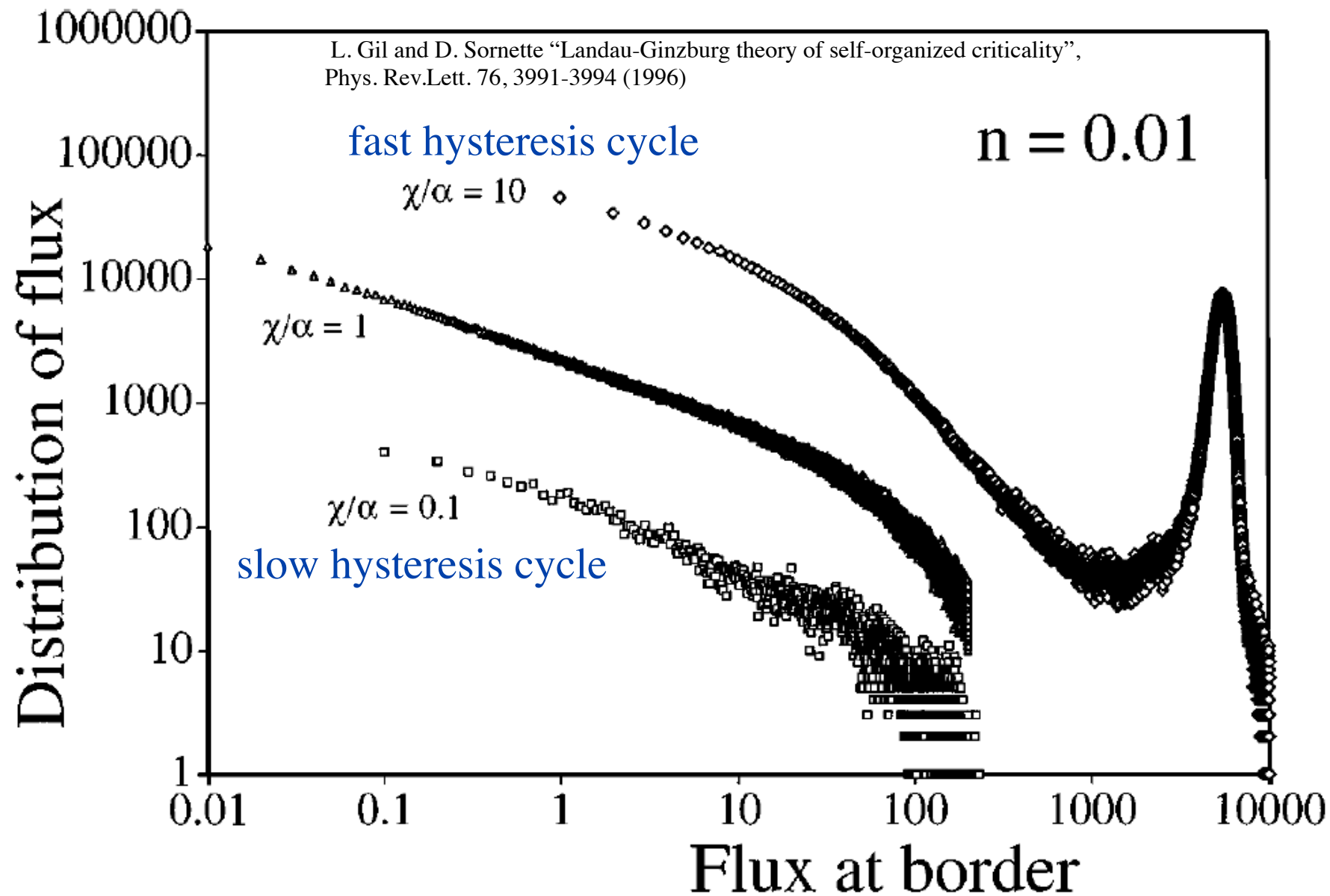geometry is well-described by the geometry of random directed polymers.

FIG. 3. Distribution $P(J)$ of flux amplitudes at the right border, in the same conditions as for Fig. 1.

A 15y History of the 2008- crisis

- The ITC "new economy" bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
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- MBS, CDOs bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008)
- Consequences (deep loss of trust, systemic instability)
- Solutions?

- Fundamental error: "perpetual money machine"

  (overgrowth of the "financial economy" versus the "real economy)

- Encouraging over-spending to solve a crisis due to over-spending?

