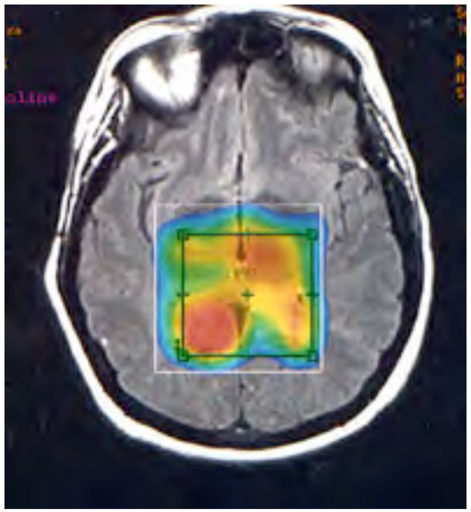
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

ETH RISK CENTER

Entrepreneurial Risks

Dragon-kings and Predictions

Diagnostics and Forecasts for the World Financial Crisis



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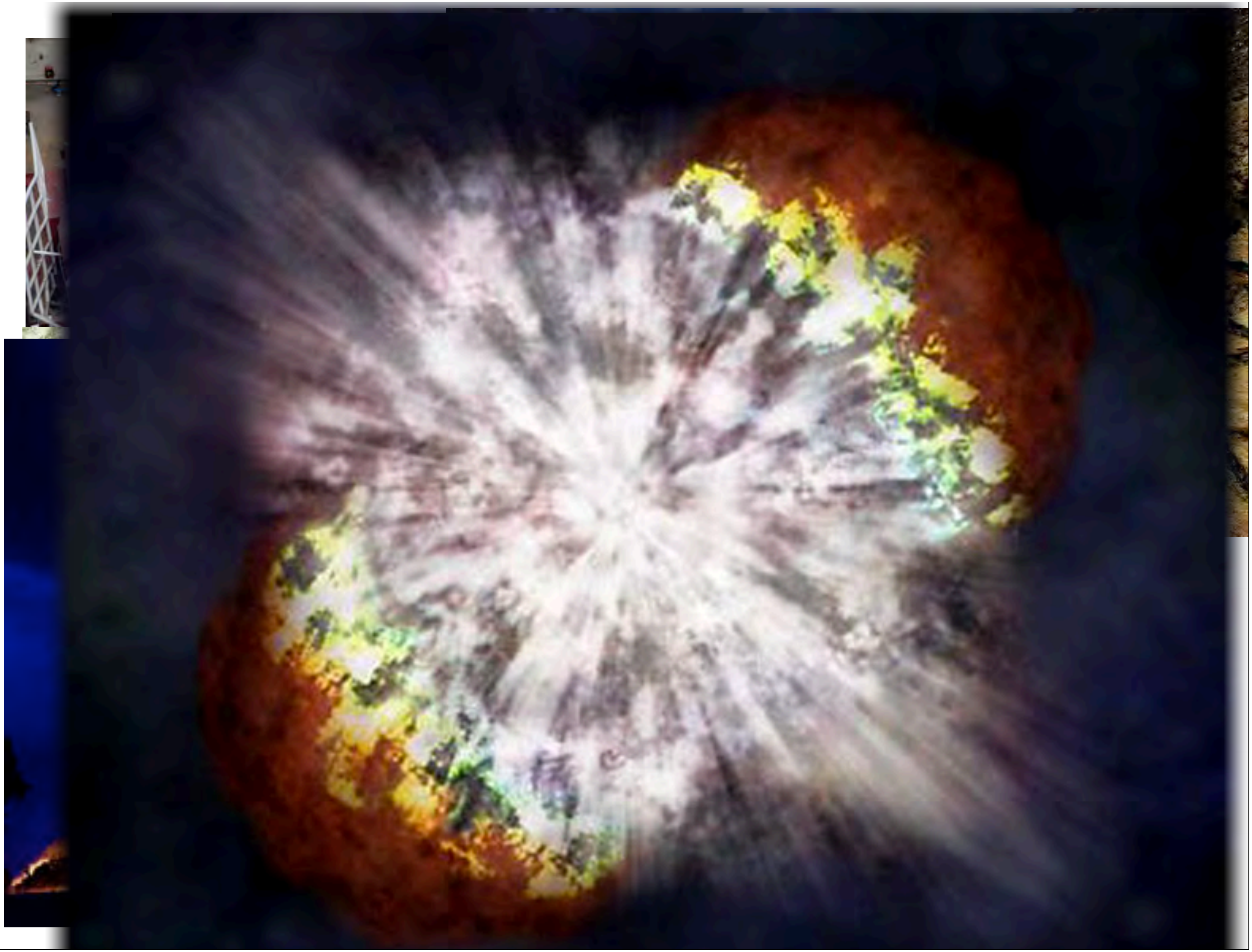
www.er.ethz.ch




risk
Pension

Extreme events are epoch changing

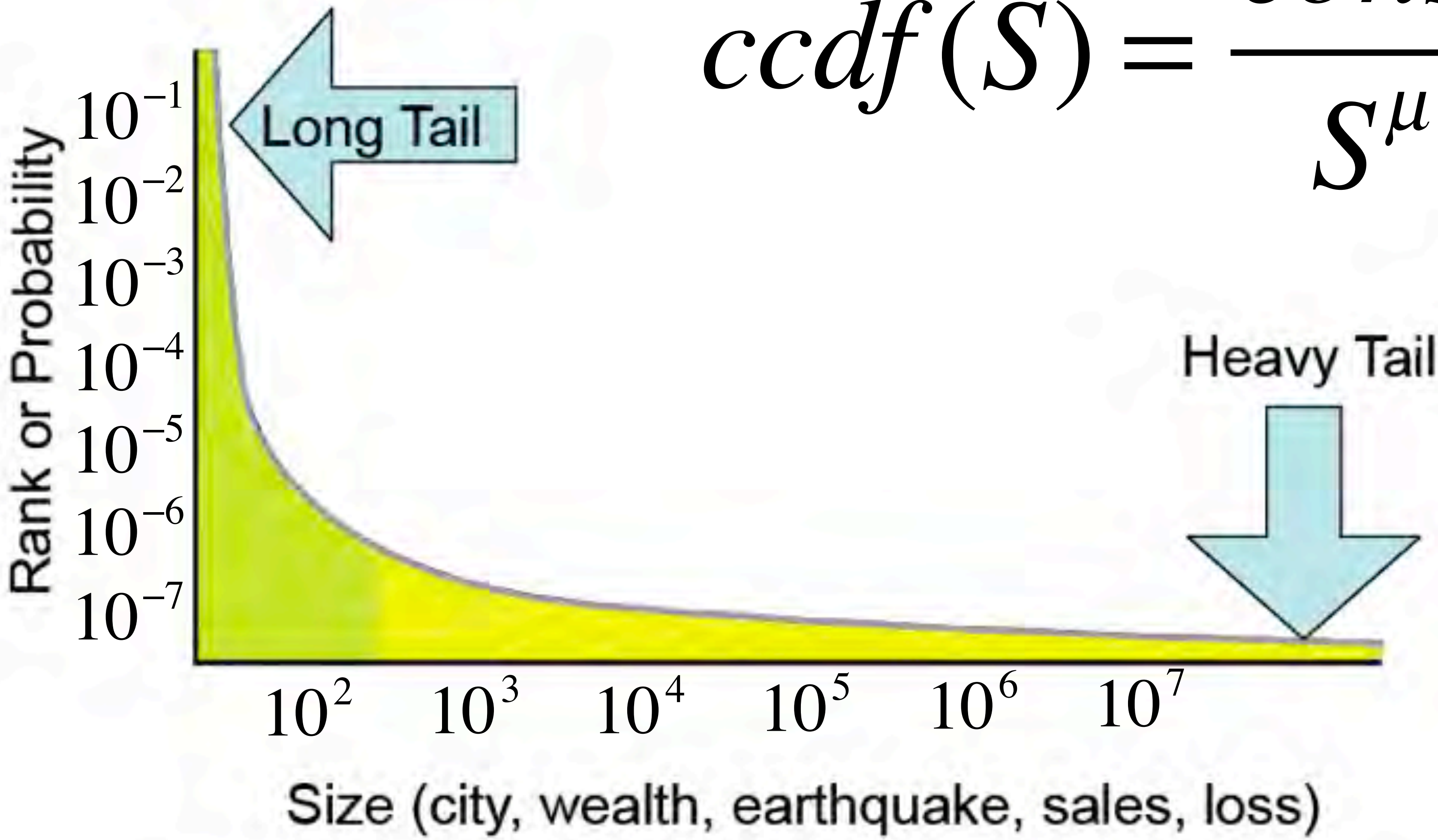
in the physical structure and in the mental spaces

- Droughts and the collapse of the Mayas (760-930 CE)... and many others... (J. Diamond, Collapse, 2005)
- French revolution (1789) and the formation of Nation states + intensity of wars (C. Warren, L.-E. Cederman and D. Sornette, Testing Clausewitz: Nationalism, Mass Mobilization, and the Severity of War, International Organization, 2011)
- Great depression and Glass-Steagall act
- Crash of 19 Oct. 1987 and volatility smile (crash risk) (D. MacKenzie, An Engine, Not a Camera, 2006)
- Enron and Worldcom accounting scandals and Sarbanes-Oxley act (2002)
- Great Recession 2007-2009: Dodd-Frank act
- European sovereign debt crisis: Europe or collapse?

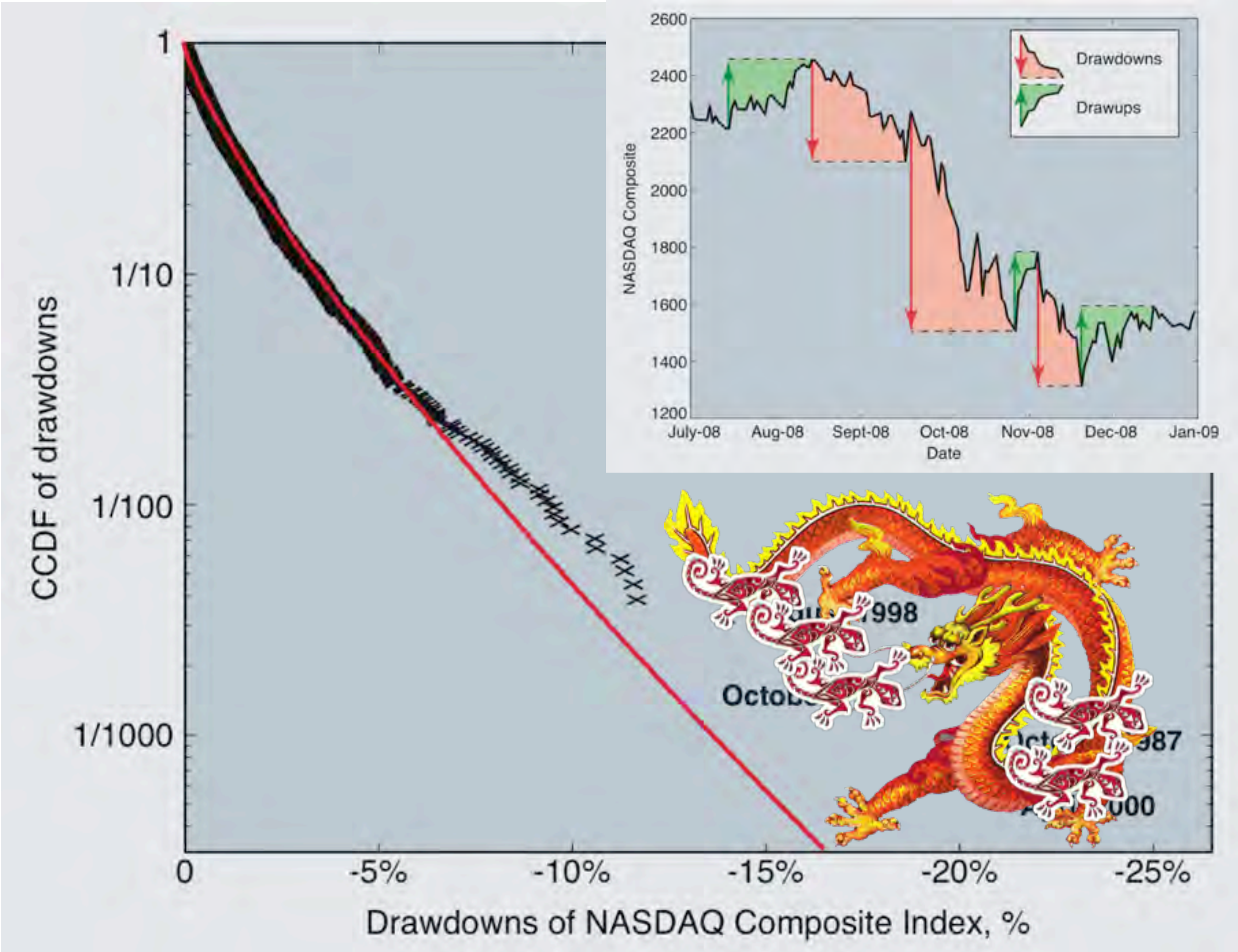
earthquakes
BLACKSWAN
runaway
precursors
MODELING
selforganization
NEURONS
falls
EVIDENCE
coherencepotentials
DEVIATIONS
MODELING
WORLDDEMOGRAPHY
deviations
EPILEPSY
populationdynamics
DRAWDOWN
EVIDENCE
brain
EXTREME
earthquakes
epilepsy
crisis
STATISTICS
citation
MECHANISMS
balancing
SYNAPSES
PHASETRANSITION
FINANCE
FRACTURE
ECONOMICS
RUPTURE
mechanisms
DISTRIBUTIONS
VOLCANOES
failure
COMPETITION
EXTREME
catastrophe
earthquakes
EVIDENCE
RAINFALL
DROPLETS
HURRICANE
STATISTICS
avalanches
MECHANISMS
STORM
forecasting
OUTLIER
agents
wildfires
modeling
DEVIATIONS
CRITICALITY
LANDSLIDES
RANDOMNESS
materials
POWERLAWS
fracture
FLOODS

Standard view: fat tails, heavy tails and Power law distributions

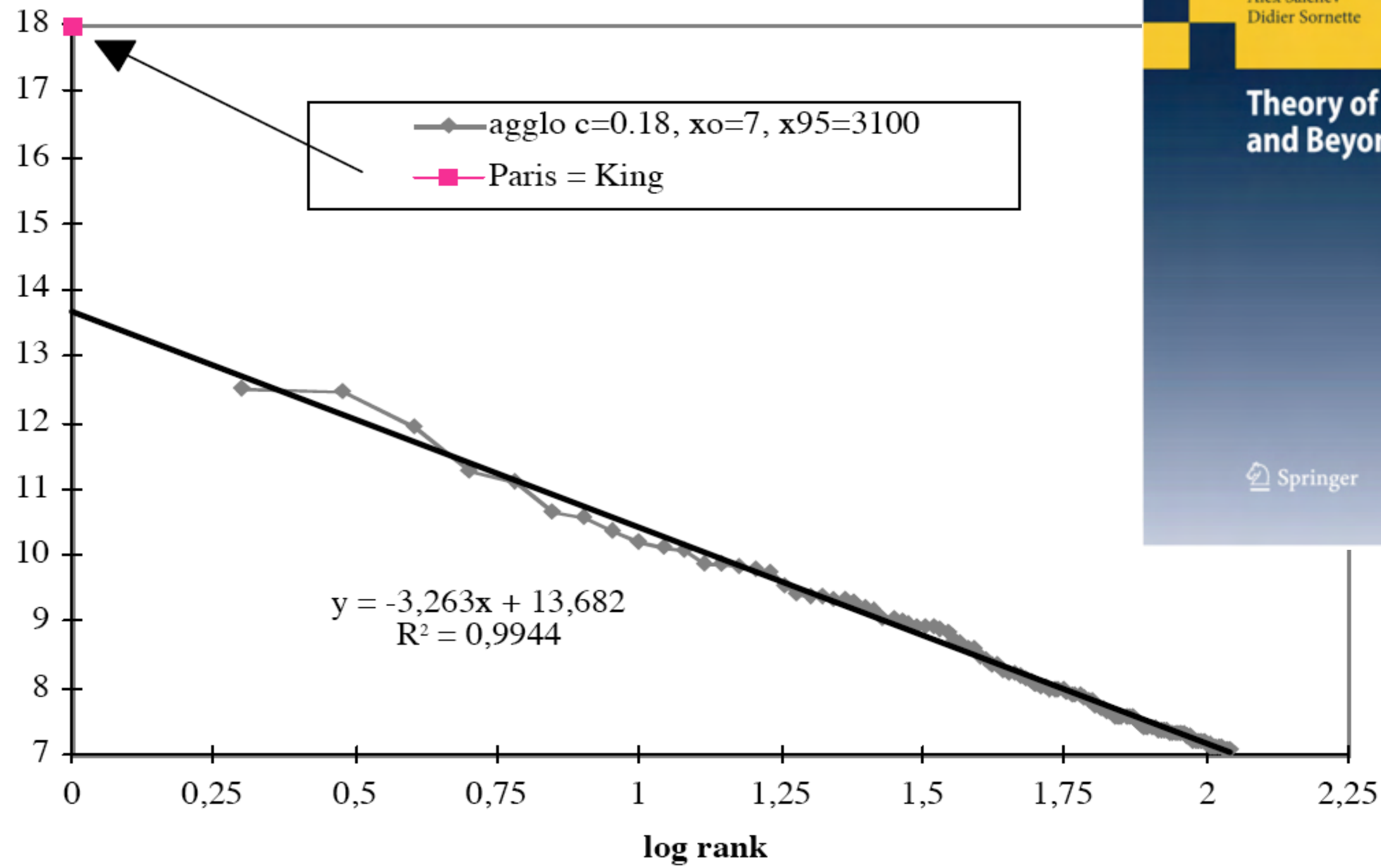
$$ccdf(S) = \frac{const}{S^{\mu}}$$



Most extremes are dragon-kings



Paris as a dragon-king



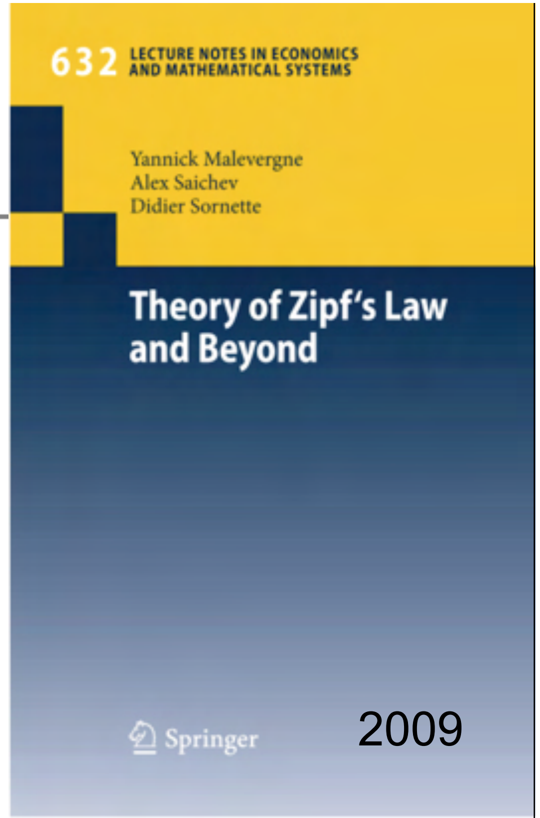
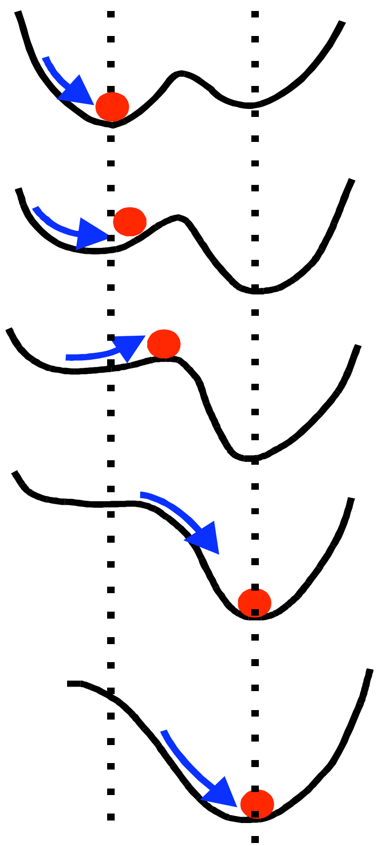


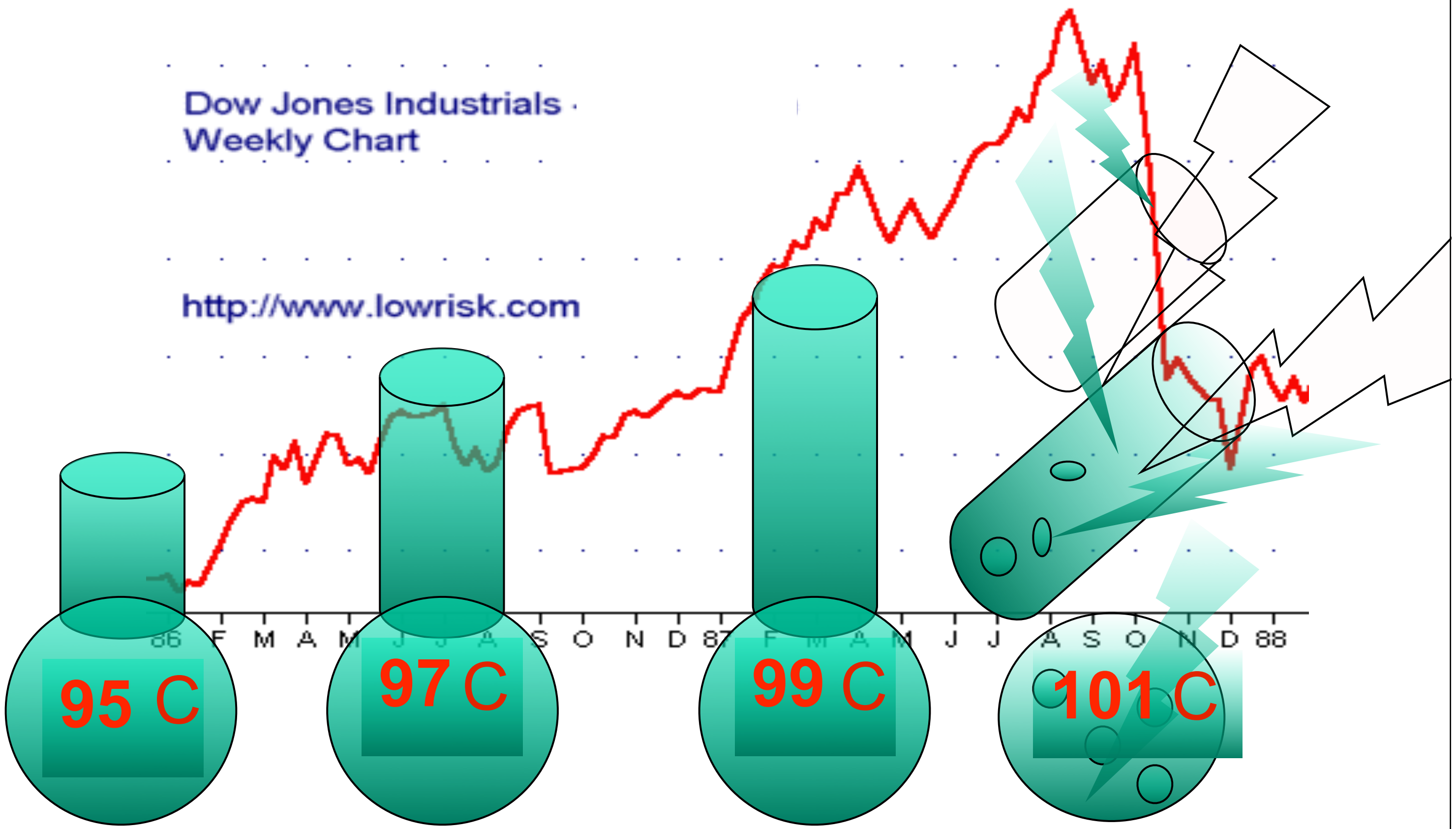
Fig. 7. French agglomerations: stretched exponential and "King effect".

Jean Laherrere and Didier Sornette, Stretched exponential distributions in Nature and Economy: ``Fat tails'' with characteristic scales, European Physical Journal B 2, 525-539 (1998)

Dragon-kings results from maturation towards an instability

Instead of
Water Level:
-economic index
(Dow-Jones etc…)





Crash = result of collective behavior of individual traders

(Sorin Solomon)

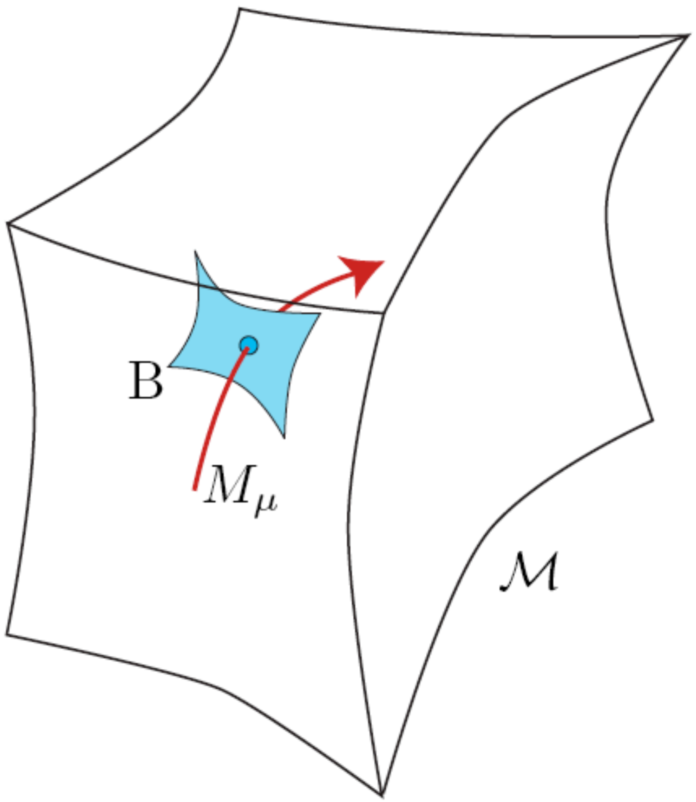
Fundamental reduction theorem

Genetically, close to a regime transition, a system bifurcates through the variation of a SINGLE (or a few) effective "control" parameter

Bifurcation: Qualitative change in behavior
as parameter is (slowly) varied
Bifurcation surface: B

Strategy 1: understand from proximity to a reference point as a function of a small parameter

Strategy 2: a few universal "normal forms"



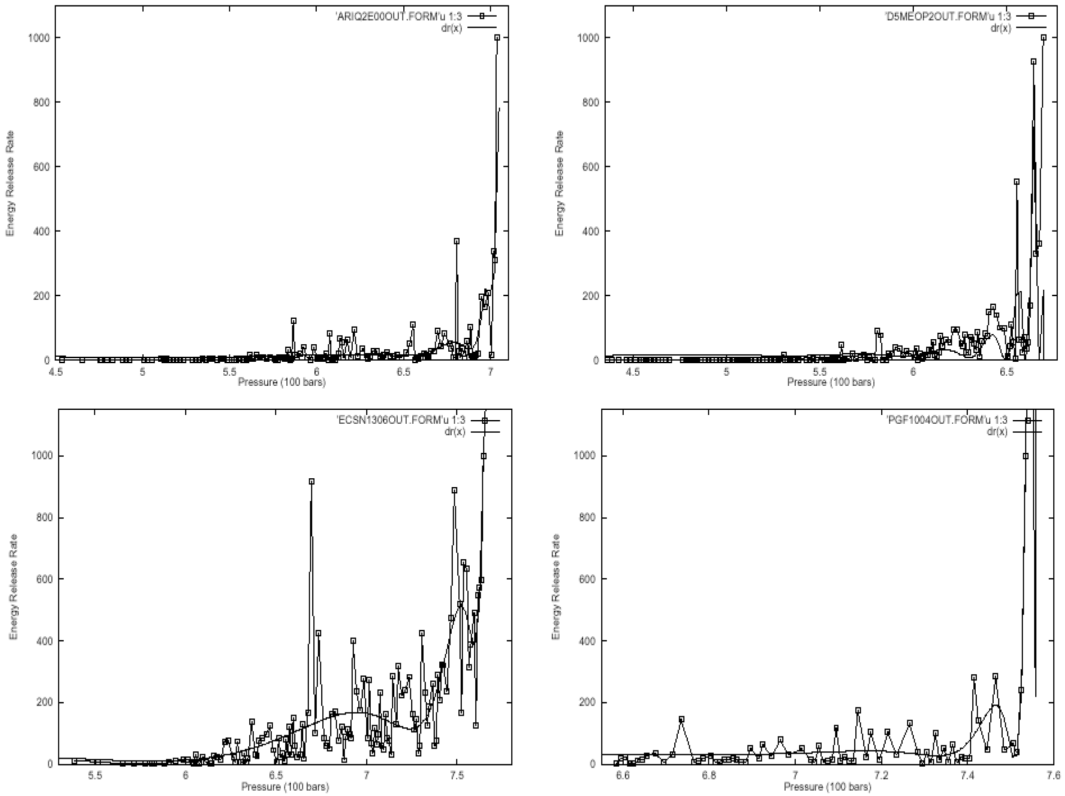
Space of all dynamical systems: $\mathcal{M}$
a particular dynamical system: $M \in \mathcal{M}$

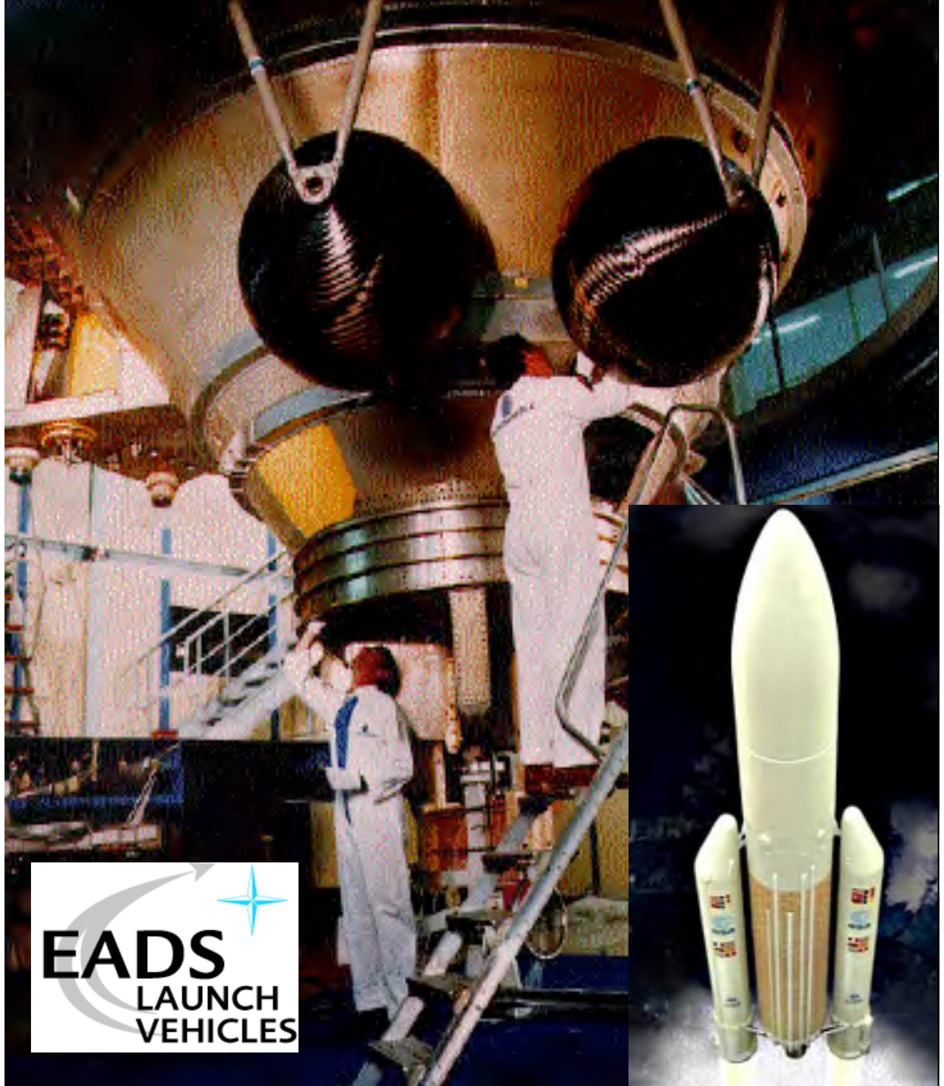
Signs of Upcoming Transition

Early warning signals as predicted from theory

- Slower recovery from perturbations
- Increasing (or decreasing) autocorrelation
- Increasing (or decreasing) cross-correlation with external driving
- Increasing variance
- Flickering and stochastic resonance
- Increased spatial coherence
- **Degree of endogeneity/reflexivity**
- **Finite-time singularities**

Diagnostic of Ariane rocket pressure tanks

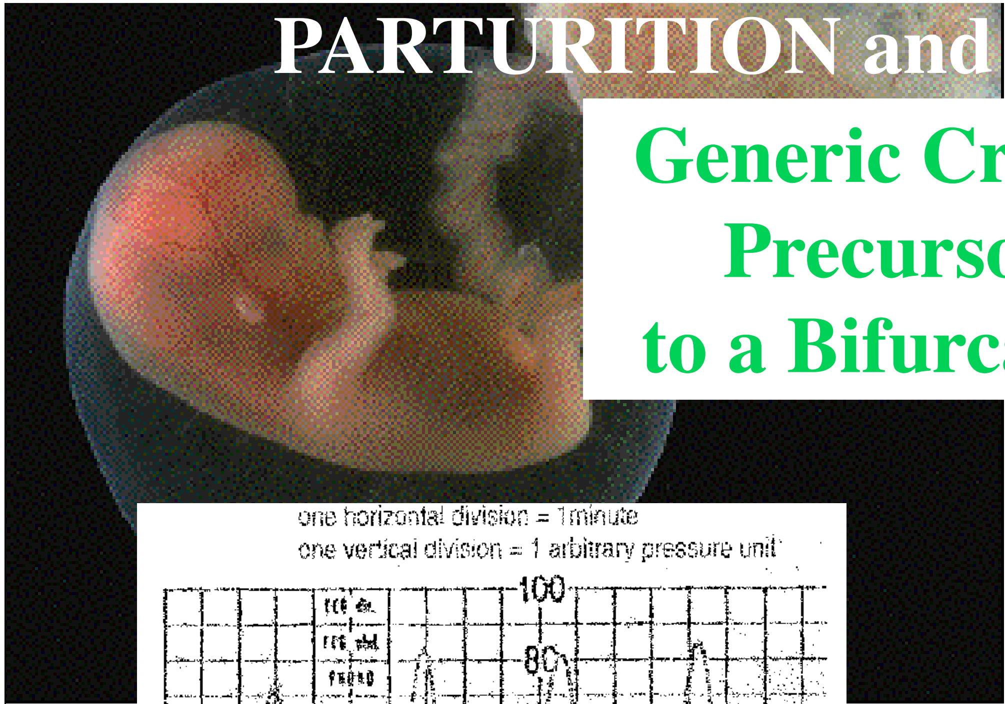




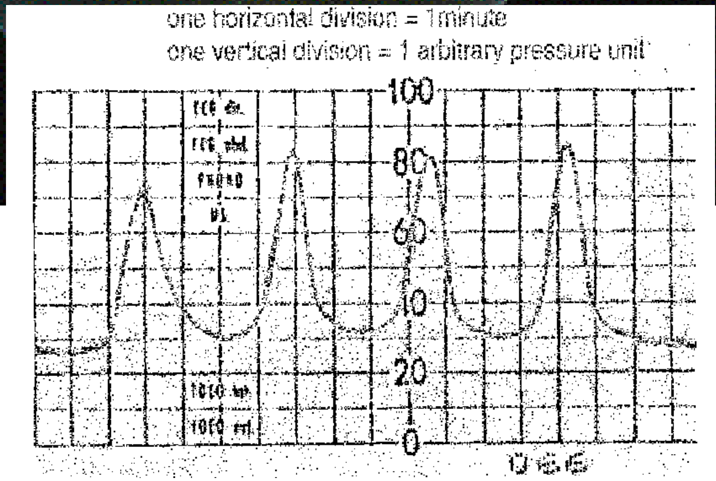
- Increasing variance
- Increased spatial coherence
- Finite-time singularity

Our prediction system is now used in the industrial phase as the standard testing procedure.

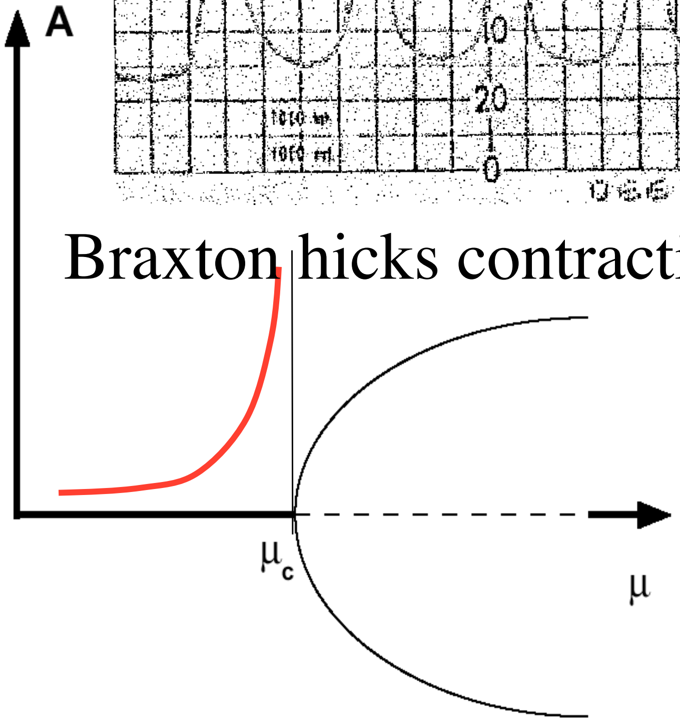
PARTURITION and EPILEPTIC SEIZURES



Generic Critical Precursors to a Bifurcation



Braxton hicks contractions



-Amplitude of fluctuations

-Response to external forcing

Beyond power laws: 8 examples of "Dragons"

Financial economics: Outliers and dragons in the distribution of financial drawdowns.

Population geography: Paris as the dragon-king in the Zipf distribution of French city sizes.

Material science: failure and rupture processes.

Hydrodynamics: Extreme dragon events in the pdf of turbulent velocity fluctuations.

Metastable states in random media: Self-organized critical random directed polymers

Brain medicine: Epileptic seizures

Geophysics: Characteristic earthquakes? Great avalanches? Floods? Mountain collapses? Meteological events? and so on

Ionosphere and magneto-hydrodynamics: Global auroral energy deposition

Extreme Risks: Dragon-Kings versus Black Swans

1. Geosciences of the solid envelop
   1.1. Earthquake magnitude.
   1.2. Volcanic eruptions.
   1.3. Landslides.
   1.4. Floods.

2. Meteorological and Climate sciences
   2.1. Rains, hurricanes, storms.
   2.2. Snow avalanches.

3. Material Sciences and Mechanical Engineering
   3.1. Acoustic emissions.
   3.2. Hydrodynamic turbulence.

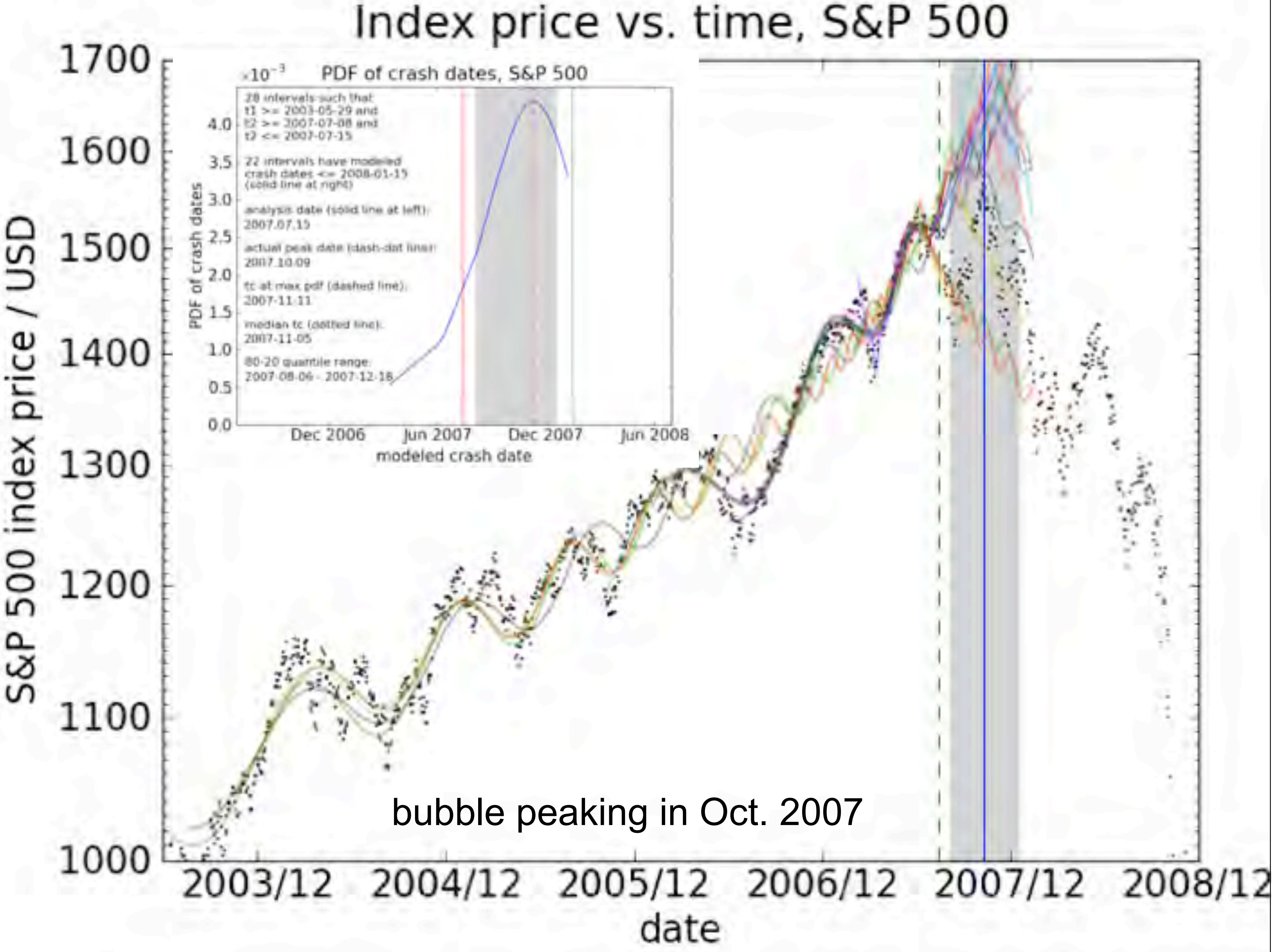
4. Economics : financial drawdowns, distribution of wealth

5. Social sciences: distribution of firm sizes, of city sizes, of social groups...

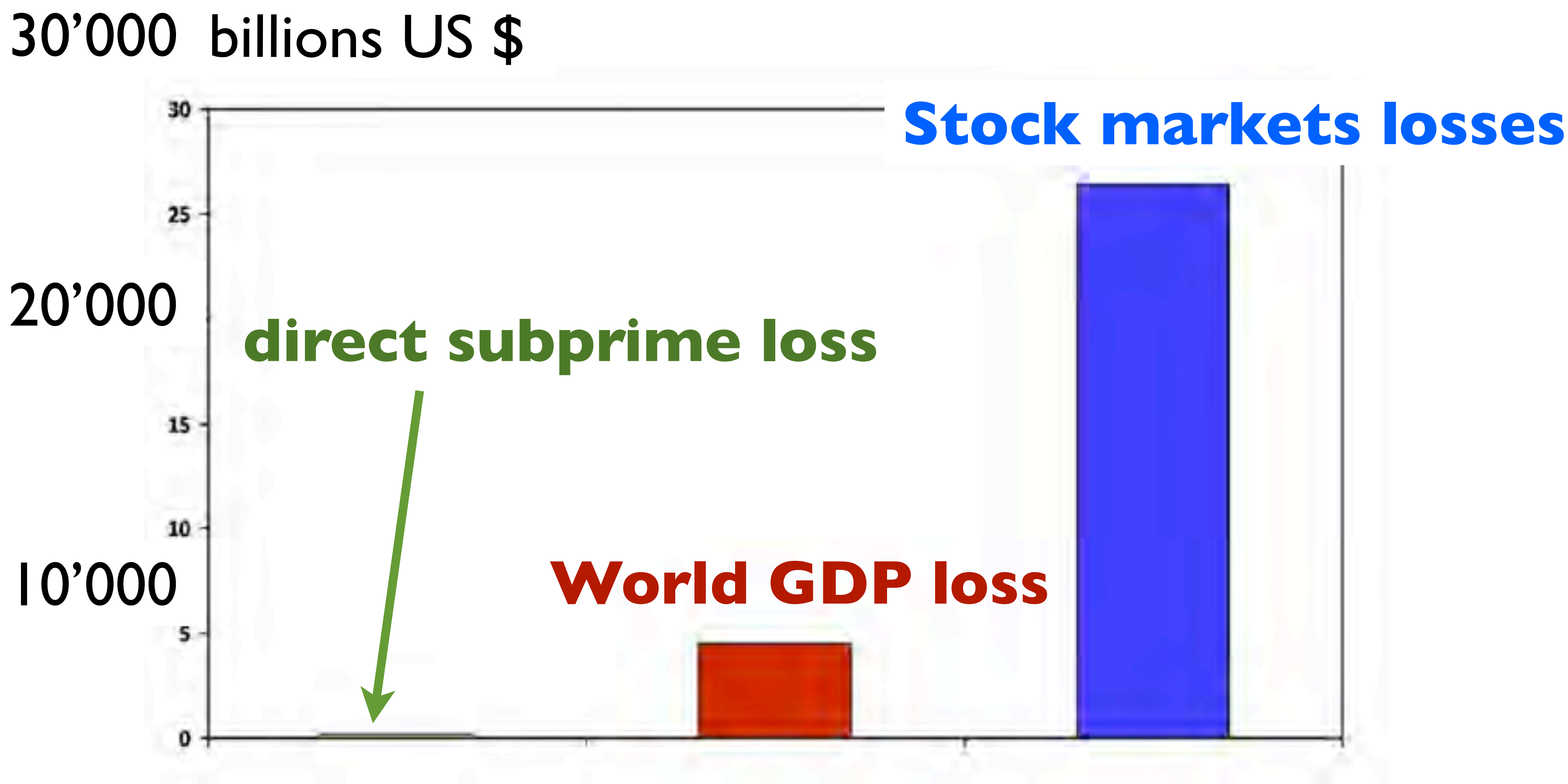
6. Social sciences : wars, strikes, revolutions, city sizes

7. Medicine: epileptic seizures, epidemics

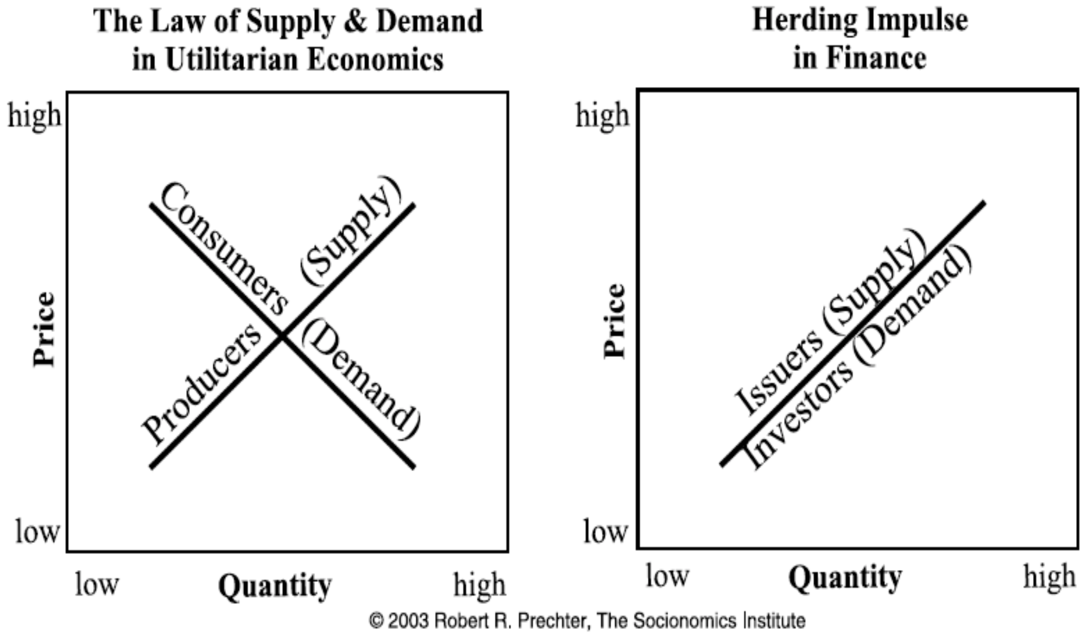
8. Environmental sciences : extinctions of species, forest fires
   8.1. Evolution and extinction of species.
   8.2. Forest fires.


Index price vs. time, S&P 500
S&P 500 index price / USD
1700
1600
1500
1400
1300
1200
1100
1000
2003/12
2004/12
2005/12
2006/12
2007/12
2008/12
date
PDF of crash dates, S&P 500
×10⁻³
PDF of crash dates
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
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
Dec 2006
Jun 2007
Dec 2007
Jun 2008
modeled crash date
bubble peaking in Oct. 2007

THE GREAT RECESSION
(2008-2009)



Positive feedbacks



-bubble phase
-crash phase

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

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

$$m = 1/(d-1) > 0 \text{ and } t_c = t_0 + m p_0^{1-d}/c.$$

positive feedback of increasing return

=> growth of the return (and not just of the price)

=> Faster-than-exponential transient unsustainable growth of price

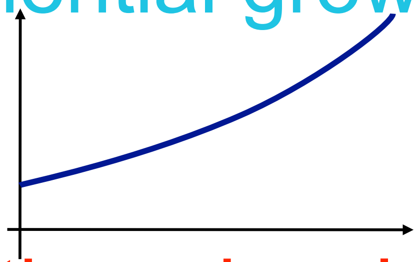
=> Mathematically, this translates into FINITE-TIME SINGULARITY

Growth Processes

$$\frac{dp}{dt} \sim p(t)^{1+\delta}$$

- exponential growth

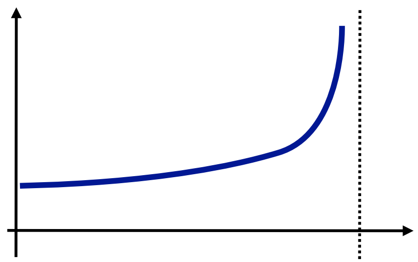
$\delta = 0$



$$p(t) \sim e^t$$

- finite-time singularity

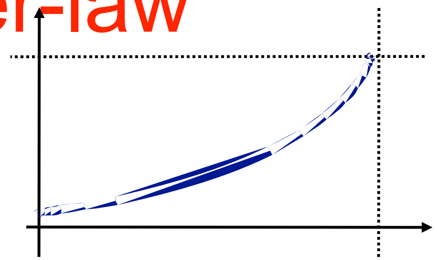
$\delta > 0$



$$p(t) \sim \frac{1}{(t_c - t)^{1/\delta}}$$

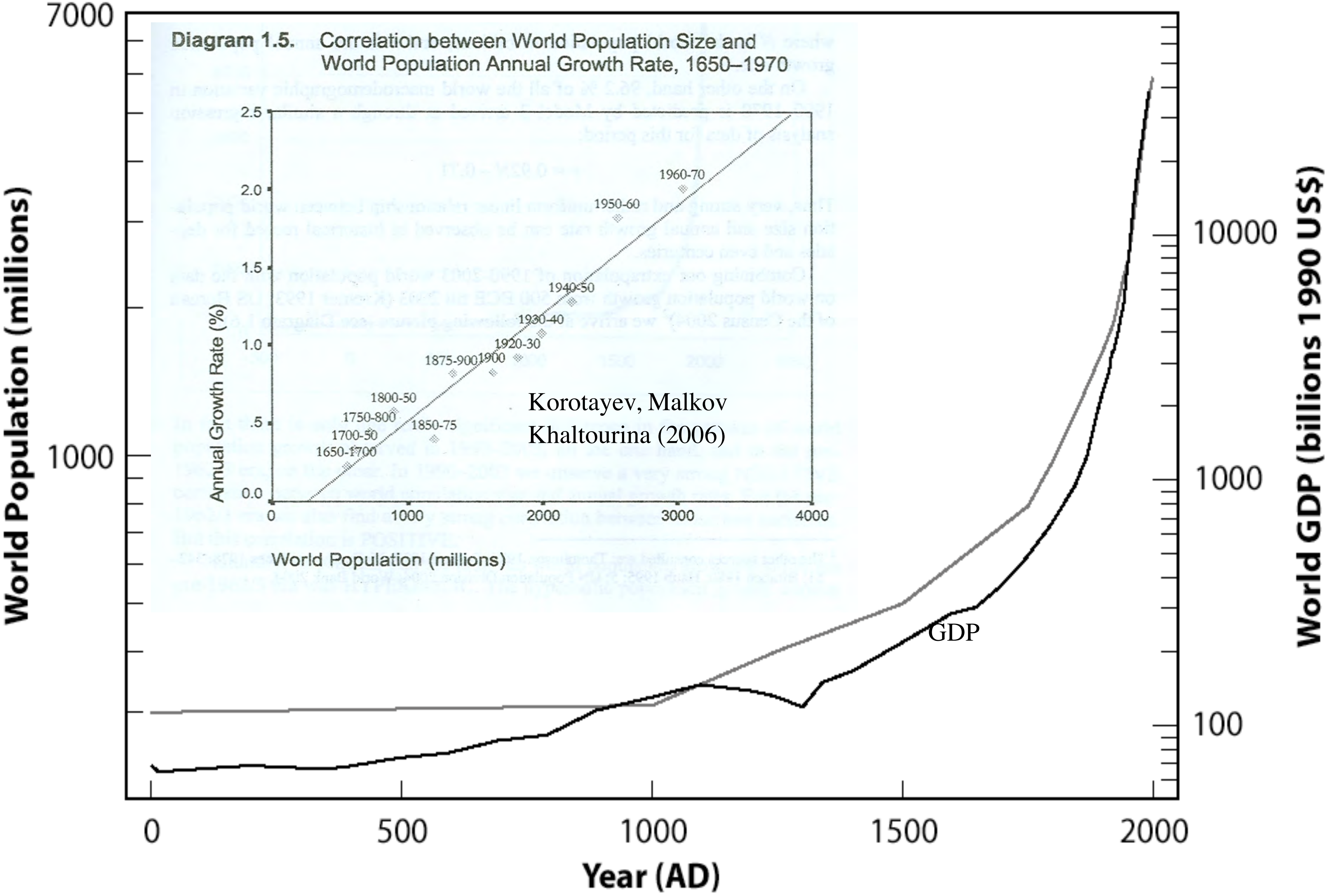
- power-law

$\delta < 0$



$$p(t) \sim t^{1/|\delta|}$$

Super-exponential growth (positive feedbacks)