- Over-pessimism following over-optimism

- Melting the cash-flow freeze (ex: WIR direct network banking in Switzerland (www.wir.ch))

- Long-term growth based on returning to fundamentals (human capital, infrastructure promoting new innovations and growth...)

- Novel opportunities for innovation and Earth sustainability

- Preventing other financial bubbles: a new definition of inflation (Financial Ratio Index (FRI), total fixed assets + working capital, excess supply of money...)

The next 15 years?

Japan is a unique country.
Population and GDP are nearly saturated.
Interest rate is almost 0.
Non-growing economy is already realized.
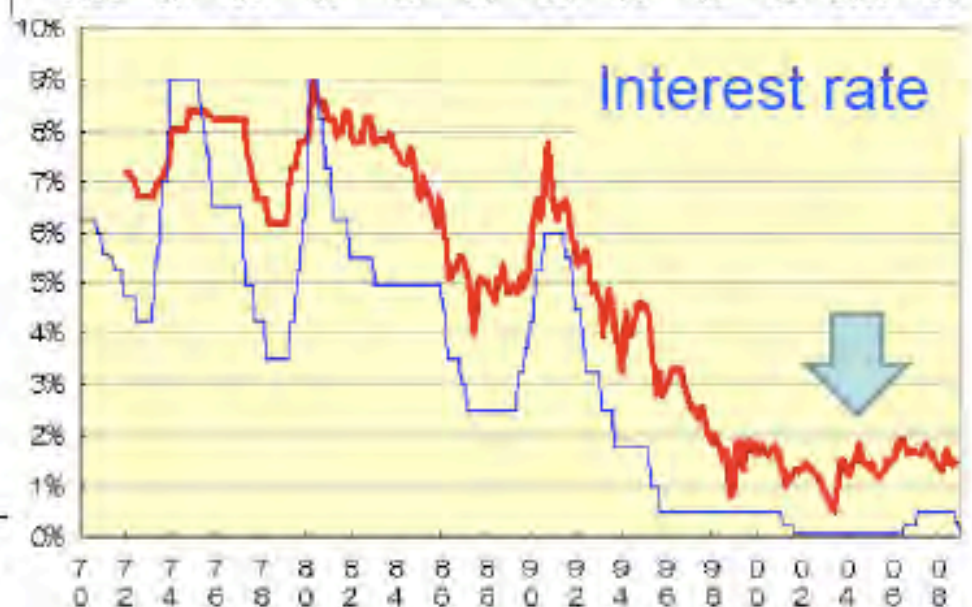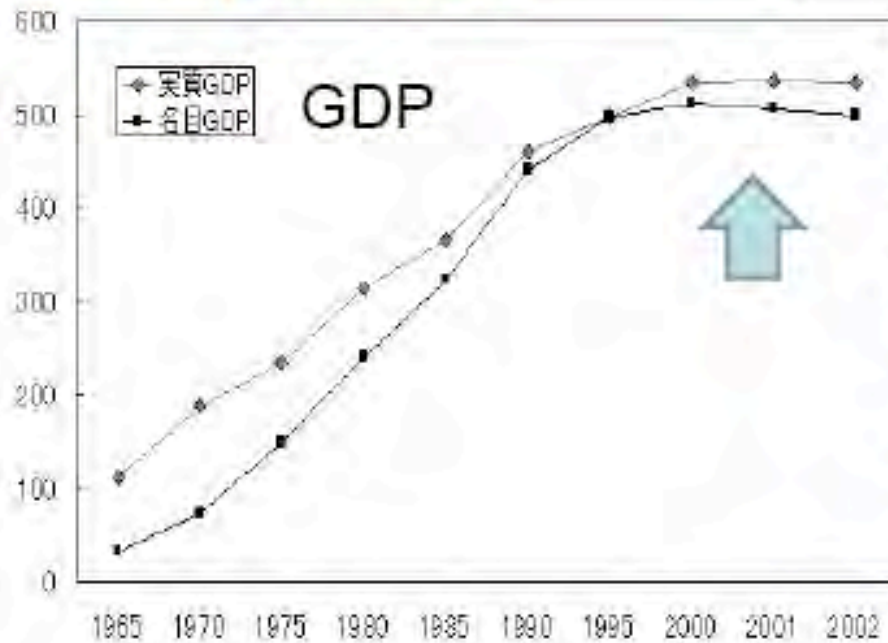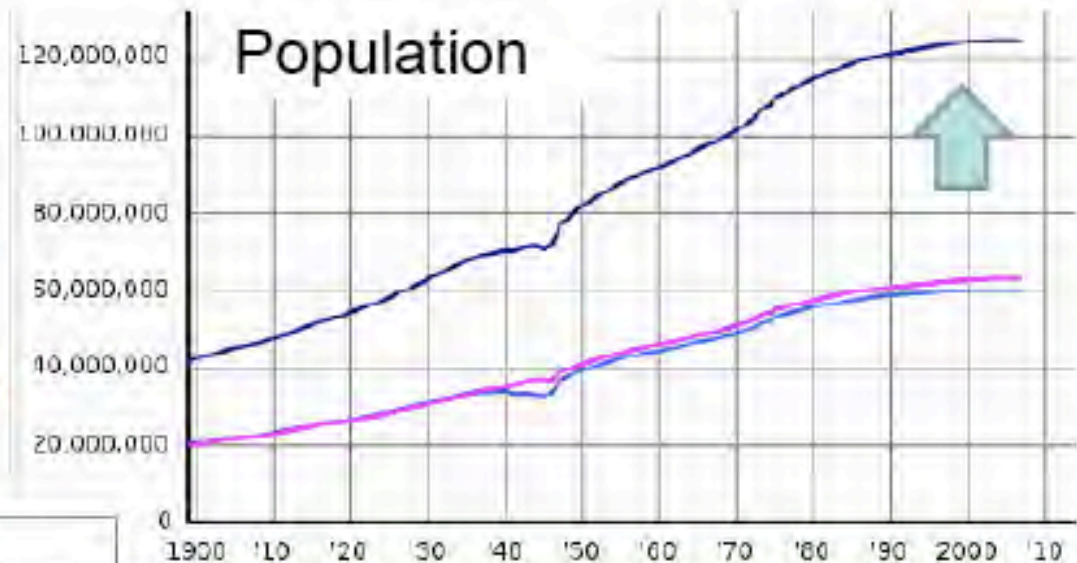
- Intelligence of the crowd: general loss of trust can be restored by removing uncertainty through frank clarification