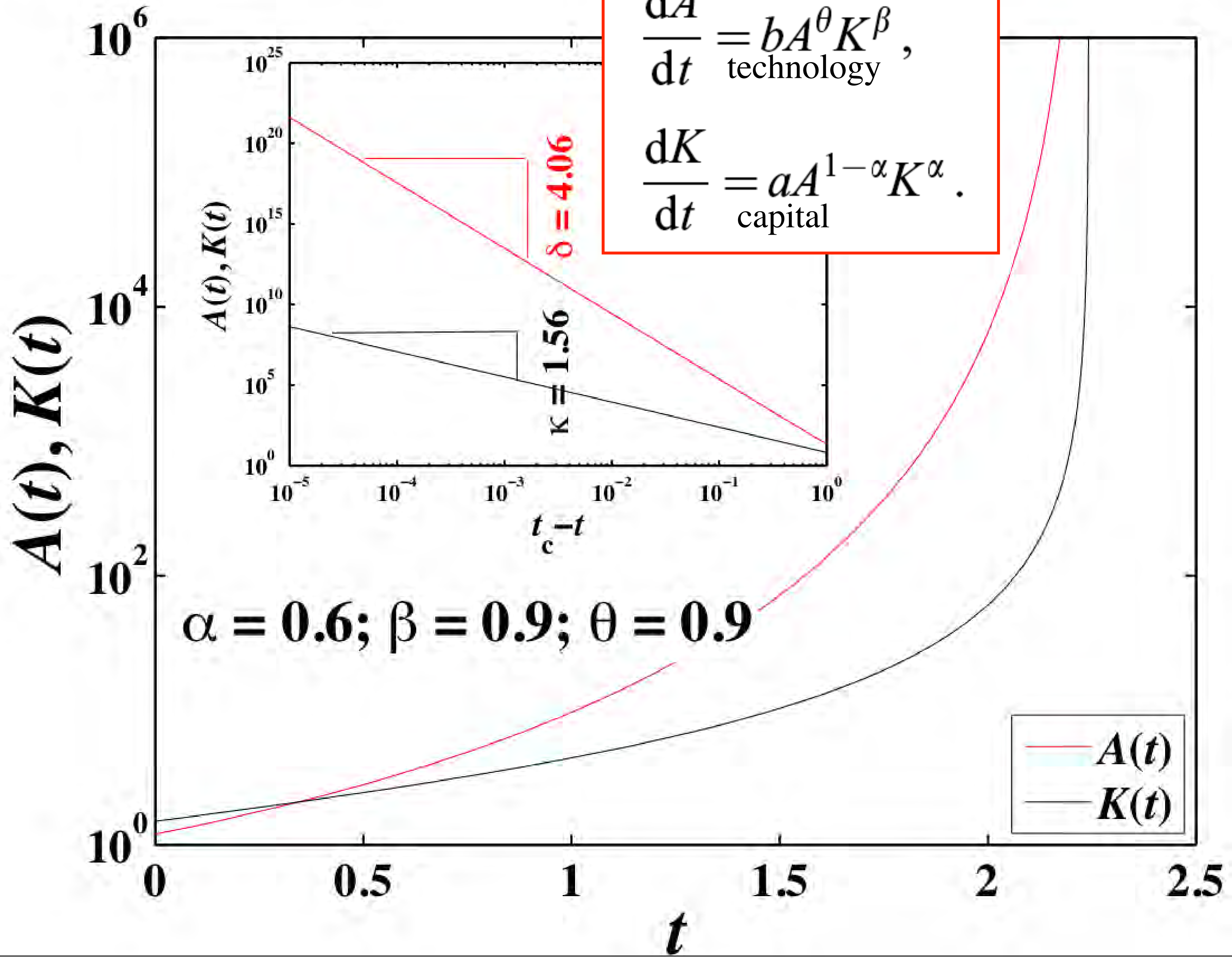


Multivariate endogeneous growth models and FTS

Case θ+β>1 : FTS

$$\frac{dA}{dt} = \underbrace{bA^{\theta}K^{\beta}}_{\text{technology}},$$

$$\frac{dK}{dt} = \underbrace{aA^{1-\alpha}K^{\alpha}}_{\text{capital}}.$$



Mechanisms for positive feedbacks in the stock market

- Technical and rational mechanisms
  1. Option hedging
  2. Insurance portfolio strategies
  3. Market makers bid-ask spread in response to past volatility
  4. Learning of business networks, human capital
  5. Procyclical financing of firms by banks (boom vs contracting times)
  6. Trend following investment strategies
  7. Algorithmic trading
  8. Asymmetric information on hedging strategies
  9. Stop-loss orders
  10. Portfolio execution optimization and order splitting
  11. Deregulation (Grimm act repelling the Glass-Steagal act)

- 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)
  3. "Social Proof" mechanism

Collective behavioral phenomena

Imitation

Imitation

Informational cascades

"Well, heck! If all you smart cookies agree, who am I to dissent?"

THE JOURNAL OF FINANCE • VOL. LX, NO. 6 • DECEMBER 2005

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*

ABSTRACT

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.

IN THIS PAPER, WE EXPLORE THE HYPOTHESIS that investors spread information and ideas about stocks to one another directly, through word-of-mouth communication. This hypothesis comes up frequently in informal accounts of the behavior of the stock market.[1] For example, in his bestseller *Irrational Exuberance*, Shiller (2000) devotes an entire chapter to the subject of "Herd Behavior and Epidemics," and writes

> 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)

Humans Appear Hardwired To Learn By 'Over-Imitatio

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

Universal Bubble and Crash Scenario

Displacement

↓

Credit creation

↓

Euphoria

↓

Critical stage / Financial distress

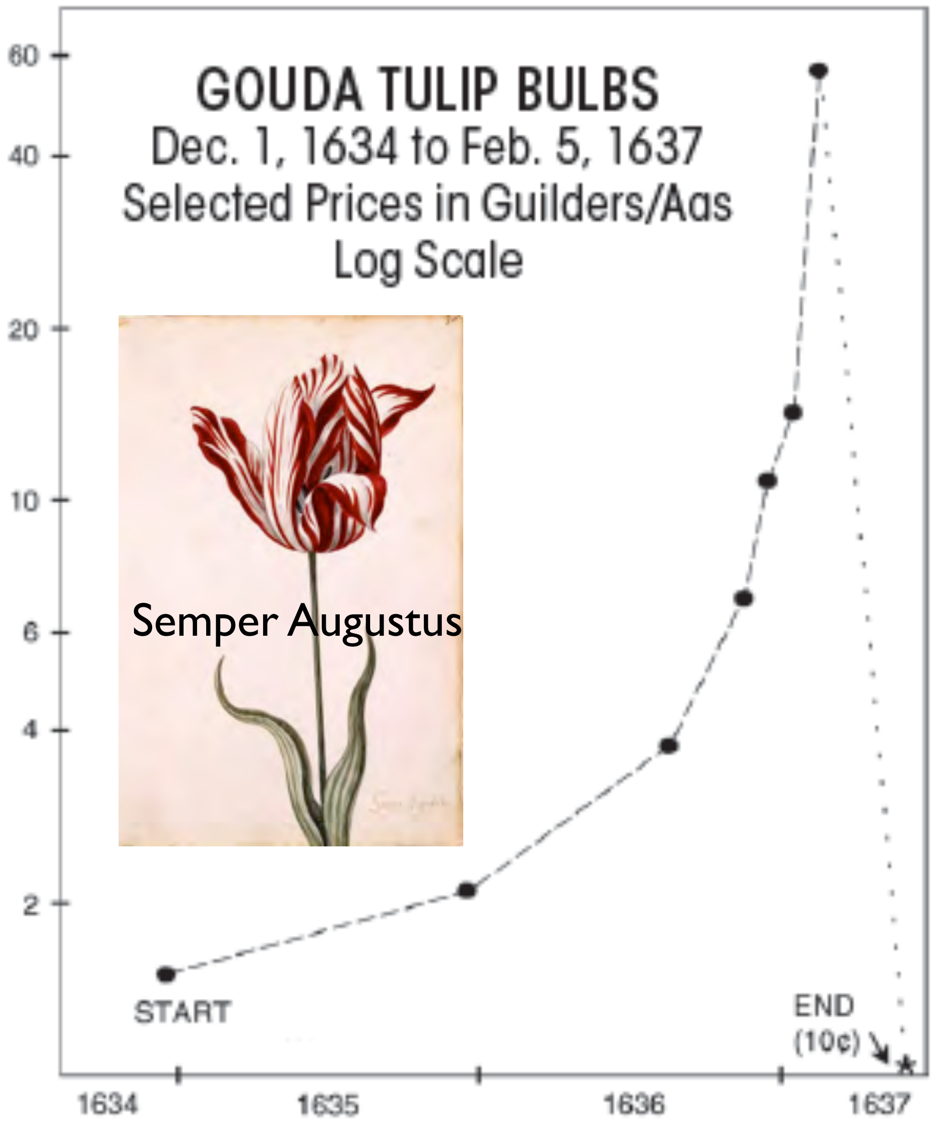
↓

Revulsion

Charles Kindleberger, Manias, Panics and Crashes (1978)

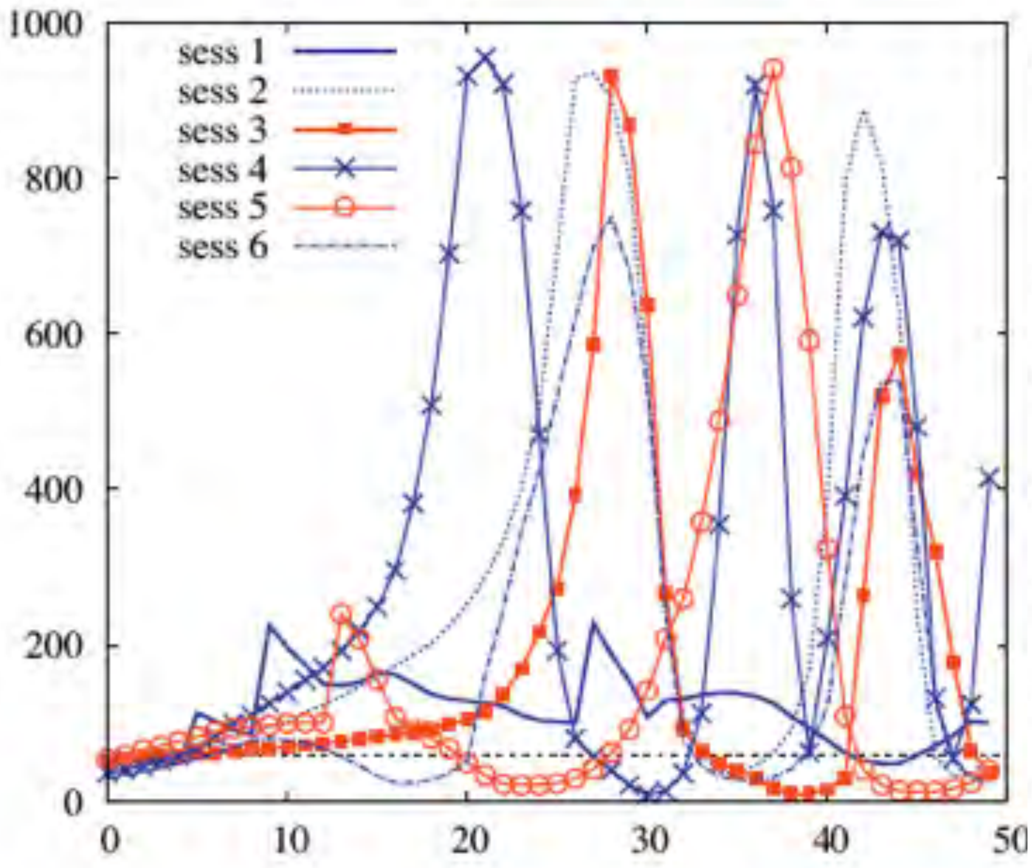
Didier Sornette, Why stock markets crash (2003)

Famous historical bubbles



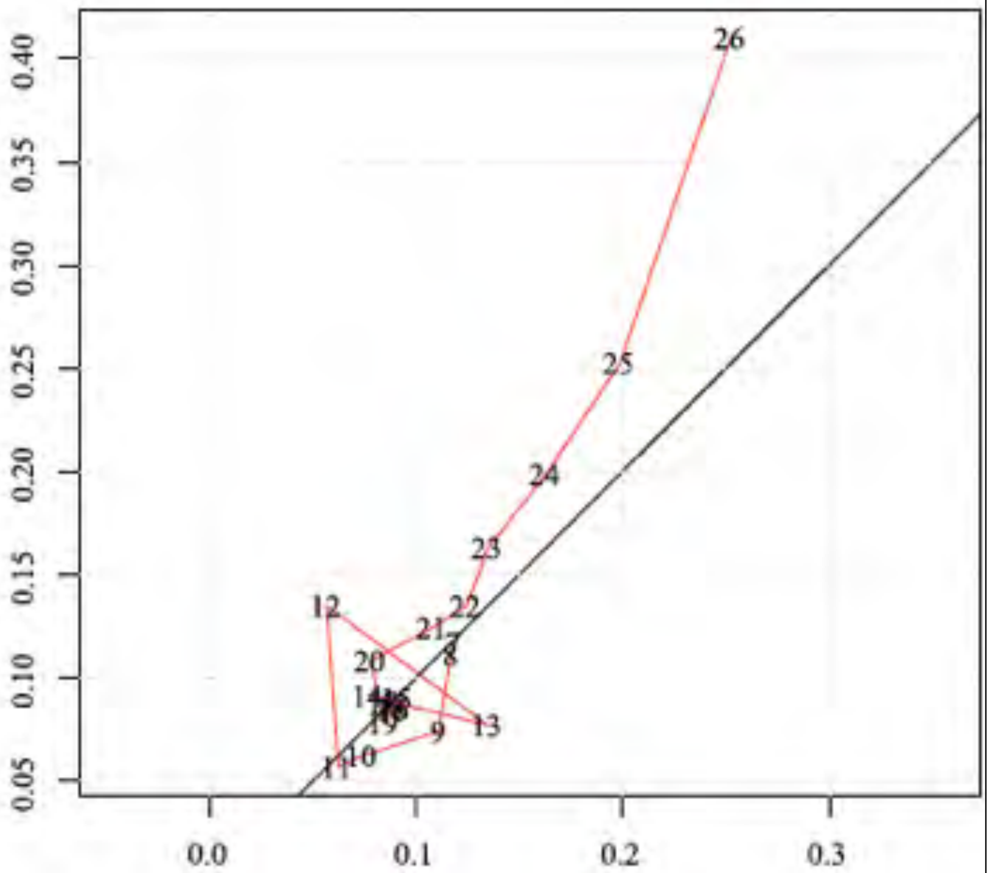
Source: Elliott Wave International; data source for South Seas, Global Financial Data

Positive feedbacks and origin of bubbles



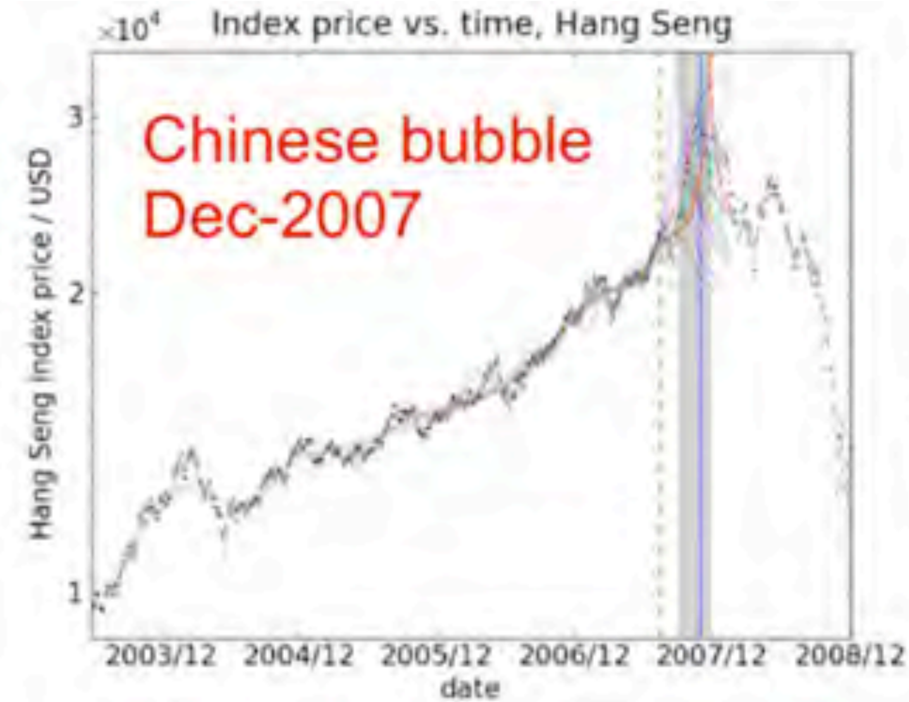
Prices in the learning-to-forecast market experiments (Hommes et al., 2008).
Five out of six markets exhibit long lasting bubbles with asset prices increasing to more than 15 times fundamental value.

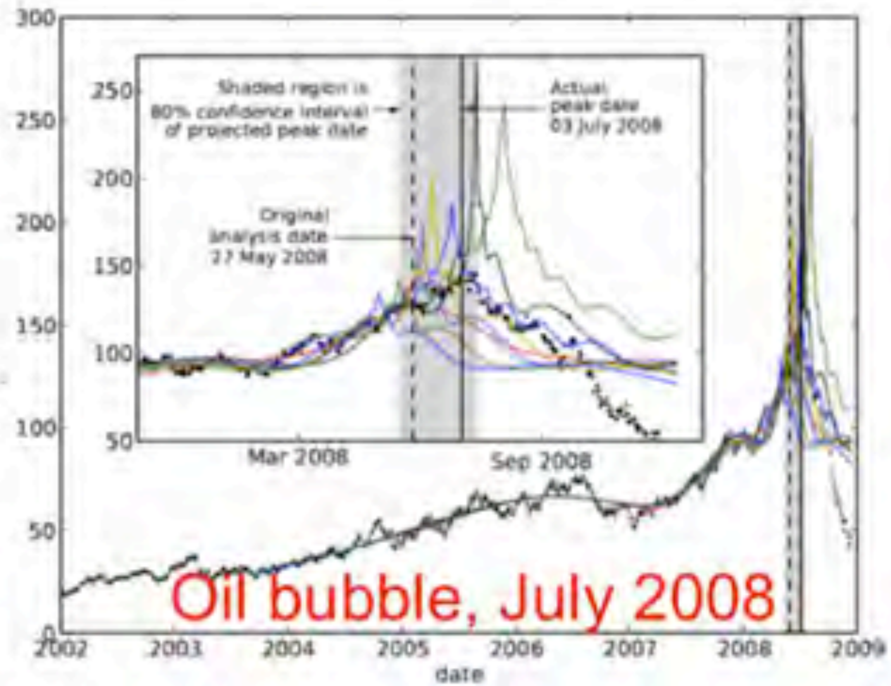
A. Hüsler, D. Sornette and C. H. Hommes Super-exponential bubbles in lab experiments: evidence for anchoring over-optimistic expectations on price, Journal Economic Behavior and Organization 92, 304-316 (2013)

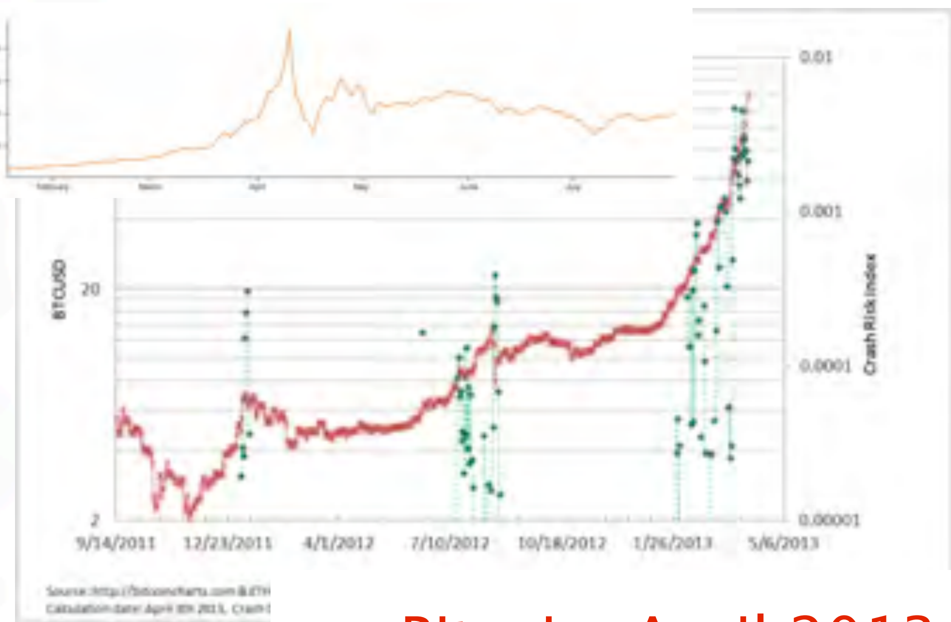


Next period returns r(t+1)versus current returns r(t) for group 2. Points on the diagonal correspond to constant growth rate (r(t+1)= r(t)), points above the diagonal (r(t+1)> r(t)) correspond to accelerating growth. Returns are defined as discrete returns:

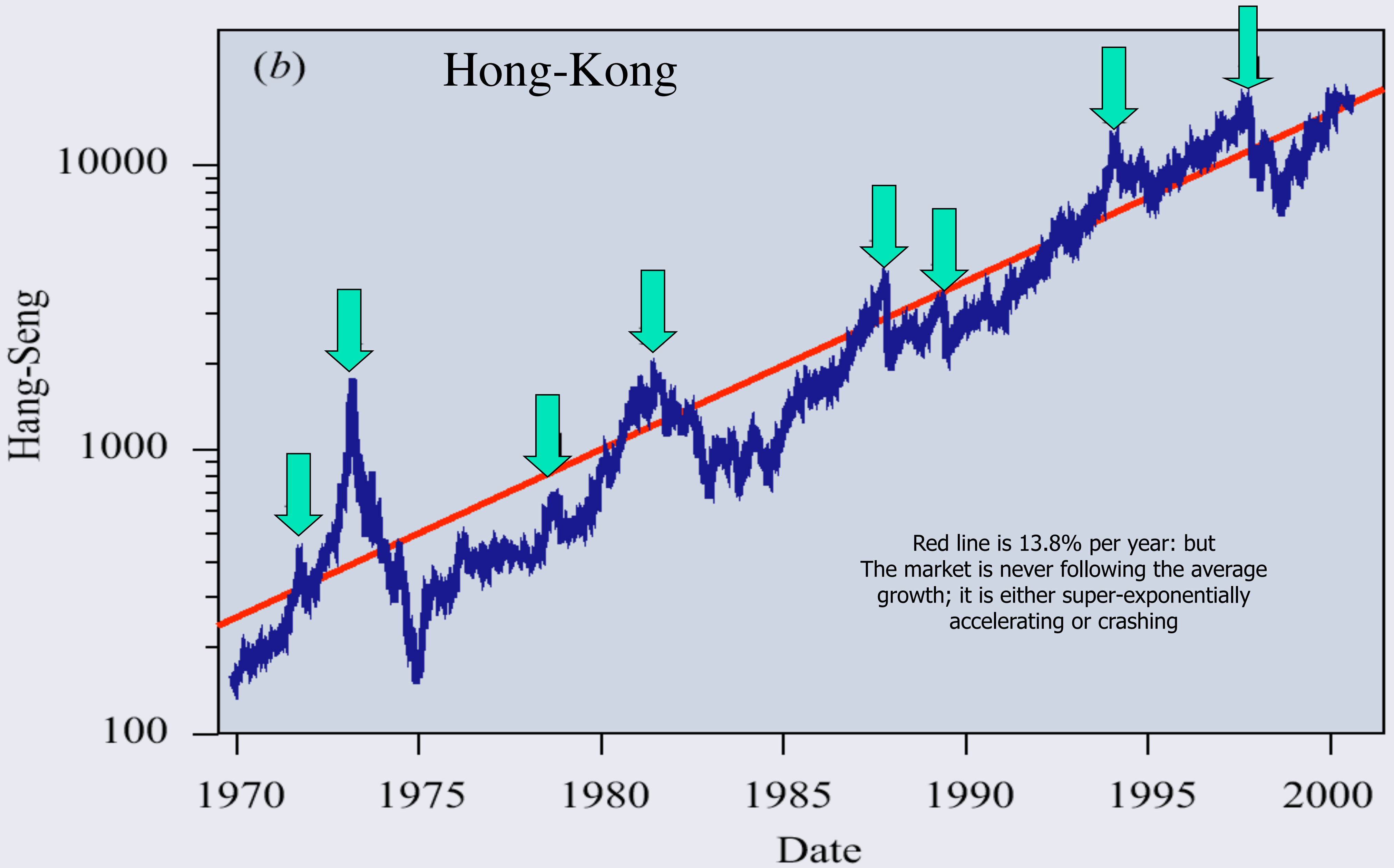
$r(t+1) = [p(t+1)/p(t)] - 1.$



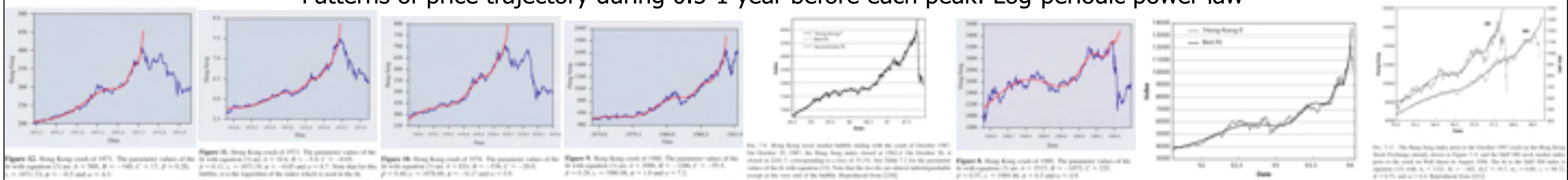




Bitcoin, April 2013



Patterns of price trajectory during 0.5-1 year before each peak: Log-periodic power law



Log-Periodic Power Law model and Extensions

From the perspective of **economics and econometrics:**

From the perspective of **complex systems**:

From the perspective of economics and econometrics	From the perspective of complex systems
Rational expectation bubble model in the presence of an (unknown) fundamental value	Rational expectation models of negative bubbles and anti-bubbles
Rational expectation bubble model in the presence of stochastic singularity time	Rational expectation bubble model with beta-function-type solution of the RG (RG: renormalization group)
Rational expectation bubble model in the presence of mean-reverting self-consistent residuals	Rational expectation bubble model with higher order solutions of the RG

The **Log-Periodic Power Law** is a combination of

Classical methods of **economics**:
extension of the Blanchard-Watson (1982) Rational Expectation bubble model

Diffusive dynamics of log-price in the presence of discontinuous jump *j*:

$$\frac{dp}{p} = \mu(t)dt + \sigma(t)dW - \kappa dj$$

Under the no-arbitrage condition

$$E_t[dp] = 0$$

the excess returns are proportional to the hazard rate:

$$\mu(t) = \kappa h(t)$$

Complex systems approach:

The crash is a tipping point (critical point), around which the system exhibits self-similar properties:

$$f(K) = g(K) + \mu^{-1} f[R(K)]$$

The renormalisation group solution has the form:

$$f(K) = \sum_{n=0}^{\infty} \mu^{-n} g[R^{(n)}(K)]$$

Where the log-periodic oscillations for hazard rate are the first order approximation of the RG solution.

$$\mathrm{E}[\ln p(t)] = A + B|t_c - t|^m + C|t_c - t|^m \cos[\omega \ln |t_c - t| - \phi]$$

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Positive feedback

$$dp/dt = cp^d \quad \text{with d>1}$$

e.g. as a result of herding in dynamics of "noise traders"

Discrete scale invariance

$$p(\lambda_n t) \sim \lambda_n^\alpha p(t), \ \ n \in \mathbb{N}$$

as a result of RG solution around the tipping point (end of bubble)

Faster-than exponential growth

$$p(t) \sim (t_c - t)^{-m}$$

Log-periodic oscillations

$$p(t) \sim \cos[\omega \ln(t_c - t) + \phi]$$

Martingale hypothesis
(no "free lunch")

Johansen-Ledoit-Sornette (JLS) model
(Log-Periodic Power Law)

$$\mathrm{E}[\ln p(t)] = A + B|t_c - t|^m + C|t_c - t|^m \cos[\omega \ln|t_c - t| - \phi]$$

Extensions of the **Log-Periodic Power Law** model

From the perspective of **economics and econometrics:**

Rational expectation bubble model in the presence of an (unknown) fundamental value

Rational expectation bubble model in the presence of stochastic singularity time

Rational expectation bubble model in the presence of mean-reverting self-consistent residuals

From the perspective of **complex systems**:

Rational expectation models of negative bubbles and anti-bubbles

Rational expectation bubble model with beta-function-type solution of the RG
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Extensions of the **Log-Periodic Power Law** model

From the perspective of **economics and econometrics:**

addresses the problem of the joint estimation of the fundamental and bubble components

mechanism for bubble survival by lack of synchronization due to heterogenous beliefs on critical **end** of bubble

Rational expectation bubble model in the presence of mean-reverting self-consistent residuals

From the perspective of **complex systems**:

Rational expectation models of negative bubbles and anti-bubbles

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Rational expectation bubble model with higher order solutions of the RG

Construction of alarms

Prices converted in stochastic singular times for crash

$$\widetilde{T}_{c,i}(t) = t_i + \left(\frac{A - \ln p(t)}{B}\right)^{\frac{1}{1-\beta}} , \qquad t = t_i - 899, \cdots, t_i \ .$$

$$T_{c,i} = \frac{1}{750}\sum_{t=1}^{750} \widetilde{T}_{c,i}(t) \qquad \tilde{t}_{c,i}(t) = \widetilde{T}_{c,i}(t) - T_{c,i}$$

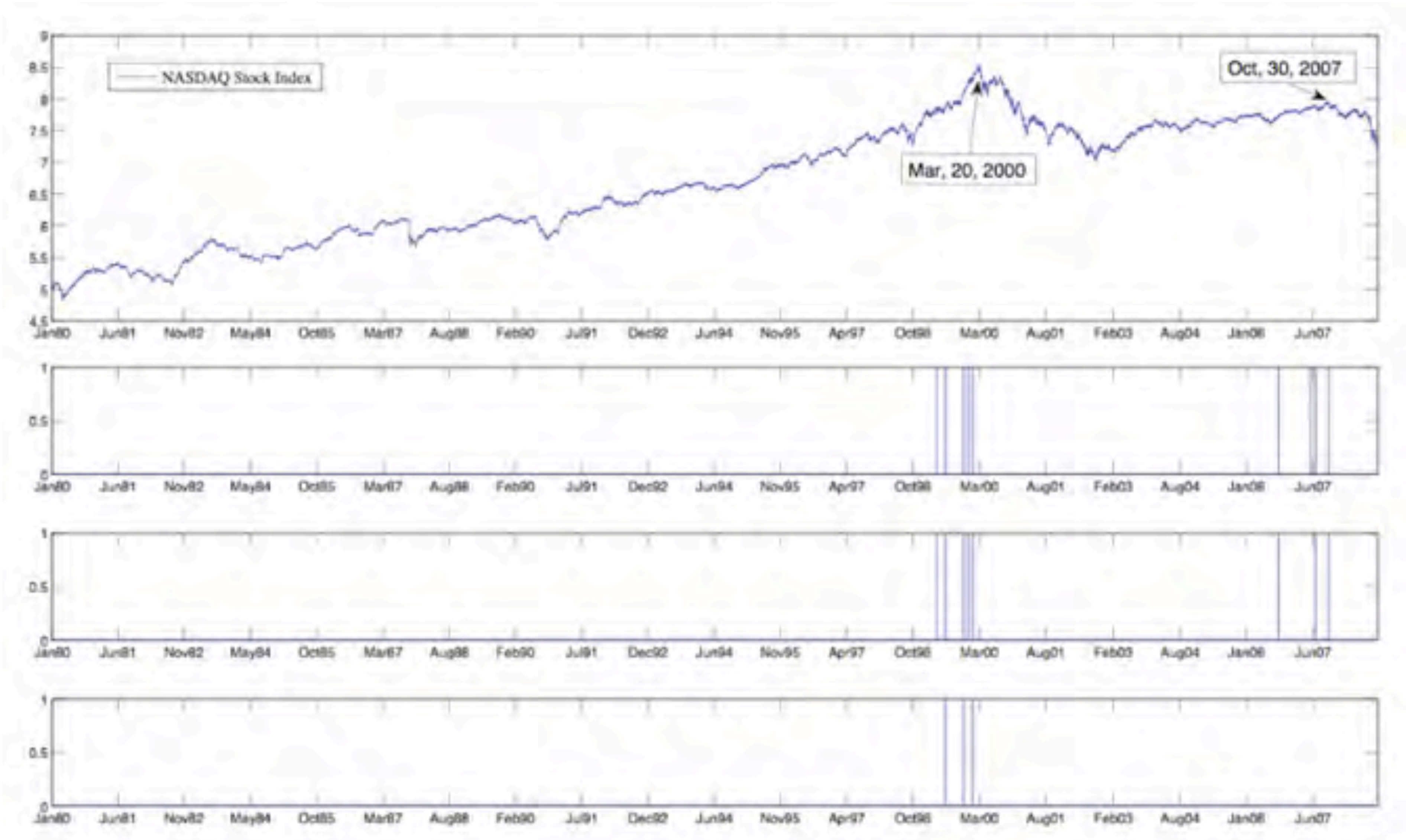
Bubble diagnostic if

(i) $0 < \beta^* < 1$ such that $m > 2$ (the signature of a positive feedback in the momentum price dynamics model) and

(ii) $-25 \leq T_{c,i} - t_i \leq 50$, such that the estimated termination time of the bubble is close to the right side of the time window.

(iii) We further refine the filtering by considering three levels of significance quantified by the value of the exponent m: level 1 ($m > 2$), level 2 ($m > 2.5$) and level 3 ($m > 3$).

(iv) Dickey – Fuller unit – root test is rejected at 99.5% significance level



Li Lin, Didier Sornette, Diagnostics of Rational Expectation Financial Bubbles with Stochastic Mean-Reverting Termination Times, in press in European Journal of Finance (2012) (http://arxiv.org/abs/0911.1921)

Extensions of the **Log-Periodic Power Law** model

From the perspective of **economics and econometrics:**

From the perspective of **complex systems**:

From the perspective of economics and econometrics	From the perspective of complex systems
addresses the problem of the joint estimation of the fundamental and bubble components	Rational expectation models of negative bubbles and anti-bubbles
mechanism for bubble survival by lack of synchronization due to heterogenous beliefs on critical **end** of bubble	Rational expectation bubble model with beta-function-type solution of the RG (RG: renormalization group)
addresses the critic of Granger and Newbold (1974) and Phillips (1986) about spurious fits of non-stationary price processes	Rational expectation bubble model with higher order solutions of the RG

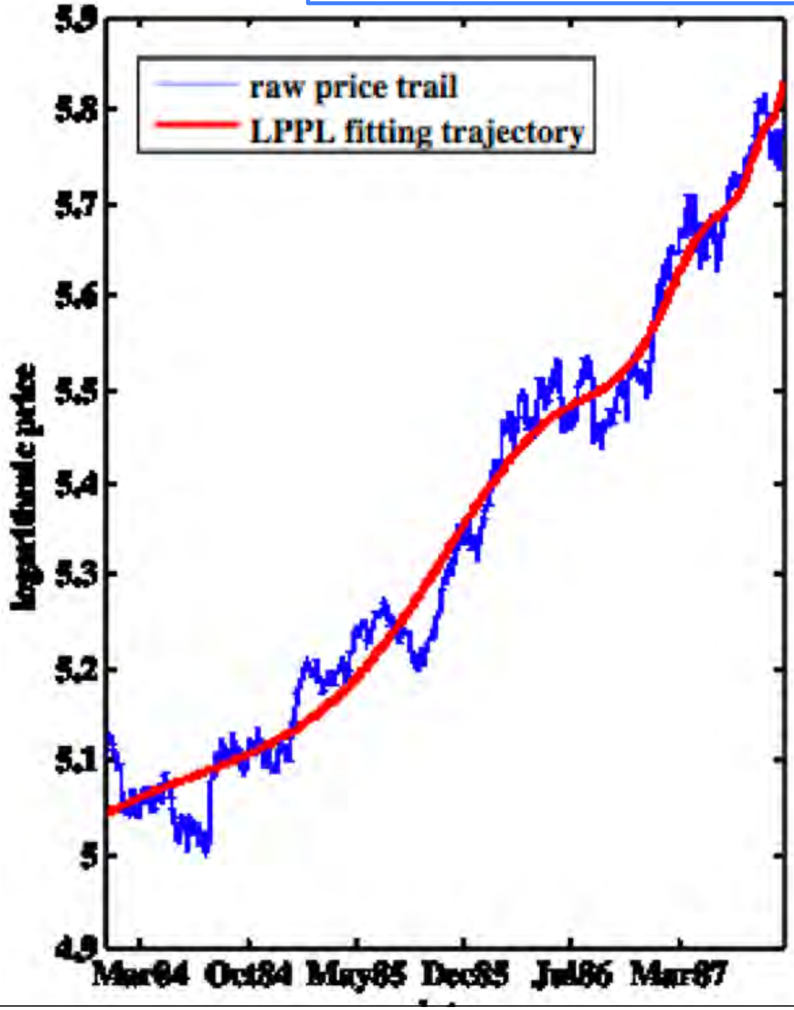
A Consistent Model of 'Explosive' Financial Bubbles With Mean-Reversing Residuals

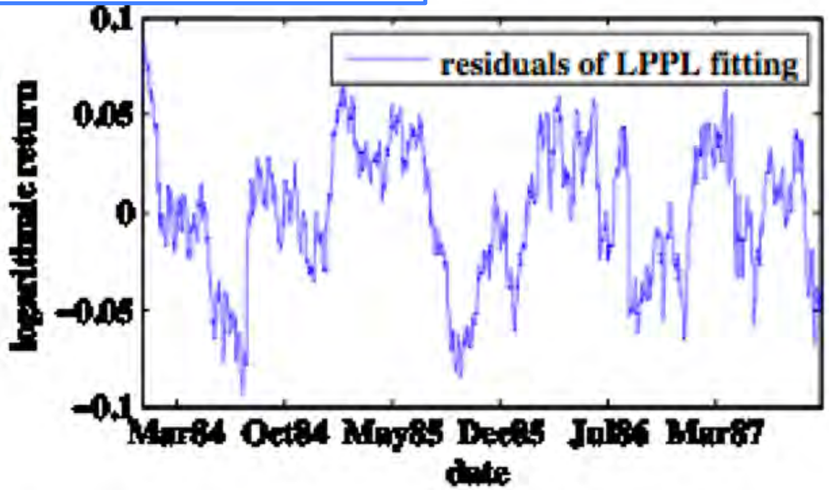
L. Lin, R. E. Ren and D. Sornette (2009)

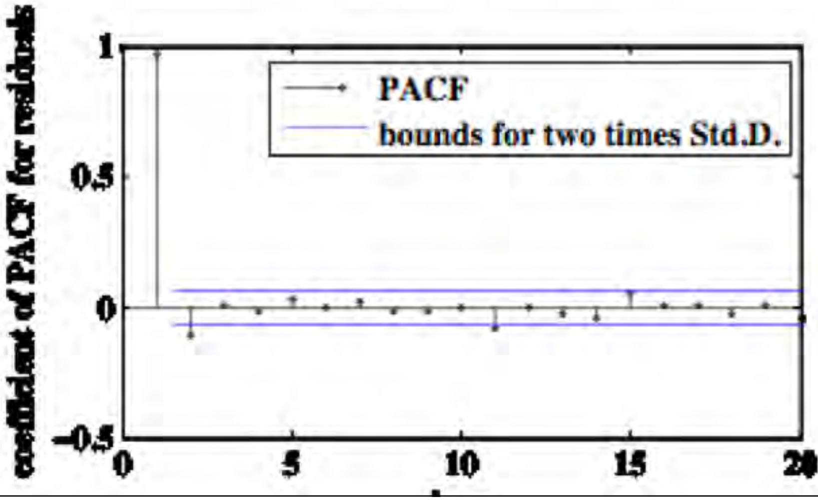
http://papers.ssrn.com/abstract=1407574

$$\frac{dI}{I} = \mu(t)dt + \sigma_Y dY + \sigma_W dW - \kappa dj$$

$$dY = -\alpha Y dt + dW \ .$$







Rational Expectation formulation

Volatility Confined LPPL= deterministic component +*Ornstein-Uhlenbeck process*

LPPL fitting

Stationary
Mean reversal

- first model: based on Rational Expectation (RE) condition
  - Original price process: $\frac{dp}{p} = \mu(t)dt + \sigma_Y dY + \sigma_W dW - kdj$

    $dY = -\alpha Y dt + dW$
  - Stochastic Discount Factor: $\frac{d\Lambda_t}{\Lambda_t} = -rdt - \rho_Y dY - \rho_W dW$
  - Under no-arbitrage condition:

Belief updating

$$\mu(t) = \text{LPPL component} + \alpha(\sigma_Y - \rho_Y)Y_t$$

$$r_{i+1} = \ln p_{t_{i+1}} - \ln p_{t_i} \sim N(\Delta H_{t_{i+1},t_i} - \alpha(\ln p_{t_i} - H_{t_i}), \sigma_u^2(t_{i+1} - t_i))$$

$$H_{t_i} = A - B(t_c - t_i)^\beta [1 + \frac{C}{\sqrt{1 + (\frac{\omega}{\beta})^2}} \cos(\omega \ln(t_c - t_i) + \phi)]$$

There is also a Behavioral discount factor formulation.

Bayesian approach

S&P500 1987 and Hong-Kong 1997

(answering to Chang and Feigenbaum, 2006)

- Bayesian Factor
  - B(model_1,model_2)= $\dfrac{\text{Marginal Likelihood (model\_1)}}{\text{Marginal Likelihood (model\_2)}}$
  - Model_1: Volatility Confined LPPL
  - Prior probability
  - Model_2: Black-Scholes model
- Calculation Results

$$\mathscr{L}_{\text{LPPL}}(2.5\% - 97.5\%) = 3173.546 - 3176.983$$

$$\mathscr{L}_{\text{BS}}(2.5\% - 97.5\%) = 3169.808 - 3170.097\,.$$

LPPL outperform BS here

$$\begin{aligned}
\mu &\sim N(0.0003, (0.01)^2) \\
\tau &\sim \Gamma(1.0\,, 10^5) \\
\alpha &\sim \Gamma(1.0\,, 0.05) \\
A &\sim N(6\,, 0.05) \\
B &\sim \Gamma(1\,, 0.01) \\
C &\sim U(0, 1) \\
\beta &\sim B(40\,, 30) \\
\omega &\sim \Gamma(16\,, 0.4) \\
\phi &\sim U(0\,, 2\pi) \\
t_c - t_N &\sim \Gamma(1\,, 30)
\end{aligned}$$

Extensions of the **Log-Periodic Power Law** model

From the perspective of **complex systems**:

Rational expectation models of negative bubbles and anti-bubbles

Rational expectation bubble model with beta-function-type solution of the RG (RG: renormalization group)

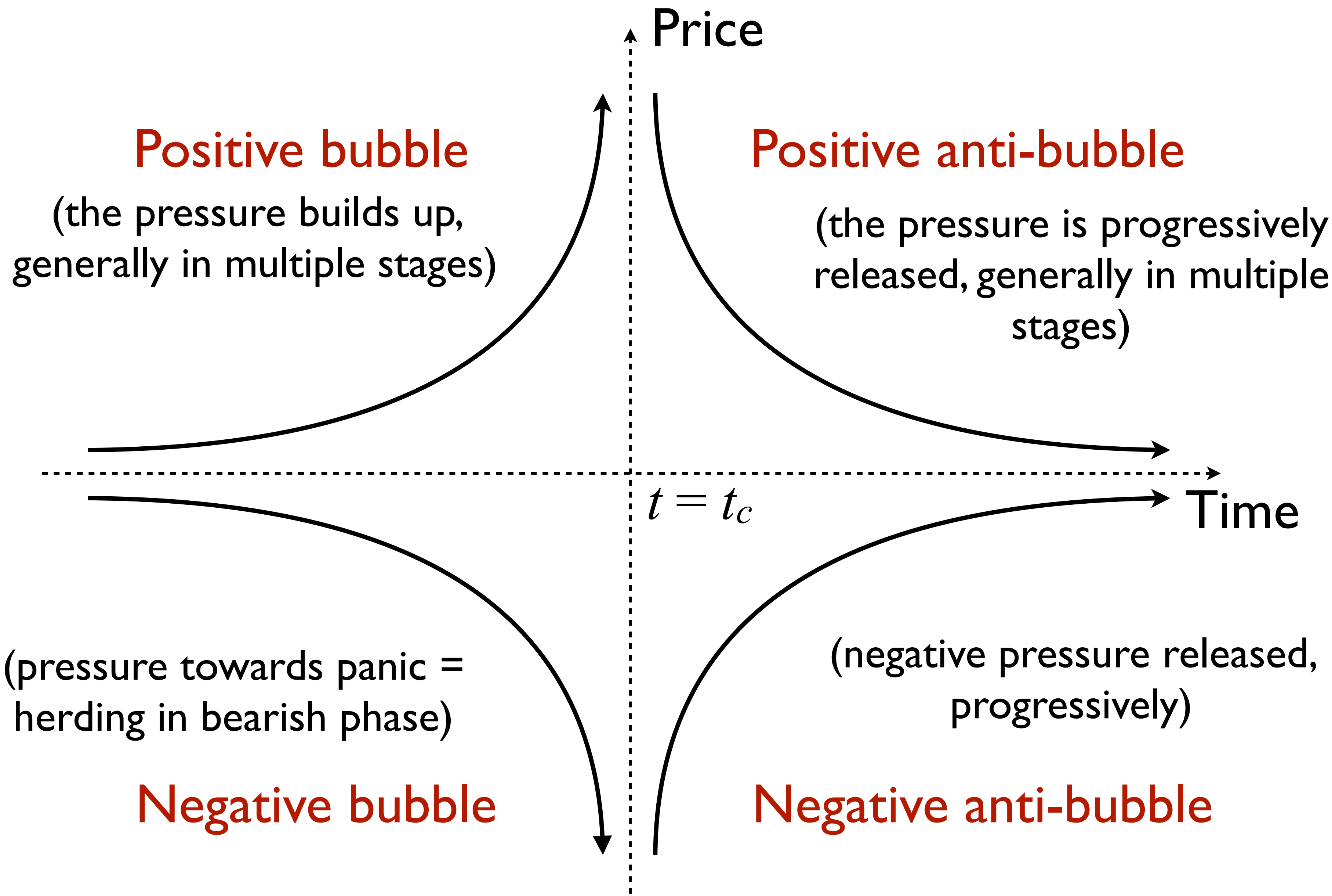
Rational expectation bubble model with higher order solutions of the RG

Extensions of the **Log-Periodic Power Law** model

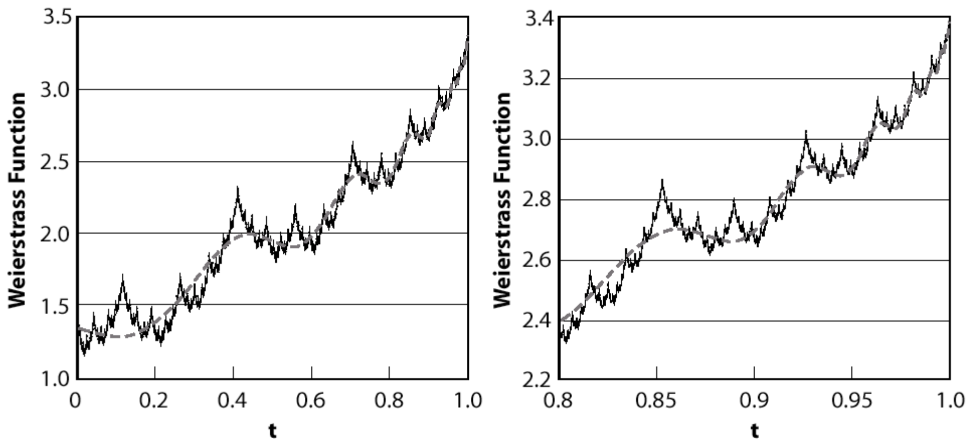
From the perspective of **complex systems**:

Rational expectation models
of negative bubbles
and anti-bubbles

Rational expectation models **of negative and anti-bubbles**



Extensions of the **Log-Periodic Power Law** model



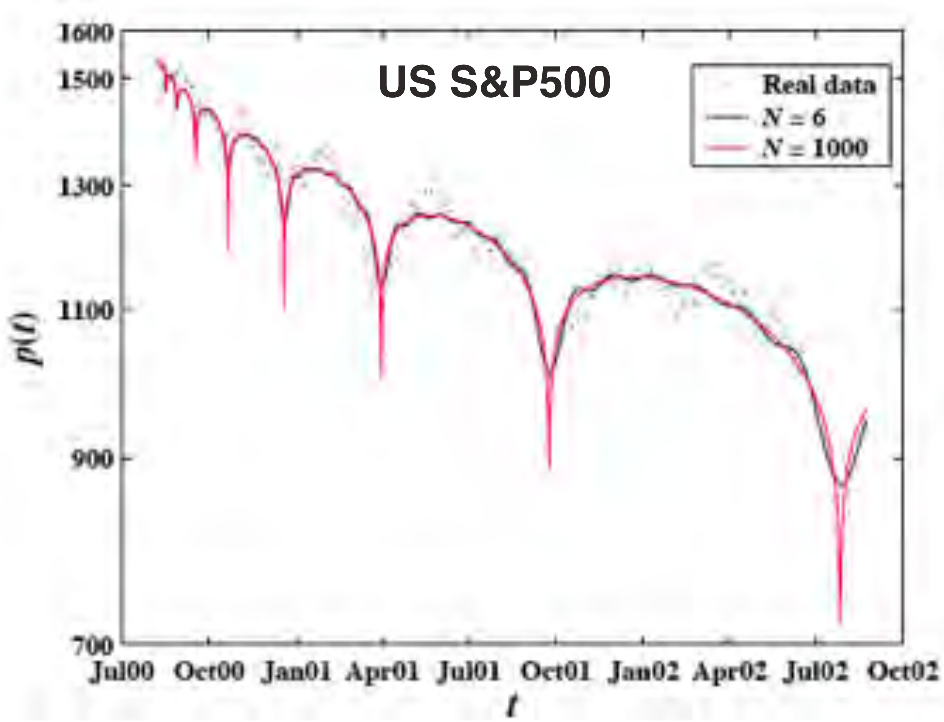
From the perspective of **complex systems**:

Rational expectation models of negative bubbles and anti-bubbles

generalized Weierstrass functions

(RG: renormalization group)

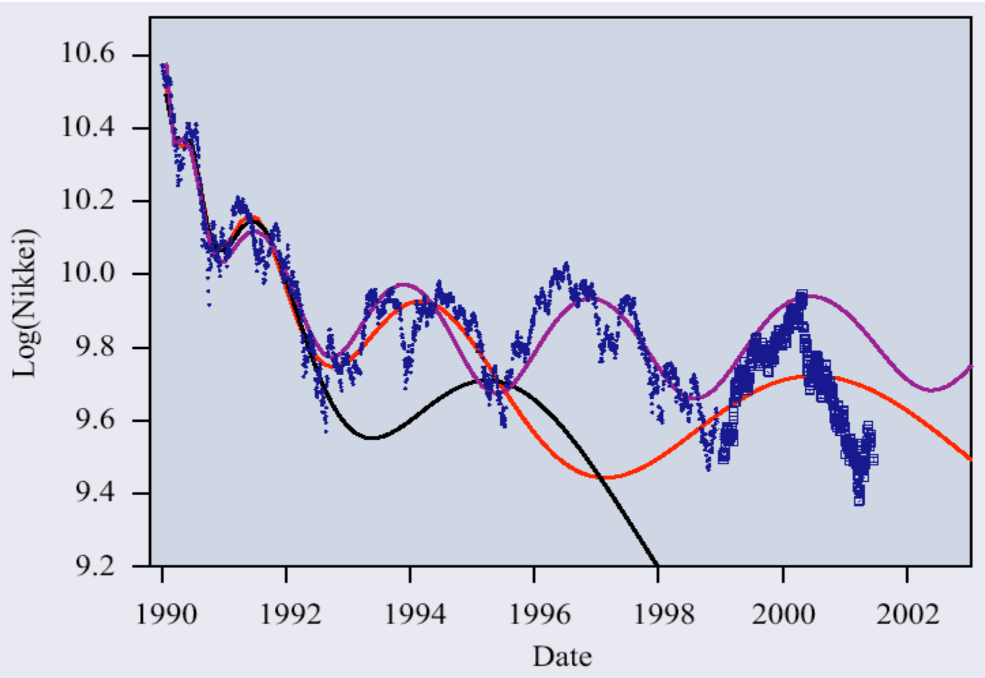
Rational expectation bubble model with higher order solutions of the RG