- Fight moral hazard (ex: clawback permission...)

- Regulations (illusion of control and the law of unintended consequences)

- Development of culture of integrity and ethical behavior (informed by behavioral psychology)

Index price vs. time, Hang Seng

$\times 10^4$

PDF of crash dates, Hang Seng

$\times 10^{-3}$

28 intervals such that
t1 >= 2003-05-29 and
t2 >= 2007-07-08 and
t2 <= 2007-07-15

12 intervals have modeled
crash dates <= 2008-01-15
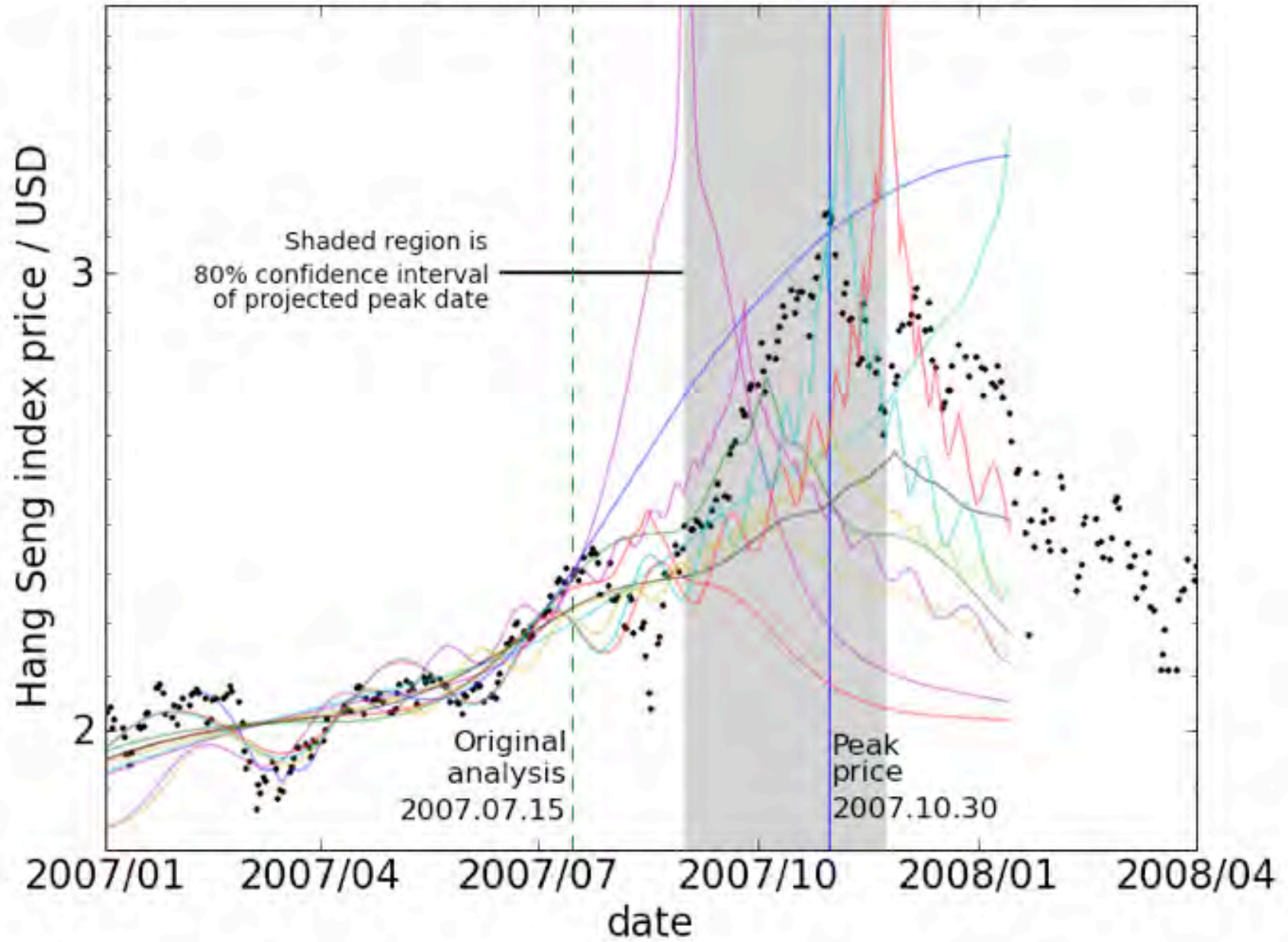(solid line at right)

analysis date (solid line at left):
2007.07.15

actual peak date (dash-dot line):
2007.10.30

tc at max pdf (dashed line):
2007-10-04

median tc (dotted line):
2007-10-01

80-20 quantile range:
2007-08-31 - 2007-11-23

PDF of crash dates

Dec 2006   Jun 2007   Dec 2007   Jun 2008
modeled crash date

Hang Seng index price / USD

2003/12   2004/12   2005/12   2006/12   2007/12   2008/12
date

Source: R. Woodard (FCO, ETH Zurich)

Index price vs. time, Hang Seng

Shaded region is 80% confidence interval of projected peak date

Original analysis 2007.07.15

Peak price 2007.10.30

Source: R. Woodard (FCO, ETH Zurich)

14 factors to propel a market bubble

1. the capitalist explosion and the ownership society,
2. cultural and political changes favoring business success,
3. new information technology,
4. supportive monetary policy and the Greenspan put,
5. the baby boom and their perceived effects on the markets,
6. an expansion in media reporting of business news,
7. analysts' optimistic forecasts,
8. the expansion of defined contribution pension plans,
9. the growth of mutual funds,
10. the decline of inflation and the effects of money illusion,
11. the expansion of the volume of trade due to discount brokers,
12. day traders,
13. twenty-four-hour trading,
14. the rise of gambling opportunities.

Why bubbles are not arbitraged away?

1. limits to arbitrage caused by noise traders (DeLong et, 1990)
2. limits to arbitrage caused by synchronization risk (Abreu and Brunnermeier, 2002 and 2003)
3. short-sale constraints (many papers)
4. lack of close substitutes for hedging (many papers)
5. heterogenous beliefs (many papers)
6. lack of higher-order mutual knowledge (Allen, Morris and Postlewaite, 1993)
7. delegated investments (Allen and Gorton, 1993)
8. psychological biases (observed in many experiments)
9. positive feedback bubbles