Extensions of the **Log-Periodic Power Law** model

From the perspective of **complex systems**:

Japanese Index: model and prediction



second-order and third-order Landau LPPL

A. Johansen and D. Sornette, Financial "anti-bubbles": log-periodicity in Gold and Nikkei collapses, Int. J. Mod. Phys. C 10(4), 563-575 (1999); Evaluation of the quantitative prediction of a trend reversal on the Japanese stock market in 1999, Int. J. Mod. Phys. C Vol. 11 (2), 359-364 (2000)

Early warning of the 2008-20?? crisis

1945-1970: reconstruction boom and consumerism

1971-1980: Bretton Woods system termination and oil shocks / inflation shocks

1981-2007: Illusion of the "perpetual money machine" and virtual financial wealth

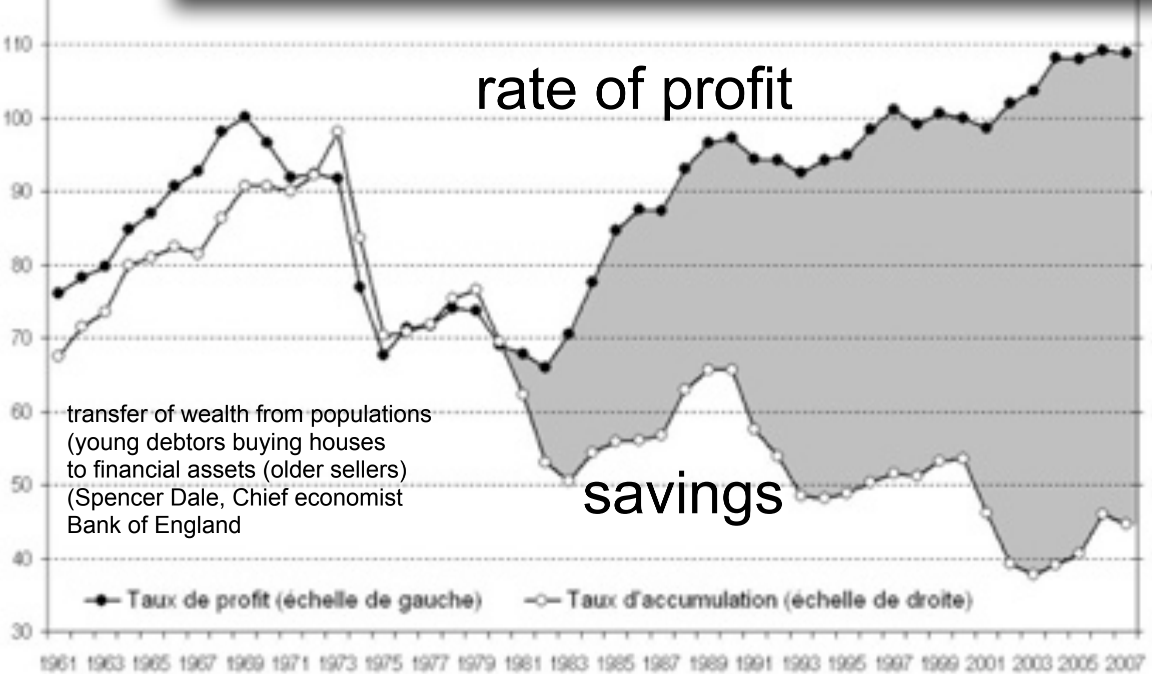
D. Sornette and P. Cauwels, The Illusion of the Perpetual Money Machine, Notenstein Academy White Paper Series (Dec. 2012) (http://arxiv.org/abs/1212.2833)

2008-2020s: New era of pseudo growth fueled by QEs and other Central Banks+Treasuries actions

- very low interest rate for a very long time (decades)
- net erosion even in the presence of apparent low (disguised) inflation
- reassessment of expectation for the social and retirement liabilities
- a turbulent future with many transient bubbles
- need to capture value and be contrarian => exploit herding and fear

2020s-20xx: Interconnection of many systemic risks

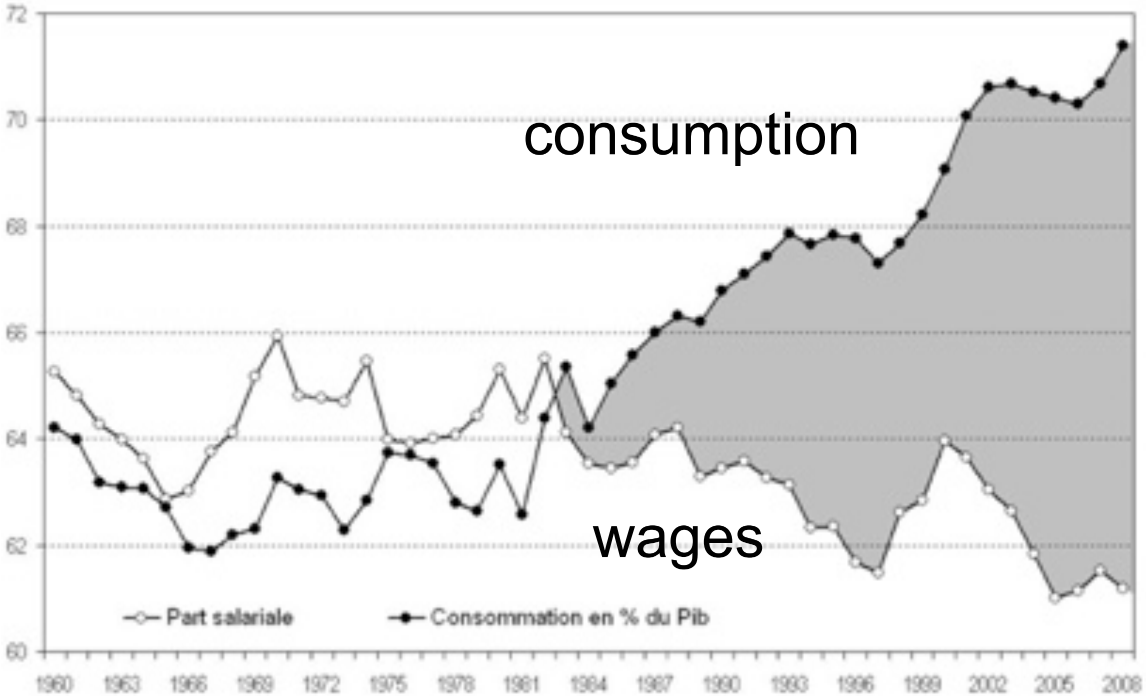
The illusionary "PERPETUAL MONEY MACHINE"



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).

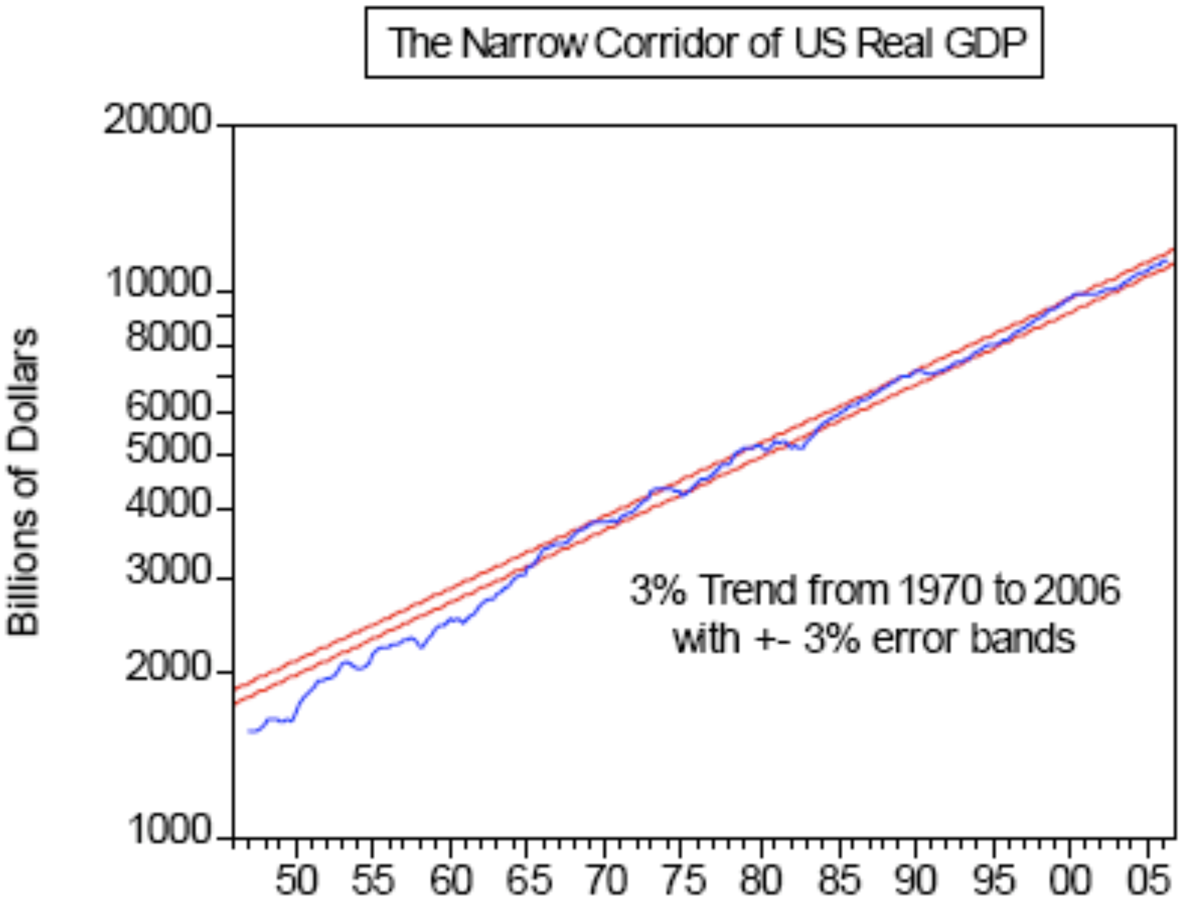
United States Share of wages and of private consumption in Gross Domestic Product (GDP)

Source of data and graphics: http://hussonet.free.fr/toxicap.xls

The illusionary "PERPETUAL MONEY MACHINE"

- 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.

- 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.



From 1982 until 2007, the U.S. only experienced two shallow recessions that each lasted just 8 months. This stretch of 25 years may be the best 25 years in the US economic history. But much of this prosperity was bought with debt, as the ratio of debt to GDP rose from $1.60 to $3.50 for each $1.00 of GDP.

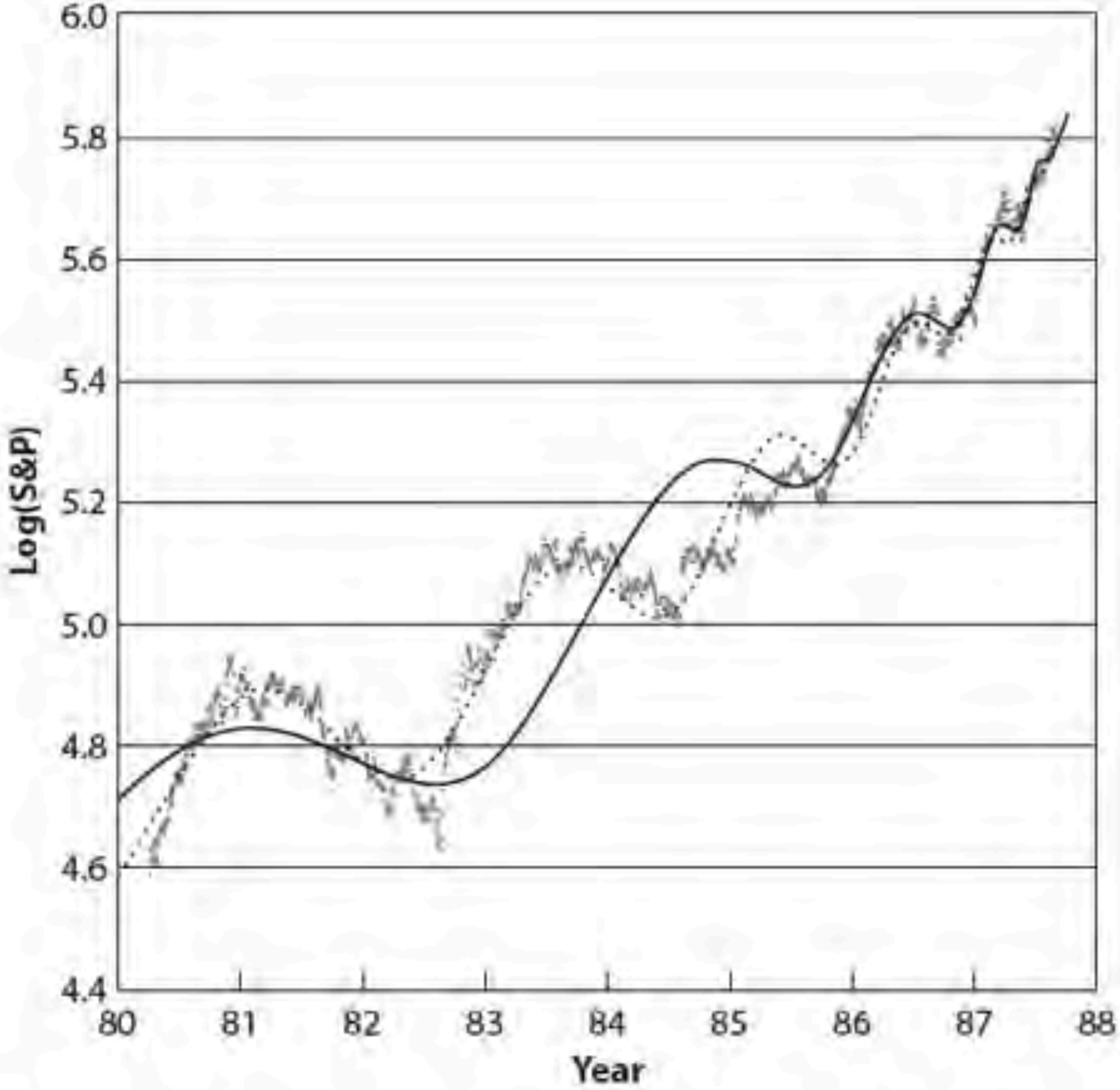
Predictability of the 2007-XXXX crisis:
30 year History of **bubbles** and of **Endogeneity**

- Worldwide bubble (1980-Oct. 1987)
- The ICT (dotcom) “new economy” bubble (1995-2000)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007)
- Stock market bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008)
- Debt bubbles

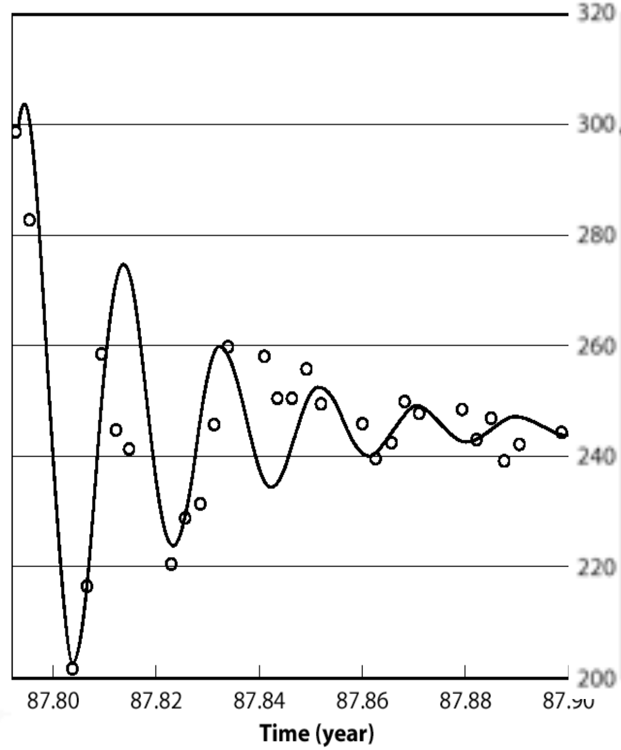
Didier Sornette and Ryan Woodard,
Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis (2009)(http://arxiv.org/abs/0905.0220)

D. Sornette and P. Cauwels,
The Illusion of the Perpetual Money Machine,
Notenstein Academy White Paper Series (Dec. 2012)
(http://arxiv.org/abs/1212.2833)

THE CRASH OF OCTOBER 1987

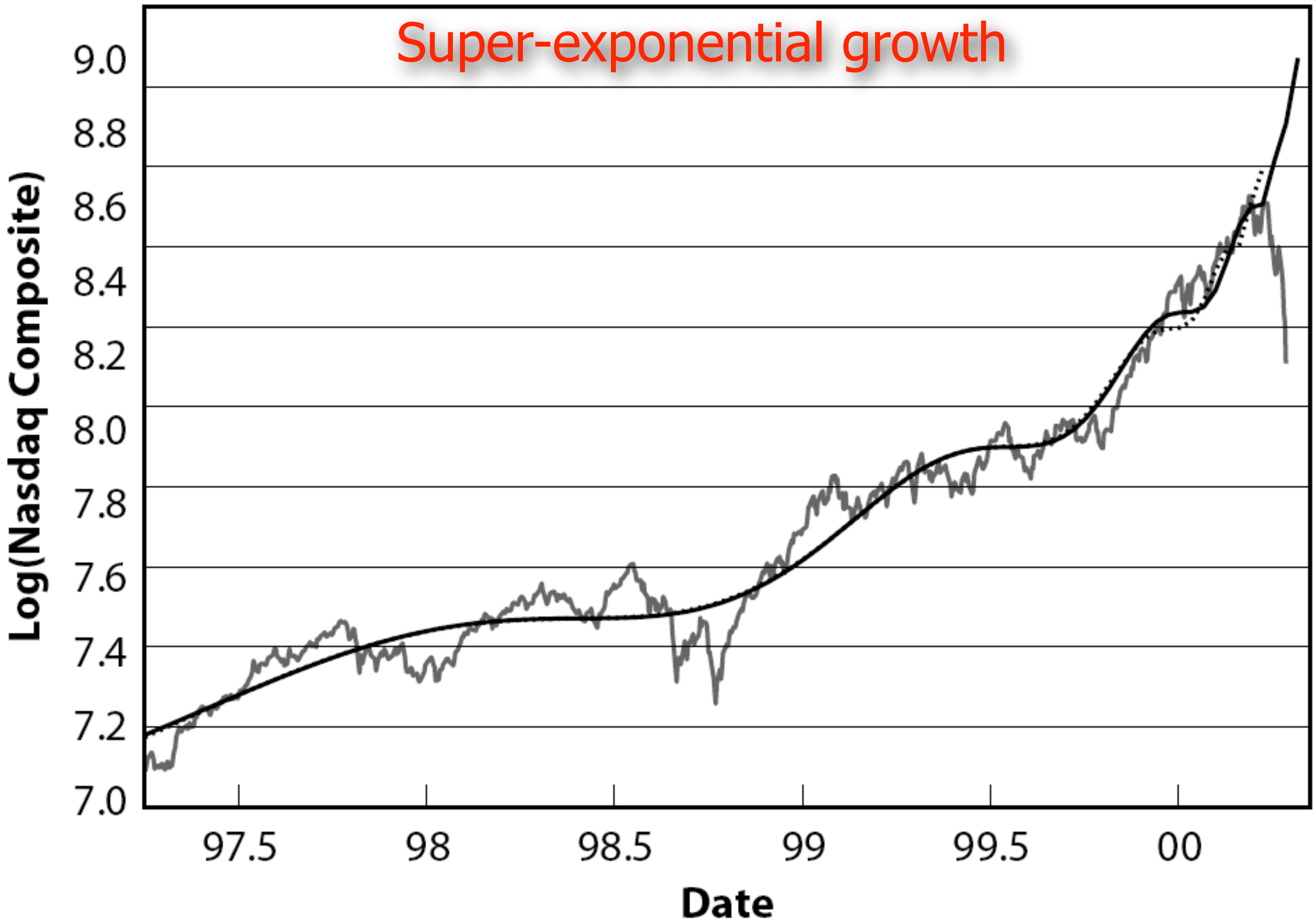


7 years



6 months

THE NASDAQ CRASH OF APRIL 2000



Real-estate in the UK

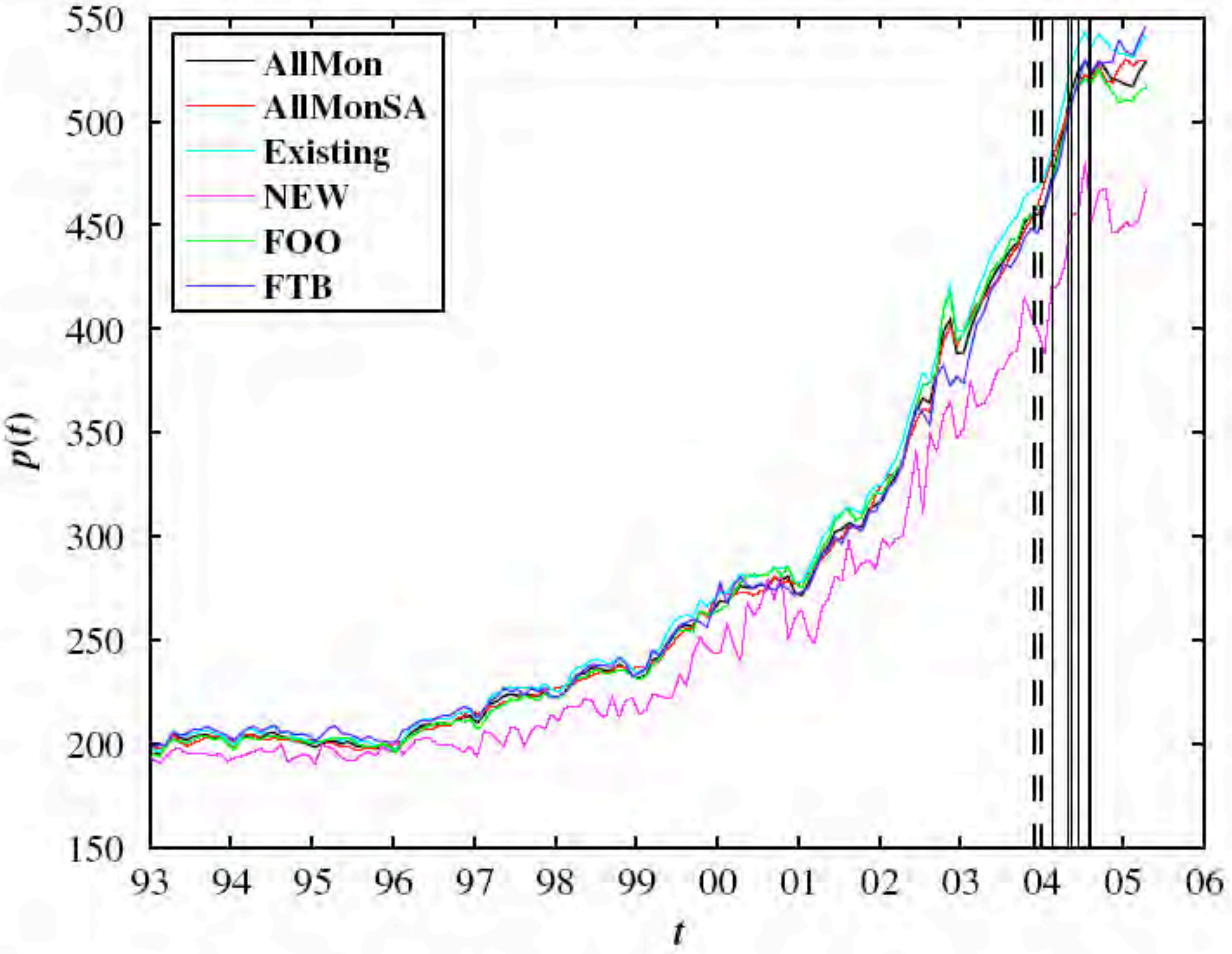


Fig. 1. (Color online) Plot of the UK Halifax house price indices from 1993 to April 2005 (the latest available quote at the time of writing). The two groups of vertical lines correspond to the two predicted turning points reported in Tables 2 and 3 of [1]: end of 2003 and mid-2004. The former (resp.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

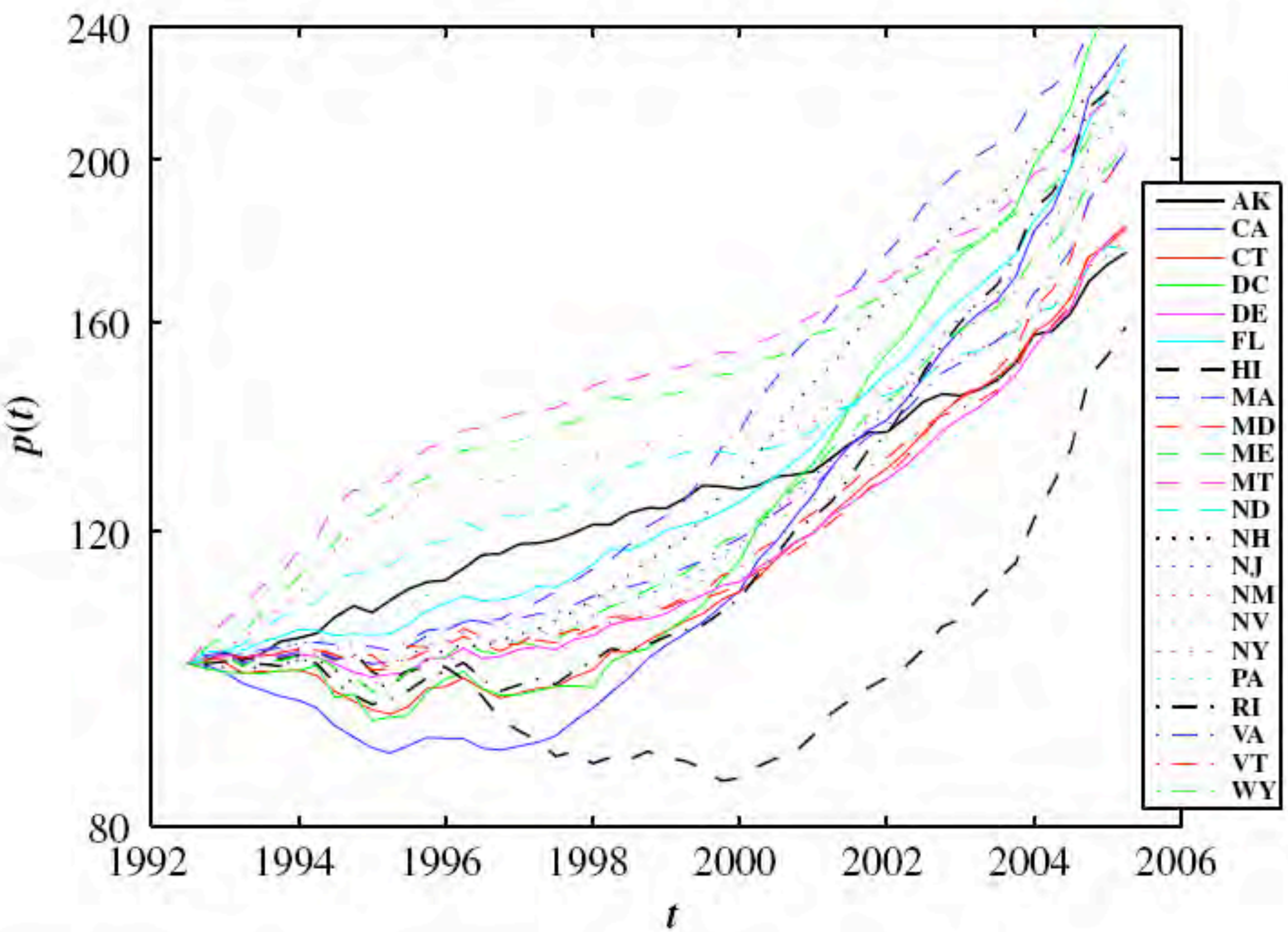
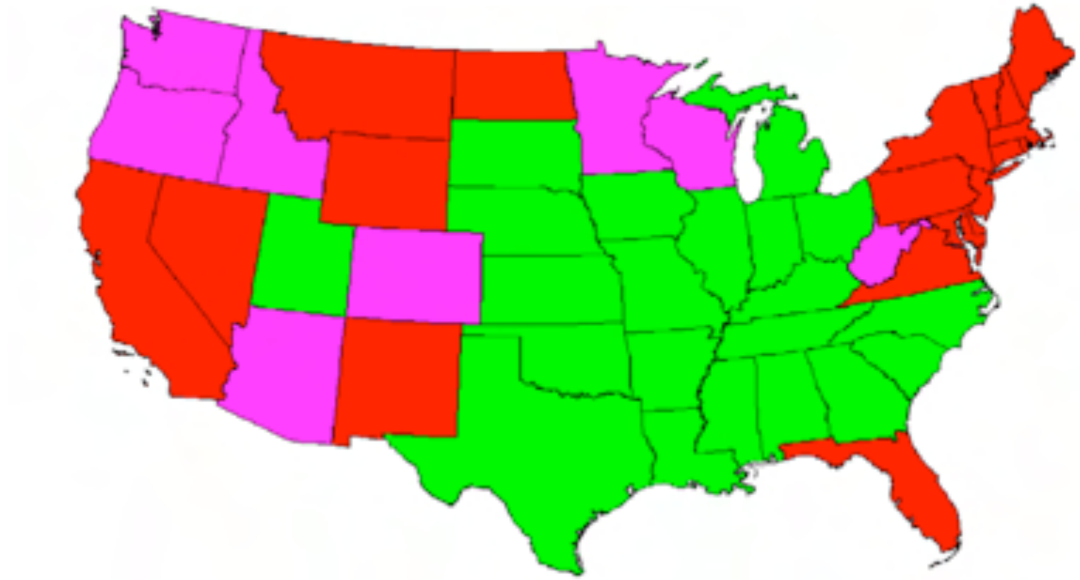


Fig. 5. (Color online) Quarterly average HPI in the 21 states and in the District of Columbia (DC) exhibiting a clear upward faster-than-exponential growth. For better representation, we have normalized the house price indices for the second quarter of 1992 to 100 in all 22 cases. The corresponding states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

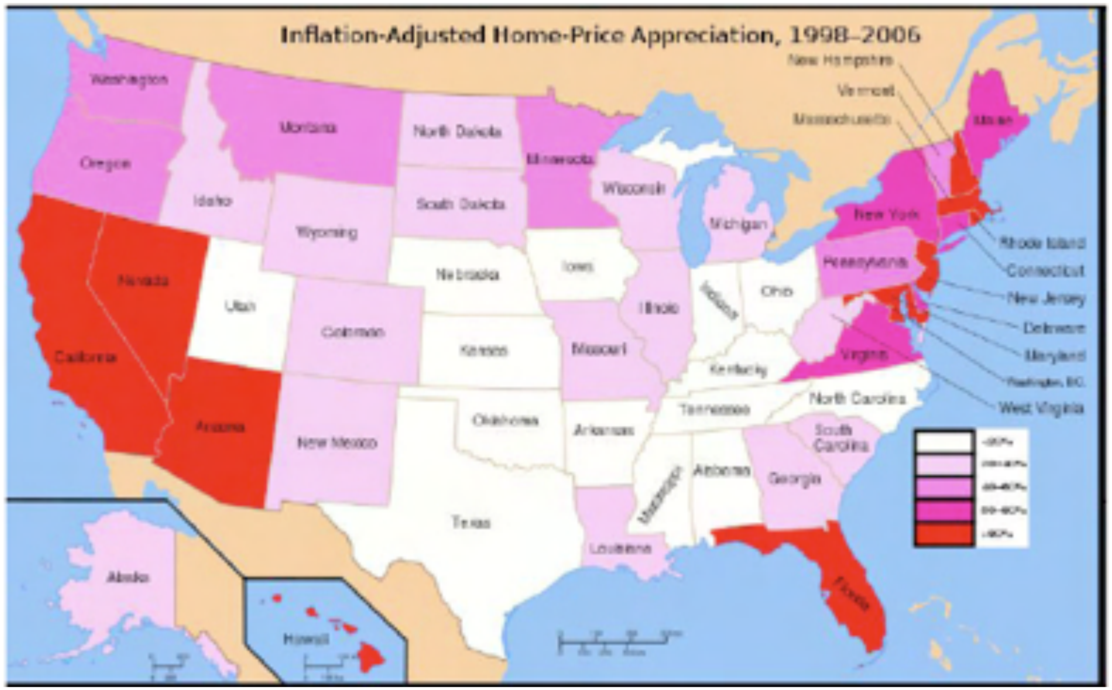
W.-X. Zhou, D. Sornette / Physica A 361 (2006) 297–308

W.-X. Zhou, D. Sornette / Physica A 361 (2006) 297–308

Our study in 2005 identifies the bubble states



Local bubbles (Froths) of Housing Markets in US, 1998-2006



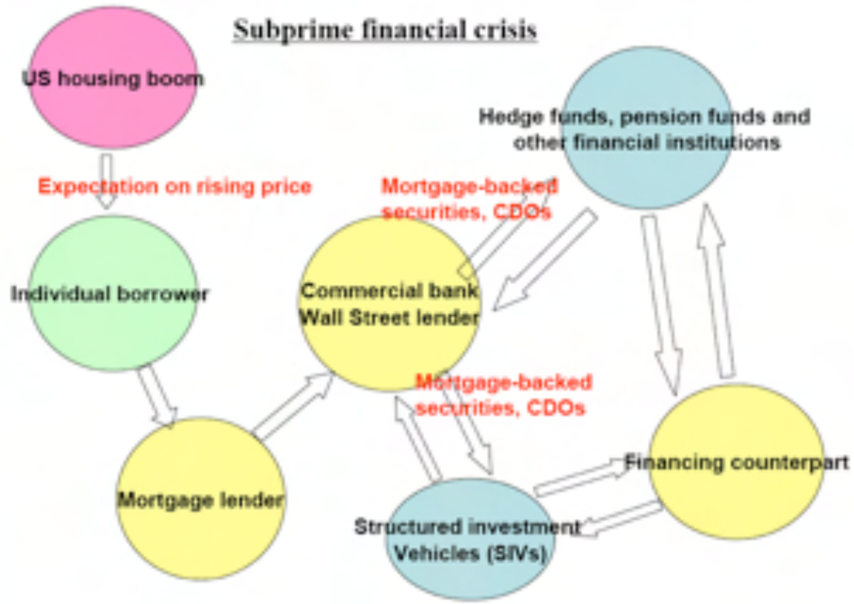
Real-estate in the USA

W.-X. Zhou and D. Sornette, Is There a Real-Estate Bubble in the US?
Physica A 361, 297-308 (2006) (http://arxiv.org/abs/physics/0506027)

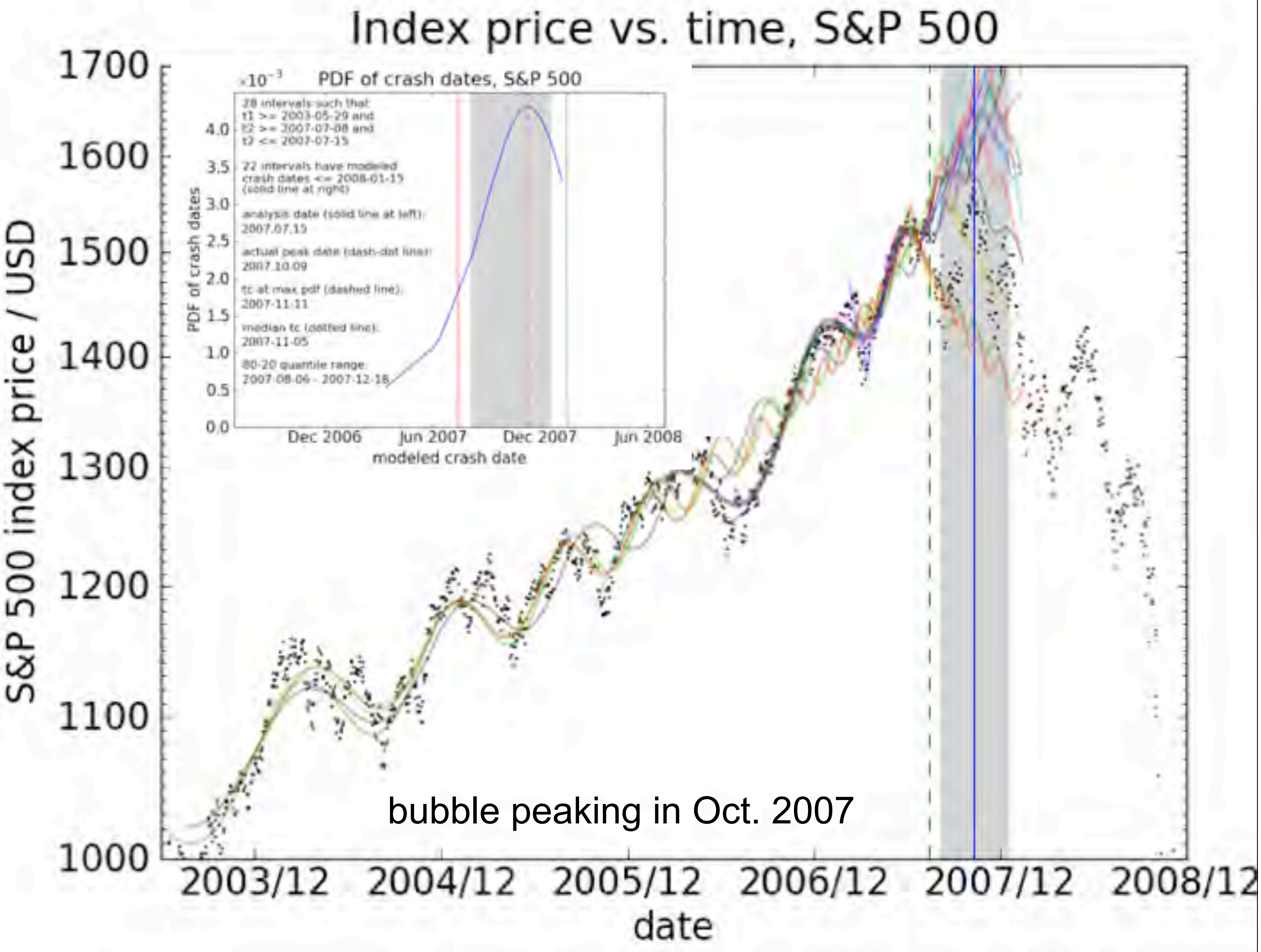
Case-Shiller YoY Change
20%
15%
10%
5%
0%
-5%
-10%
-15%
Year Over Year Change
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
http://calculatedrisk.blogspot.com/

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

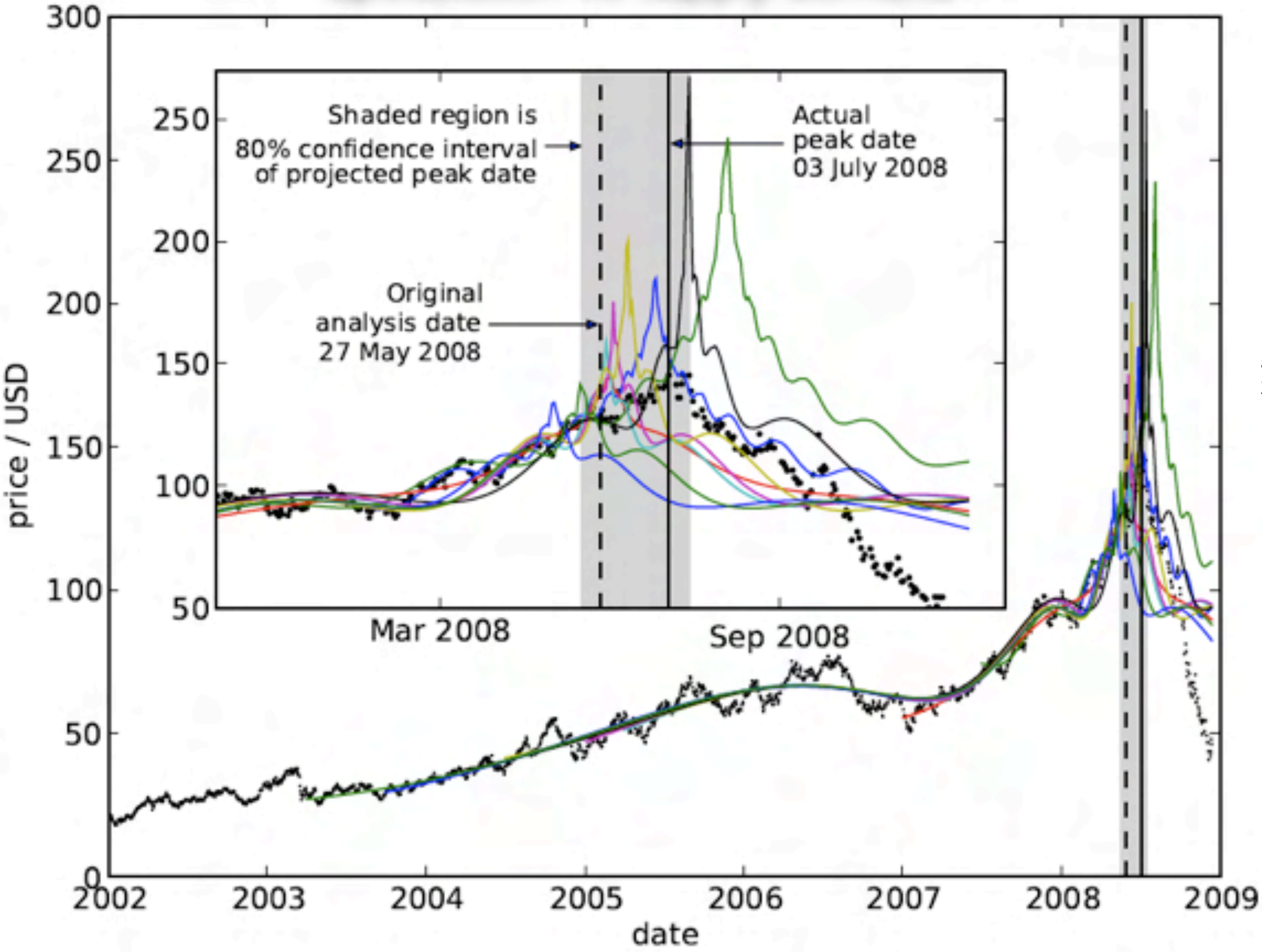
One prominent financial figure held the greatest sway in debates about the regulation and use of derivatives — exotic contracts that promised to protect investors from losses, thereby stimulating riskier practices that led to the financial crisis. For more than a decade, the former Federal Reserve Chairman Alan Greenspan has fiercely objected whenever derivatives have come under scrutiny in Congress or on Wall Street. "What we have found over the years in the marketplace is that derivatives have been an extraordinarily useful vehicle to transfer risk from those who shouldn't be taking it to those who are willing to and are capable of doing so," Mr. Greenspan told the Senate Banking Committee in 2003. "We think it would be a mistake" to more deeply regulate the contracts, he added.



"Not only have individual financial institutions become less vulnerable to shocks from underlying risk factors, but also the financial system as a whole has become more resilient."
— Alan Greenspan in 2004

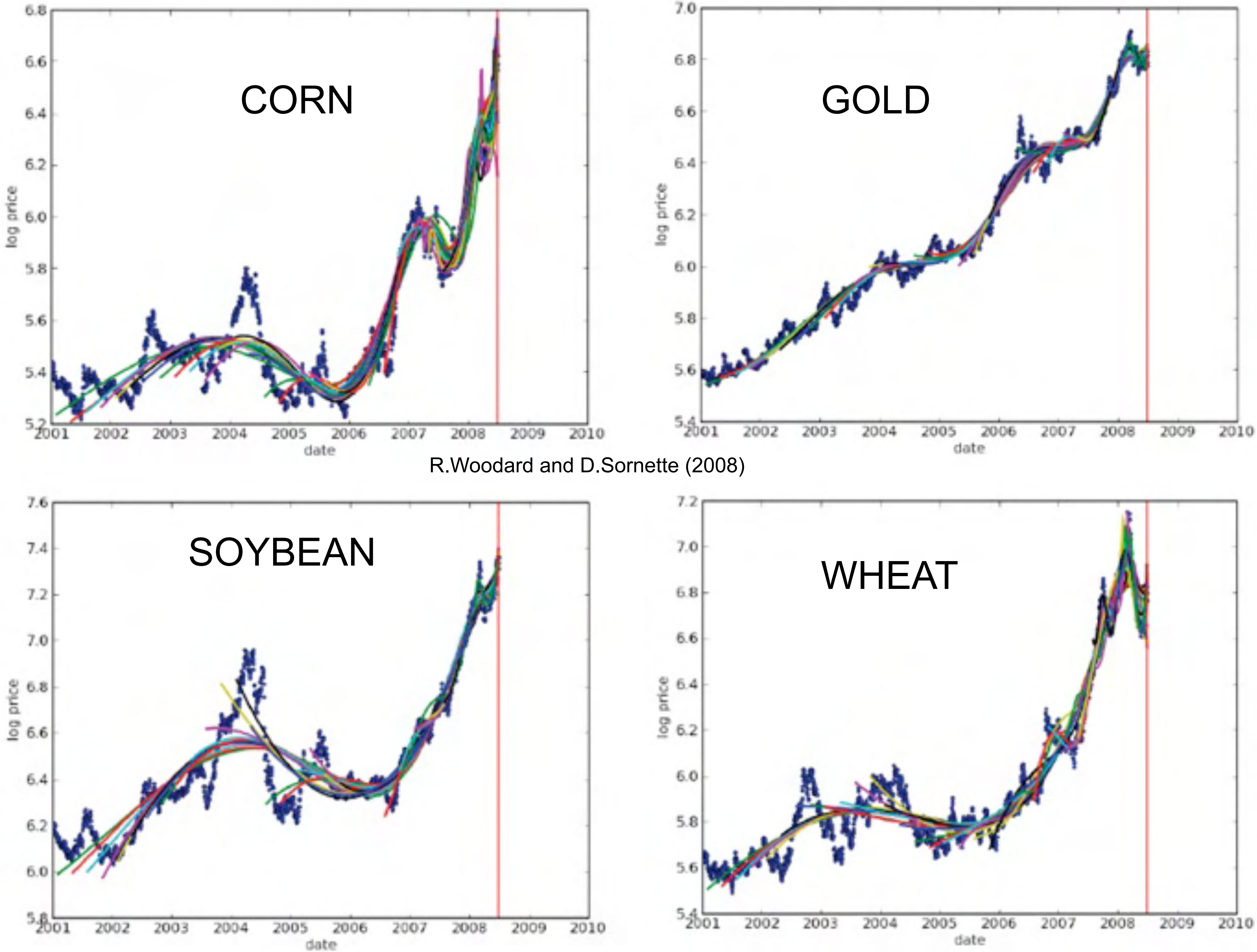

Index price vs. time, S&P 500
S&P 500 index price / USD
1700
1600
1500
1400
1300
1200
1100
1000
2003/12
2004/12
2005/12
2006/12
2007/12
2008/12
date
PDF of crash dates, S&P 500
×10⁻³
28 intervals such that
t1 >= 2003-05-29 and
t2 >= 2007-07-08 and
t2 <= 2007-07-15
22 intervals have modeled
crash dates <= 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 - 2007-12-16
PDF of crash dates
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dec 2006
Jun 2007
Dec 2007
Jun 2008
modeled crash date
bubble peaking in Oct. 2007

2006-2008 Oil bubble
Speculation vs supply-demand



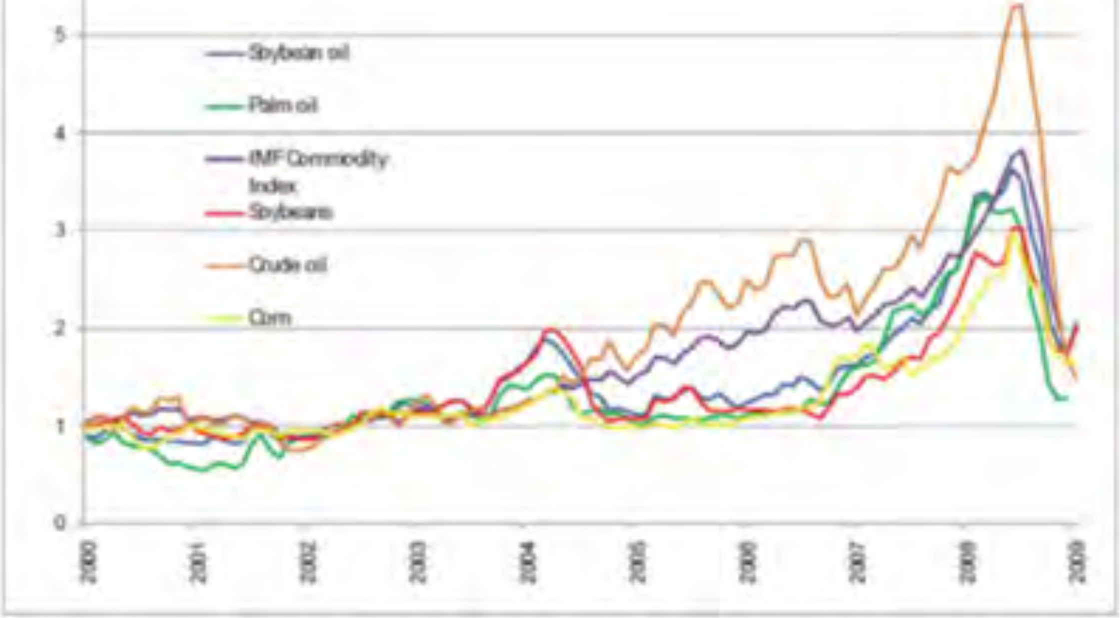
D. Sornette, R. Woodard and W.-X. Zhou, The 2006-2008 Oil Bubble and Beyond,
Physica A 388, 1571-1576 (2009)
(arXiv.org/abs/0806.1170)

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.

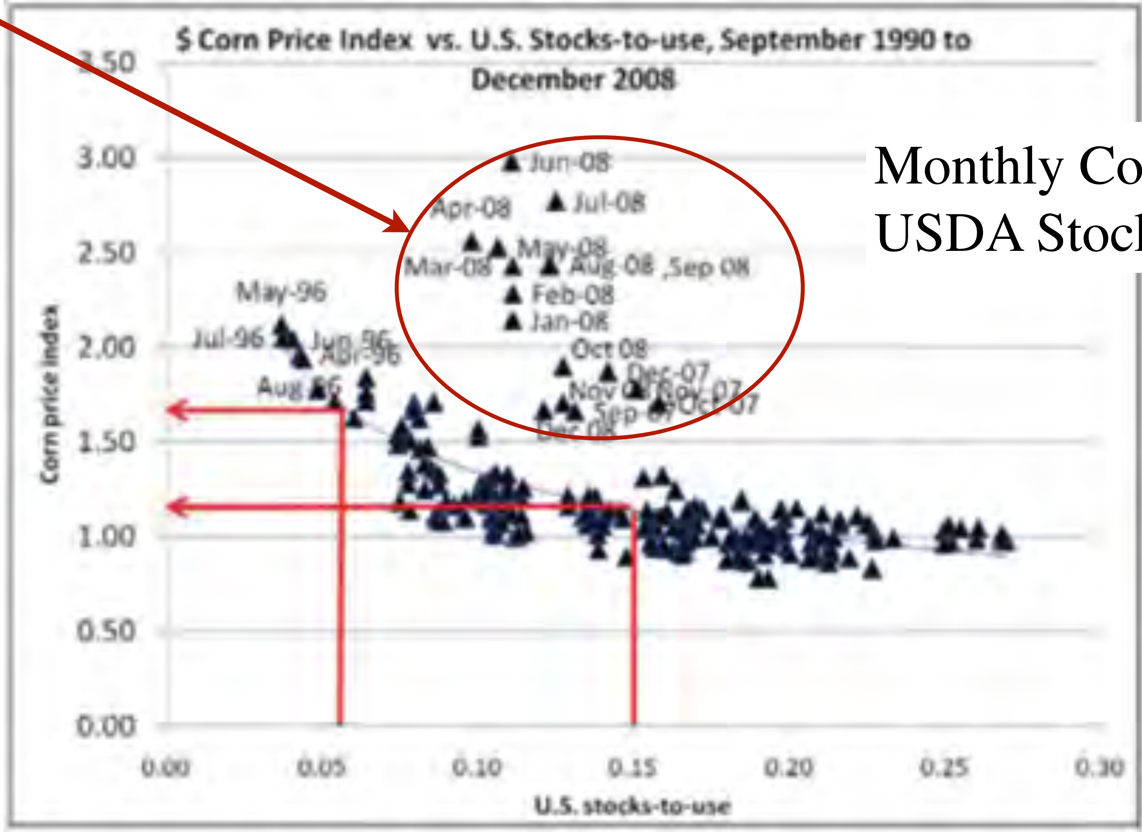


R.Woodard and D.Sornette (2008)

Energy and Agricultural Commodity Price Indices, 2000-2009

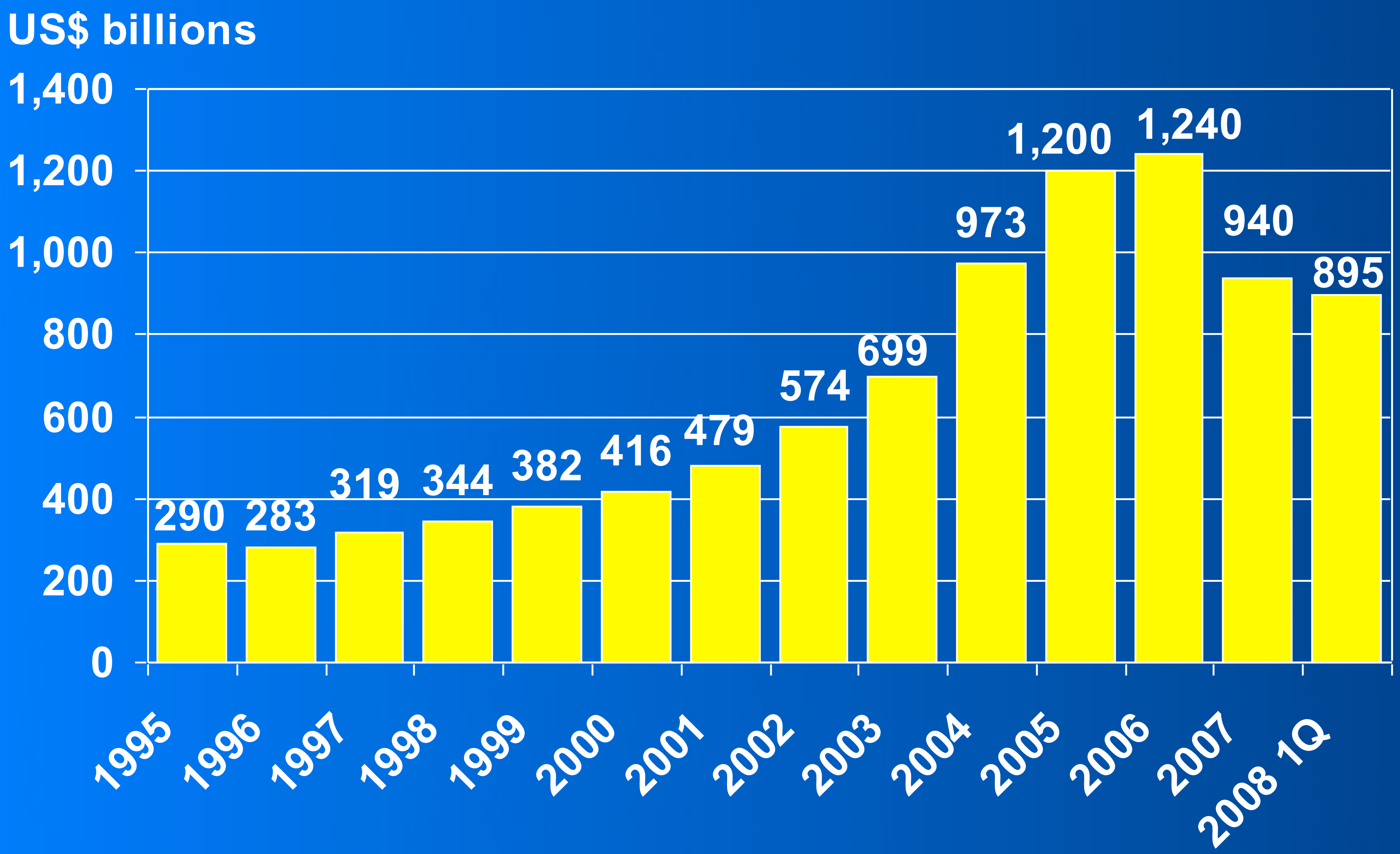


Abnormal relationship signaling a bubble



Monthly Corn Price Index and USDA Stocks

Subprime Mortgage Loans Outstanding

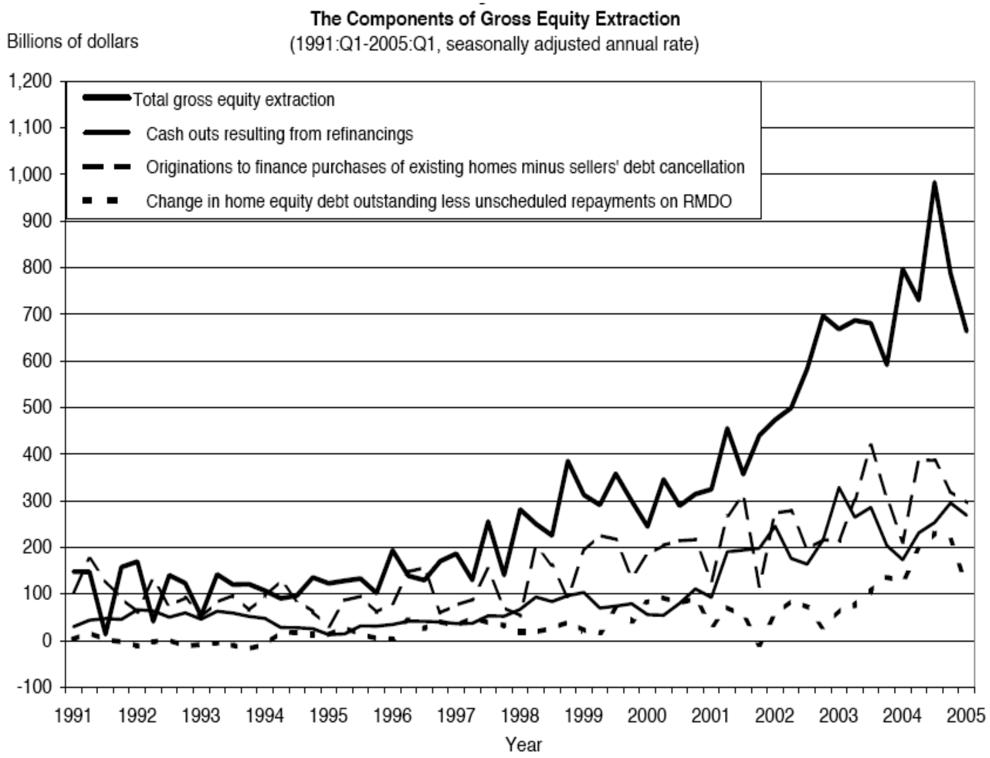


Source: Inside Mortgage Finance.

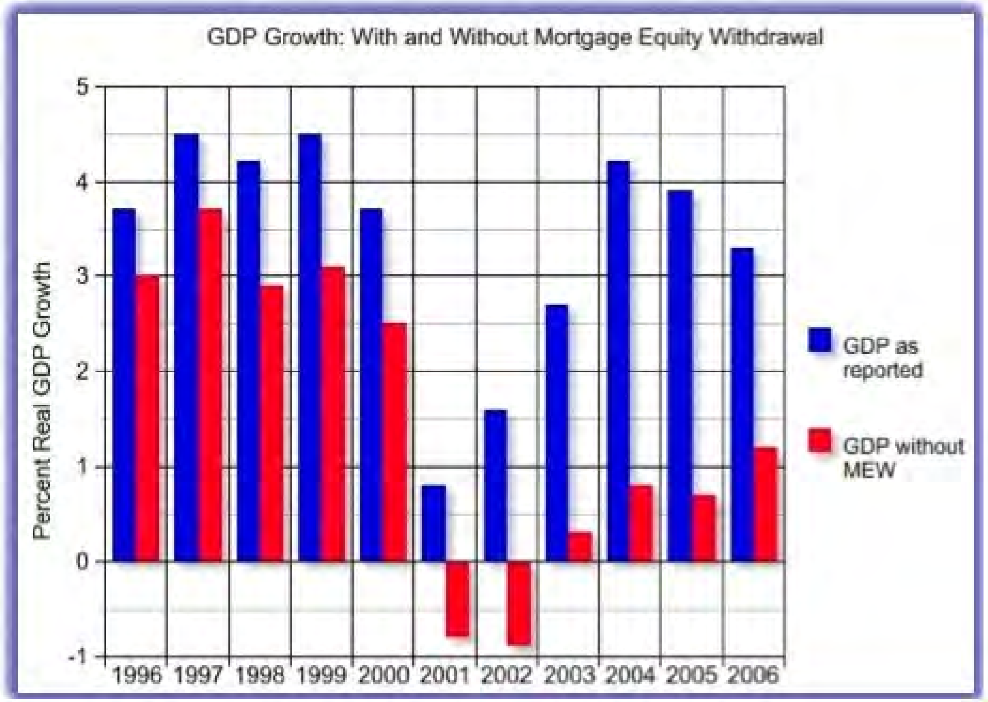
Wealth Extraction

Over the past decade and a half, (B - F) has been closely correlated with realized capital gains on the sale of homes. B-F=change in home equity debt outstanding less unscheduled repayment on RMDO

Mortgage Equity Withdrawal impact on GDP

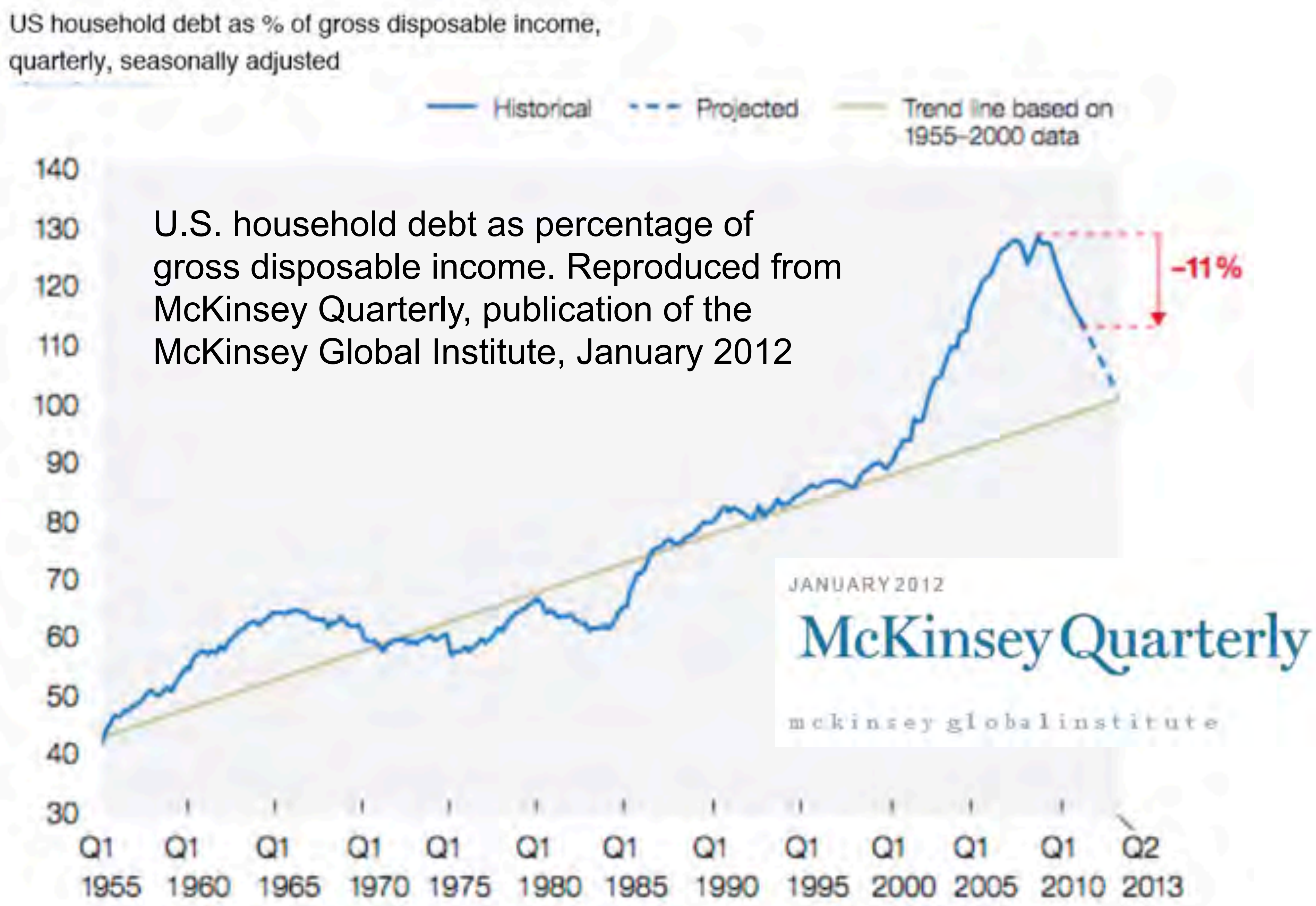


Alan Greenspan and James Kennedy (Nov. 2005)



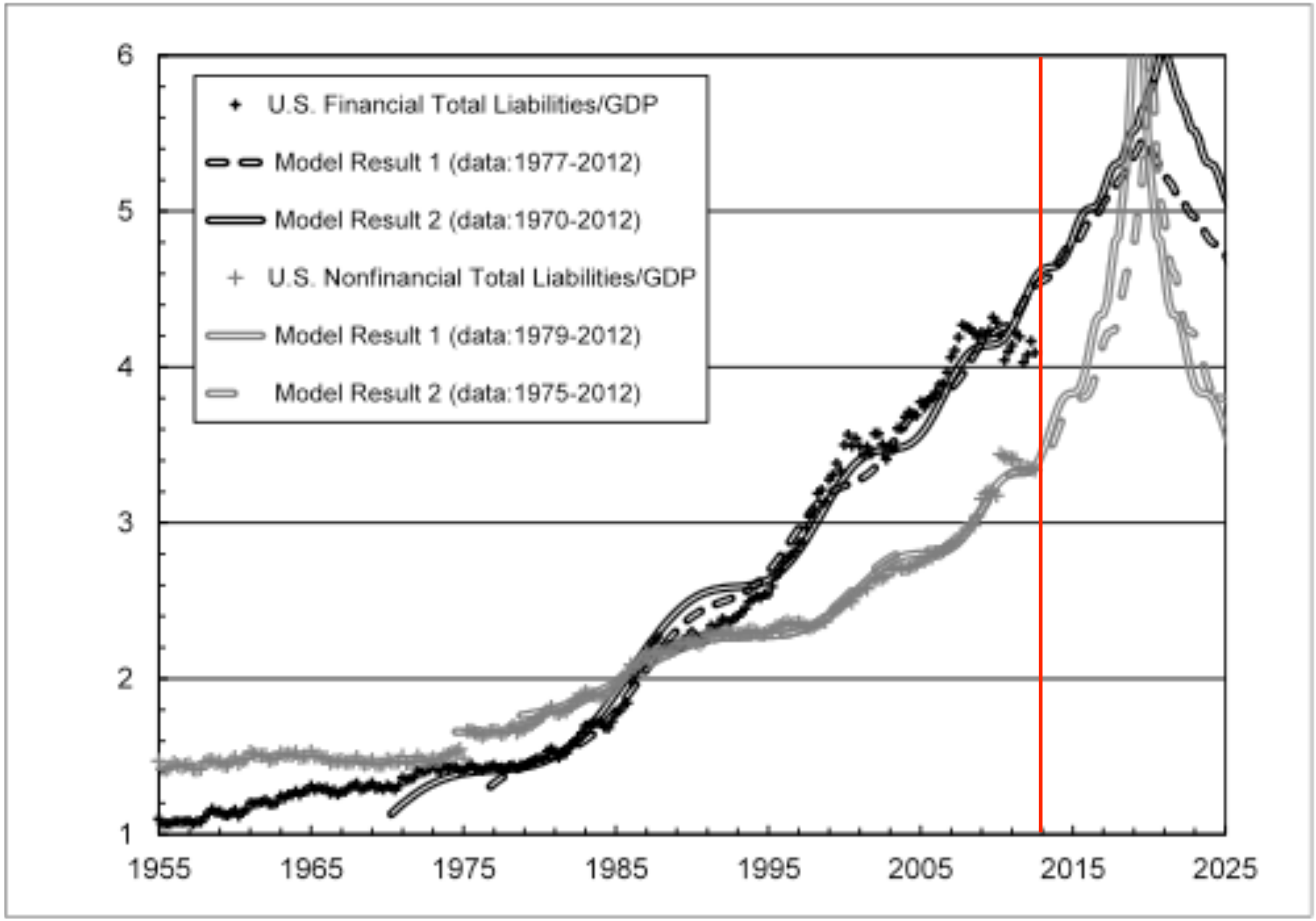
source: John Mauldin (April 09)

1981-2007: The illusionary "PERPETUAL MONEY MACHINE" continues..



Total liabilities of the U.S. financial and non- financial sectors divided by the GDP

The data are taken from the Flow of Funds accounts of the U.S. (http://www.federalreserve.gov/releases/z1/), the non-financial sector includes the federal government, government sponsored entities, household and non-profit and non-financial business. The smooth curves show the fits of the models.

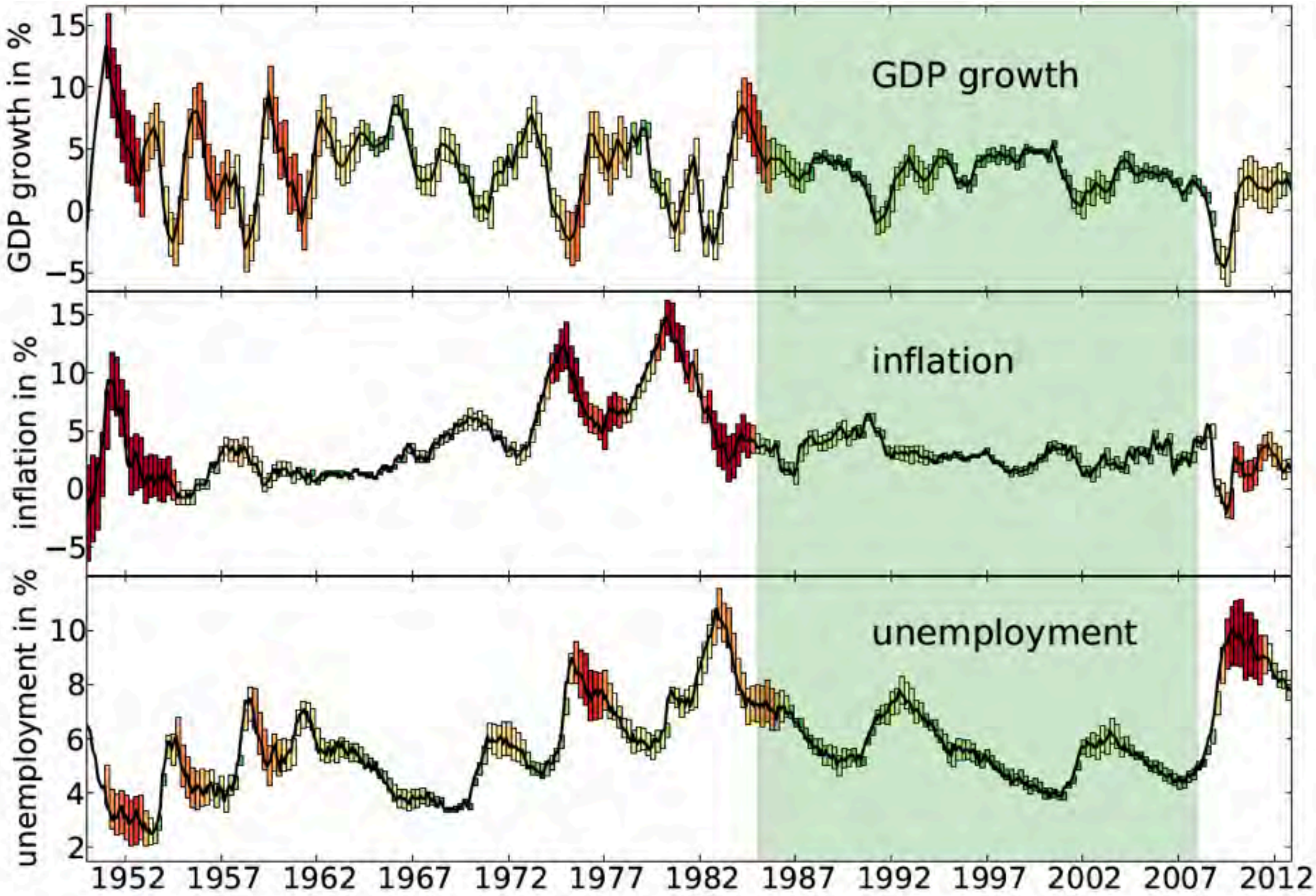


D. Sornette and P. Cauwels, The Illusion of the Perpetual Money Machine, Notenstein Academy White Paper Series (Dec. 2012) (http://ssrn.com/abstract=2191509)

This picture demonstrates that debt levels are on unsustainable tracks that, according to our bubble models, are expected to reach a critical point towards the end of the present decade.

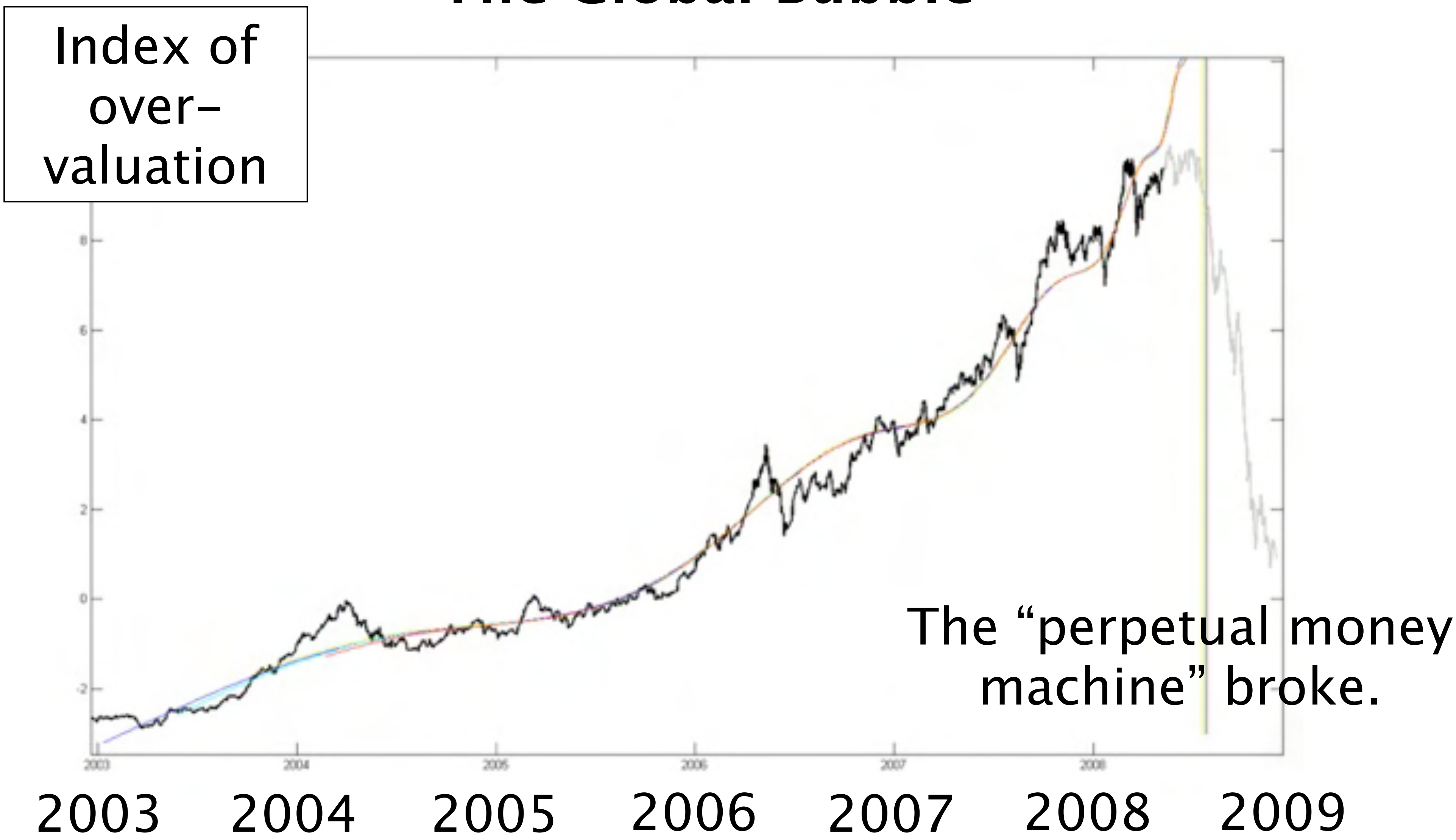

Total U.S. Debt as a % of GDP
annual
$ 50 trillions
360%
340%
320%
300%
280%
260%
240%
220%
200%
180%
160%
140%
120%
100%
2008 Q3 = 358.2
1933 = 299.8
2003 = 306.2
1875 = 156.4
1916 = 170.4
1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
Sources: Bureau of Economic Analysis, Federal Reserve, Census Bureau: Historical Statistics of the United States Colonial Times to 1970. Through Q3 2008.

THE GREAT MODERATION



source: U.S. Bureau of Labor Statistics.

The Global Bubble



PCA first component on a data set containing, emerging markets equity indices, freight indices, soft commodities, base and precious metals, energy, currencies...

D. Sornette and P. Cauwels, The Illusion of the Perpetual Money Machine, Notenstein Academy White Paper Series (Dec. 2012) (http://arxiv.org/abs/1212.2833 and http://ssrn.com/abstract=2191509)

Predictability of the 2007-XXXX crisis: 30 year History of **bubbles** and of **Endogeneity**

- Worldwide bubble (1980-Oct. 1987)
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Notenstein Academy White Paper Series (Dec. 2012)
(http://arxiv.org/abs/1212.2833)

Financial Crisis Observatory

www.er.ethz.ch/fco

D. Sornette
P. Cauwels
Q. Zhang

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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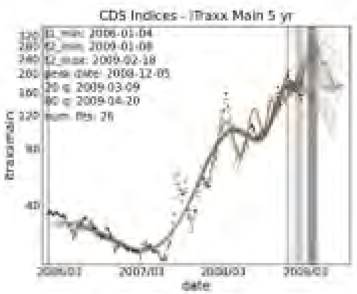
ETH Zurich - D-MTEC - Welcome to the Chair of Entrepreneurial Risks - Financial Crisis Observatory

Financial Crisis Observatory

Financial Crisis Observatory
- Description
- Highlights
- Is there an oil bubble?
- Pertinent articles
- Websites and Blogs
- Market Anxiety Measures

The Financial Crisis Observatory (FCO) is a scientific platform aimed at testing and quantifying rigorously, in a systematic way and on a large scale the hypothesis that financial markets exhibit a degree of inefficiency and a potential for predictability, especially during regimes when bubbles develop.

Current analysis and forecasts



CDS (19 February 2009)
Our analysis has been performed on data kindly provided by Amjed Younis of Fortis on 19 February 2009. It consists of 3 data sets: credit default swaps (CDS); German bond futures prices; and spread evolution of several key euro zone sovereigns. The date range of the data is between 4 January 2006 and 18 February 2009. Our log-periodic power law (LPPL) analysis shows that credit default swaps appear bubbly, with a projected crash window of March-May, depending on the index used. German bond futures and European sovereign spreads do not appear bubbly. (See report for more information.)

OIL (27 May 2008)
Oil prices exhibited a record rise followed by a spectacular crash in 2008. The peak of $145.29 per barrel was set on 3 July 2008 and a recent low of $40.81 was scraped on 5 December, a level

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- ***Hypothesis H1*: financial (and other) bubbles can be diagnosed in real-time before they end.**

- ***Hypothesis H2*: The termination of financial (and other) bubbles can be bracketed using probabilistic forecasts, with a reliability better than chance (which remains to be quantified).**

The Financial Bubble Experiment

advanced diagnostics and forecasts of bubble terminations

- ***Time@Risk*: Development of dynamical risk management methods**

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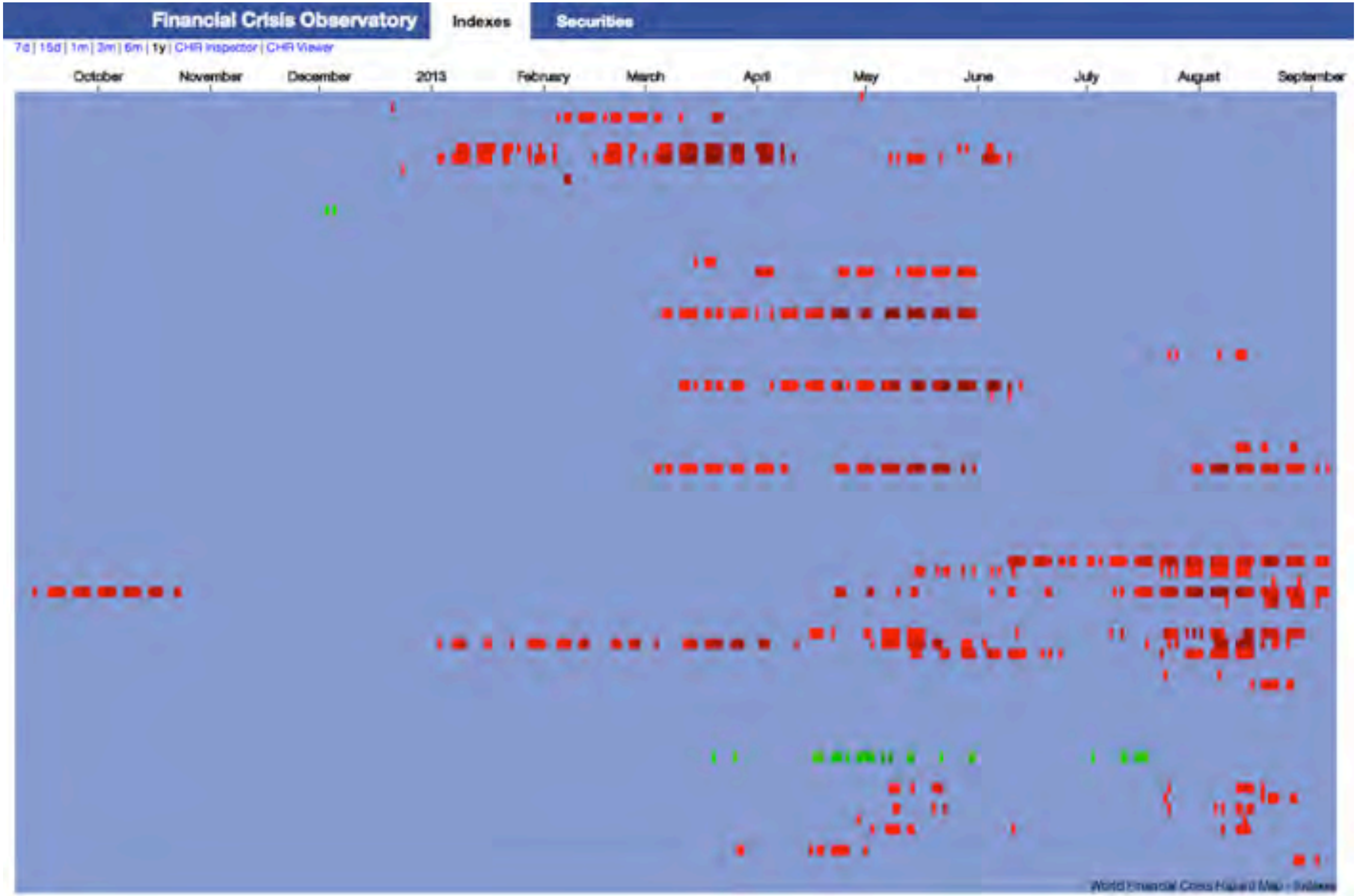

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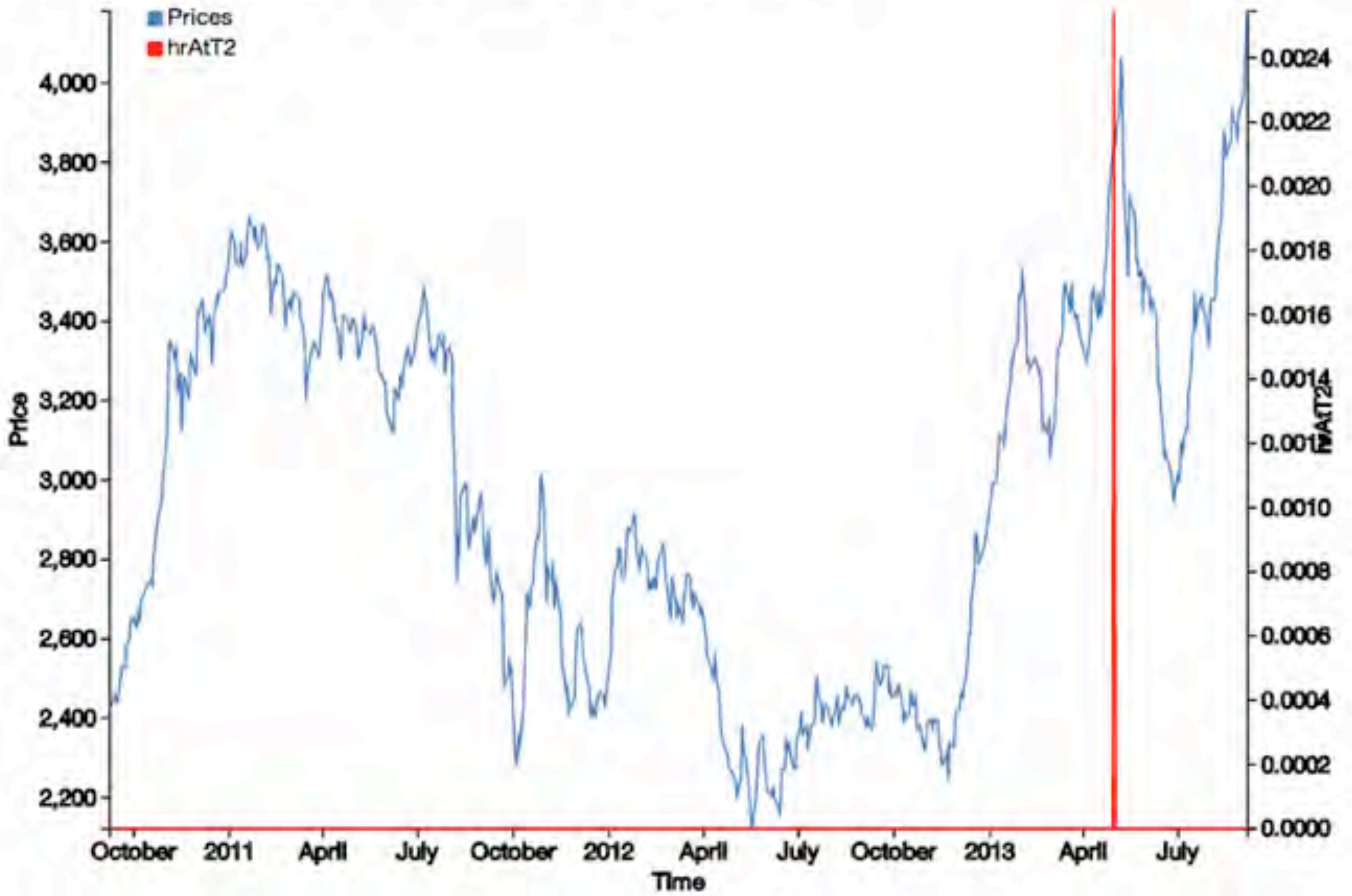

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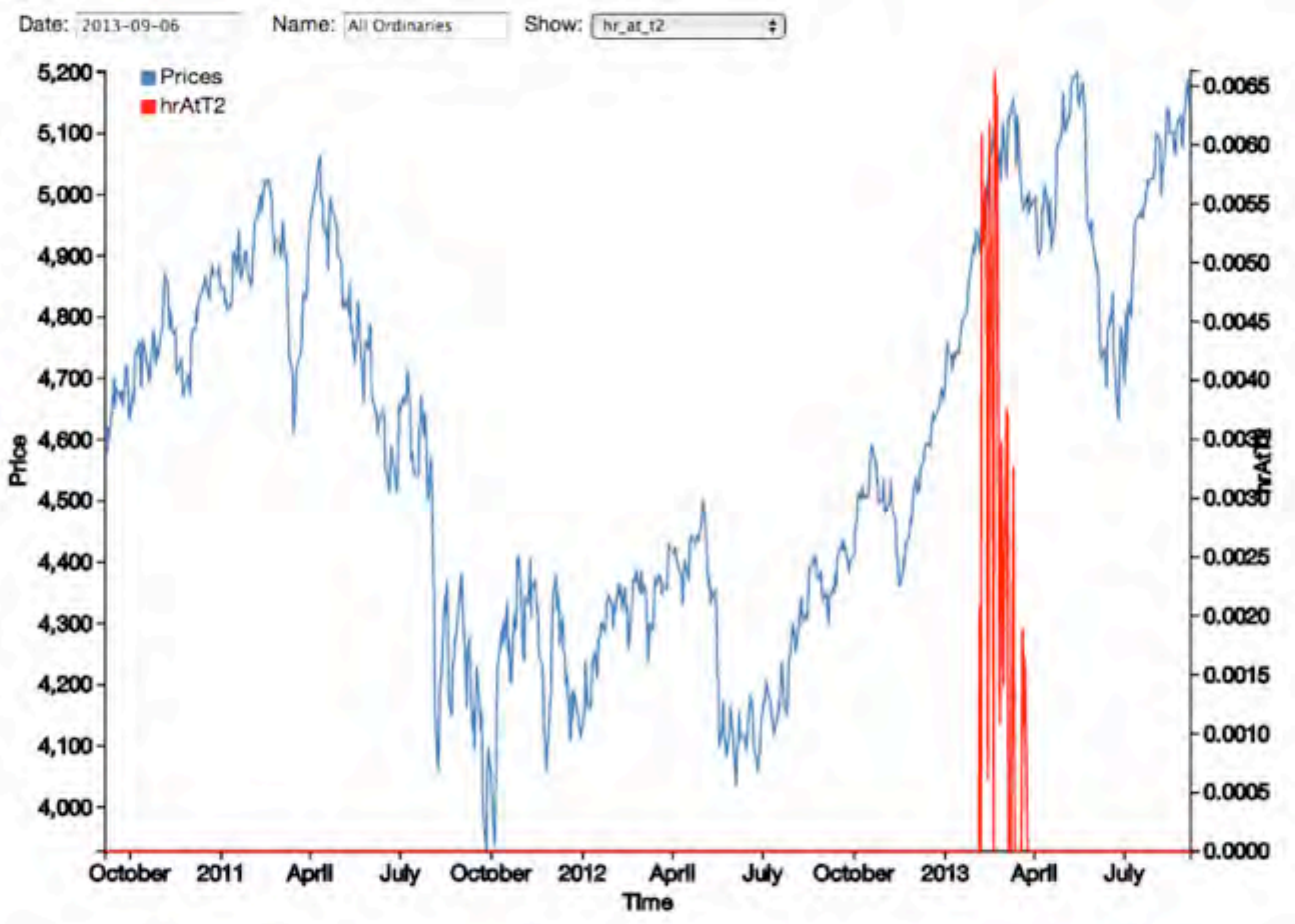

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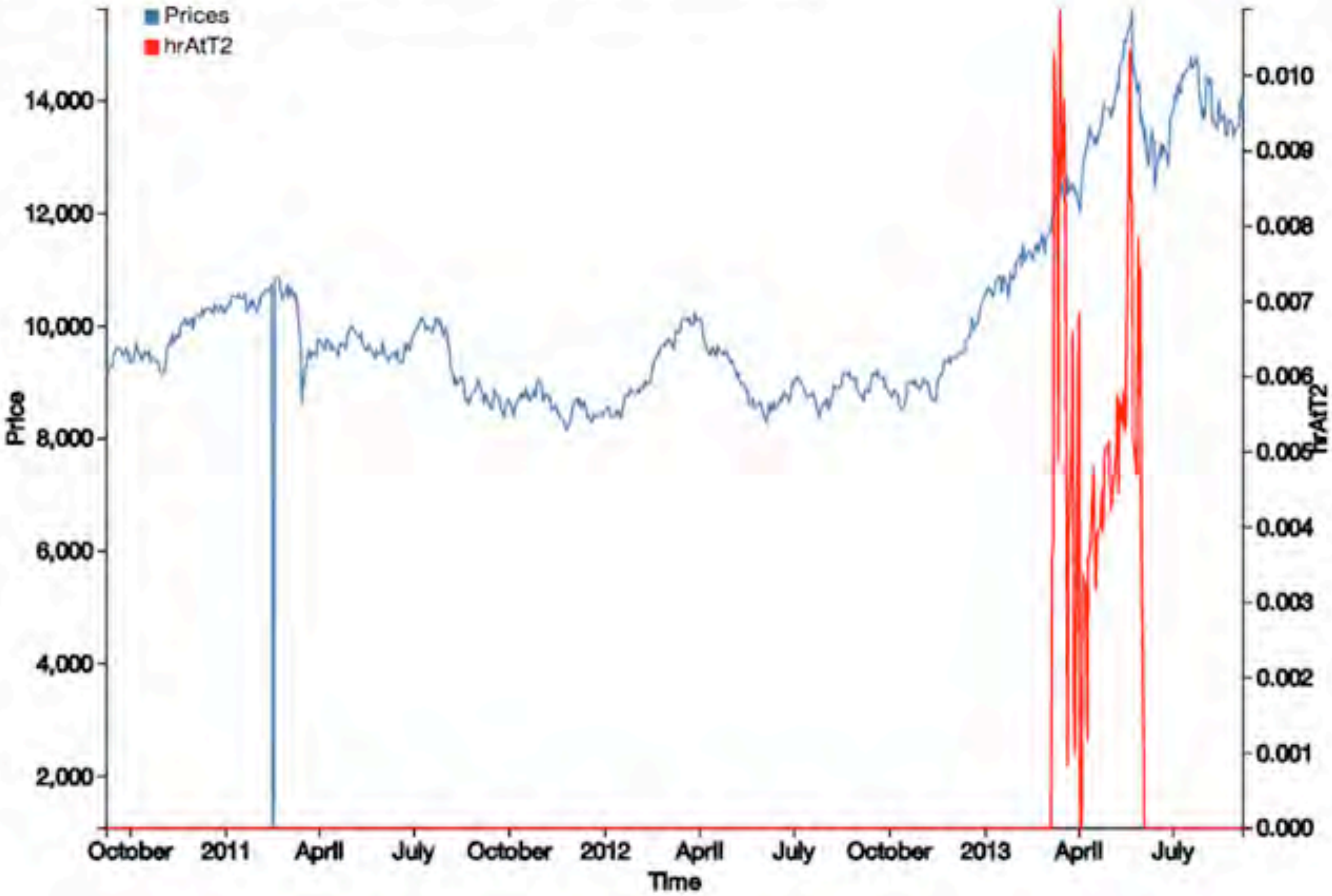
Date: 2013-09-08 Name: Nikkei 225, Tokyo Show: hr_at_t2



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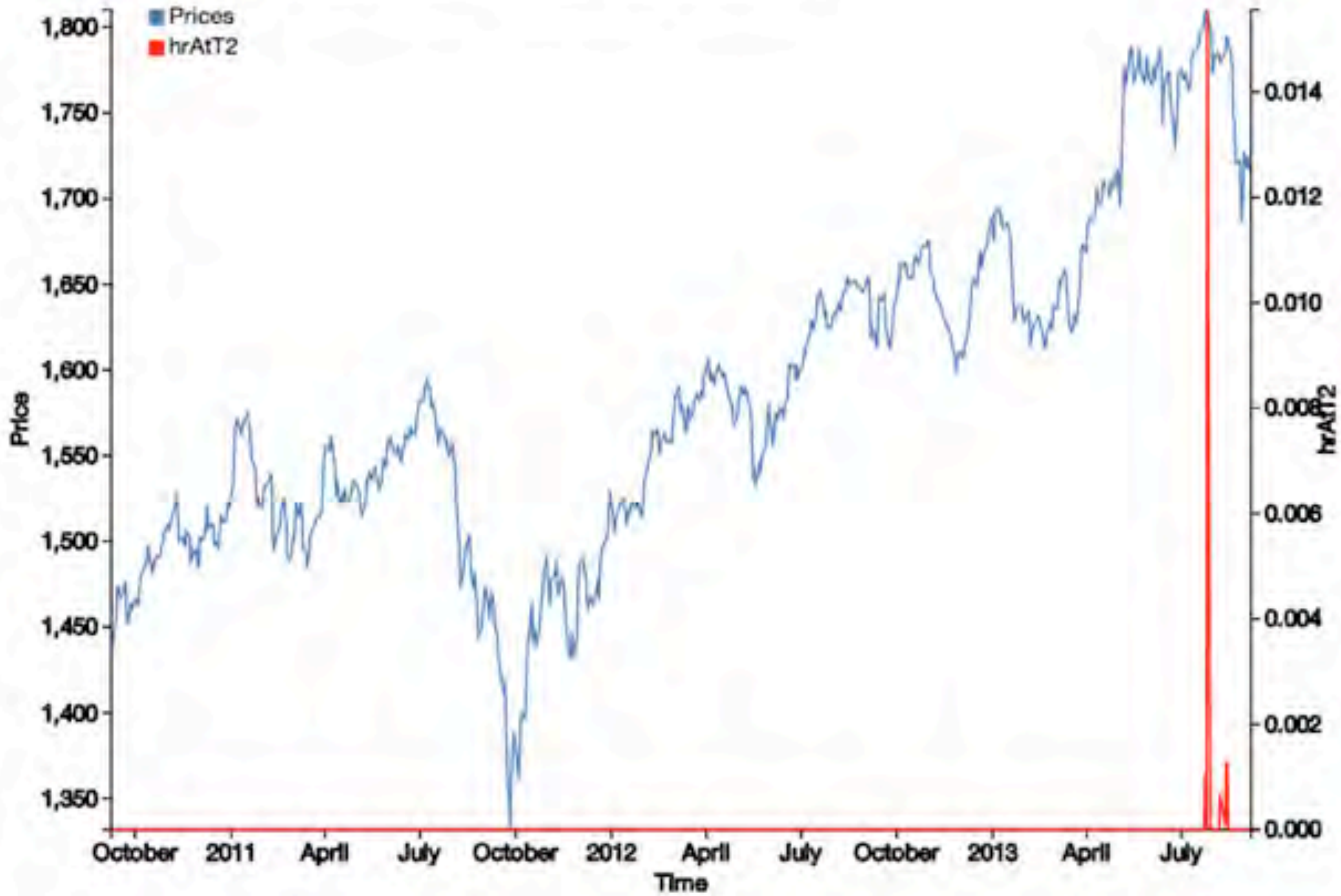

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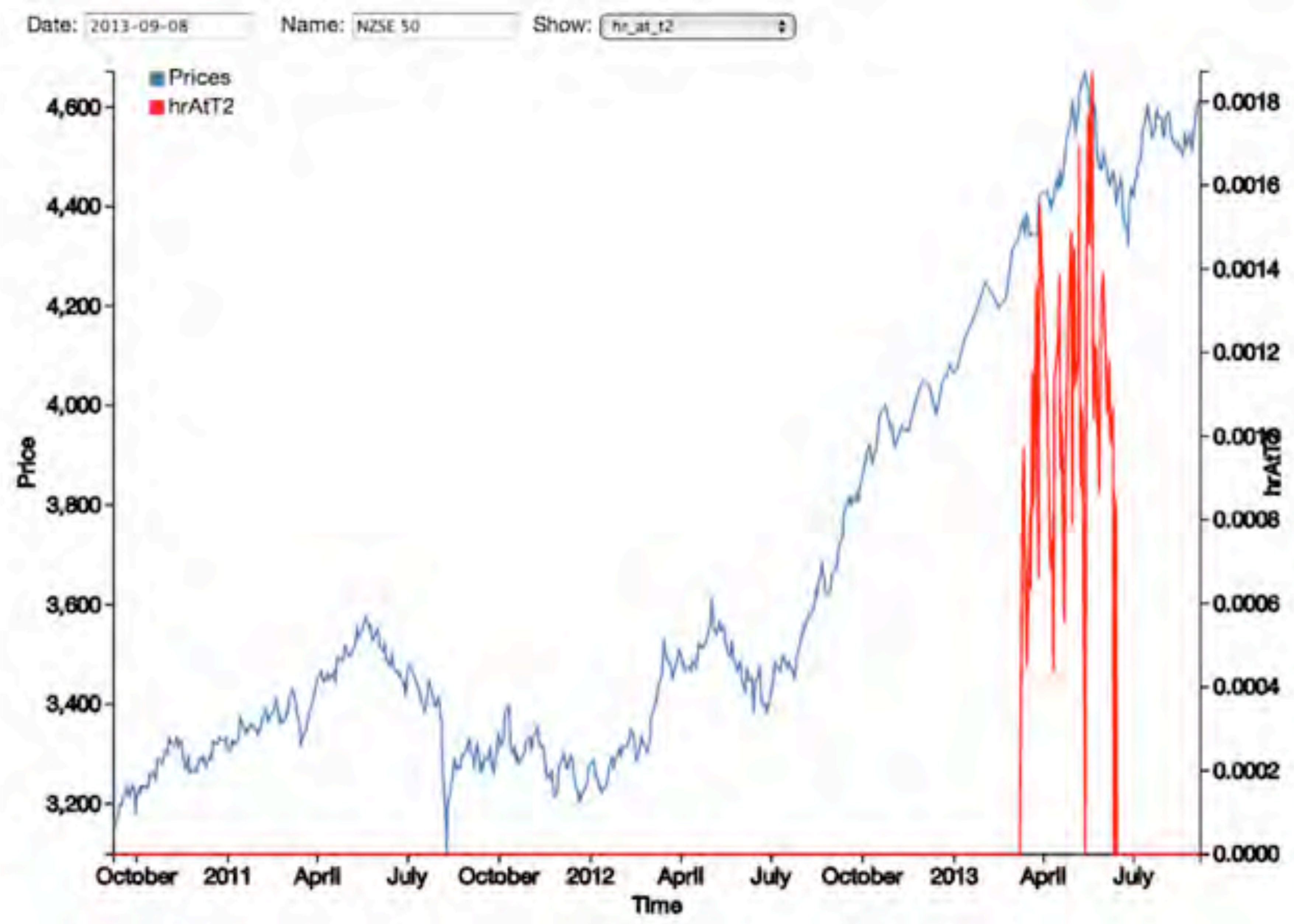

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Date: 2013-09-08 Name: NASDAQ Composite Show: hr_at_t2

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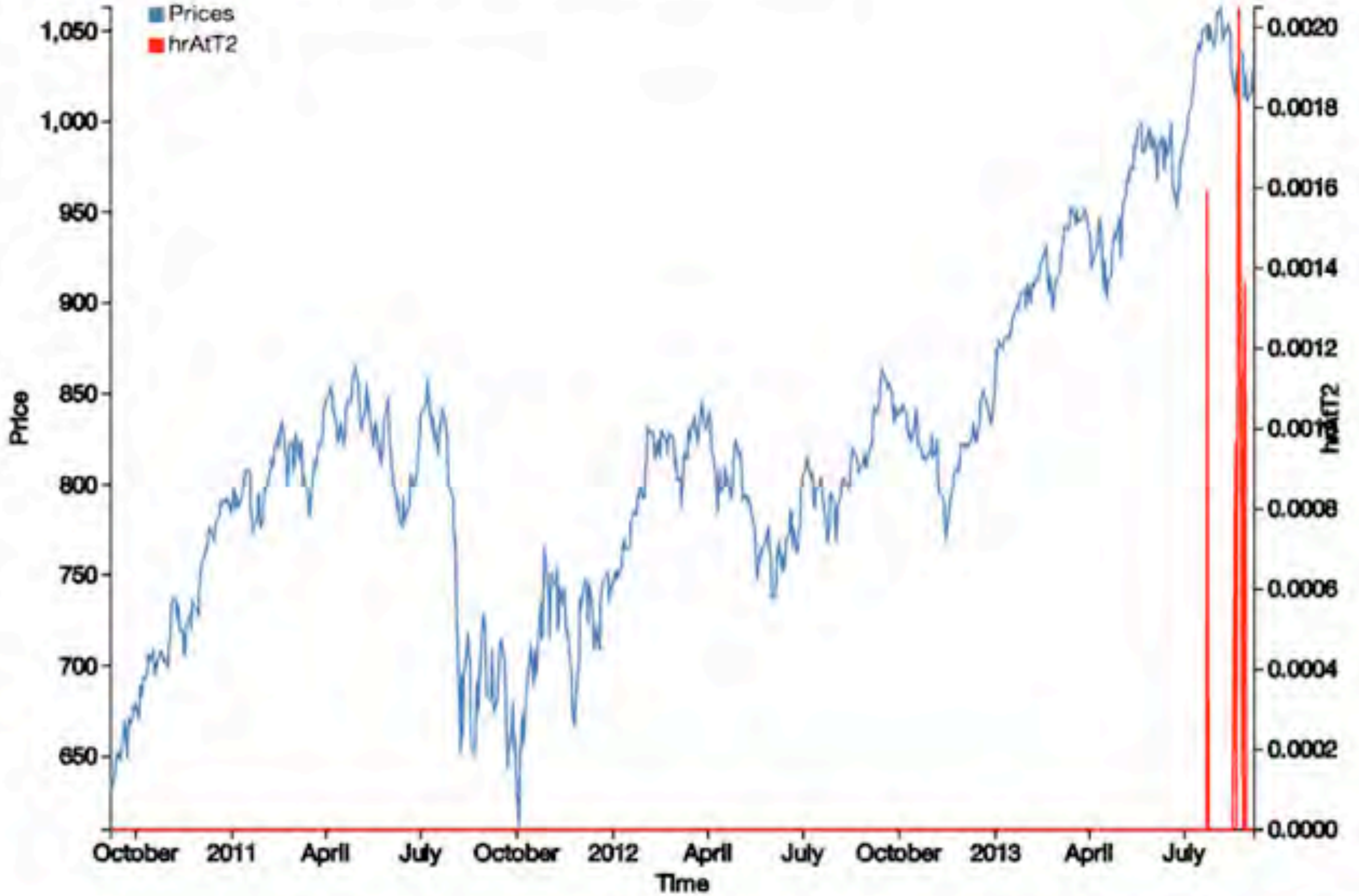
Date: 2013-09-07 Name: Russell 2000 Index Show: hr_at_t2



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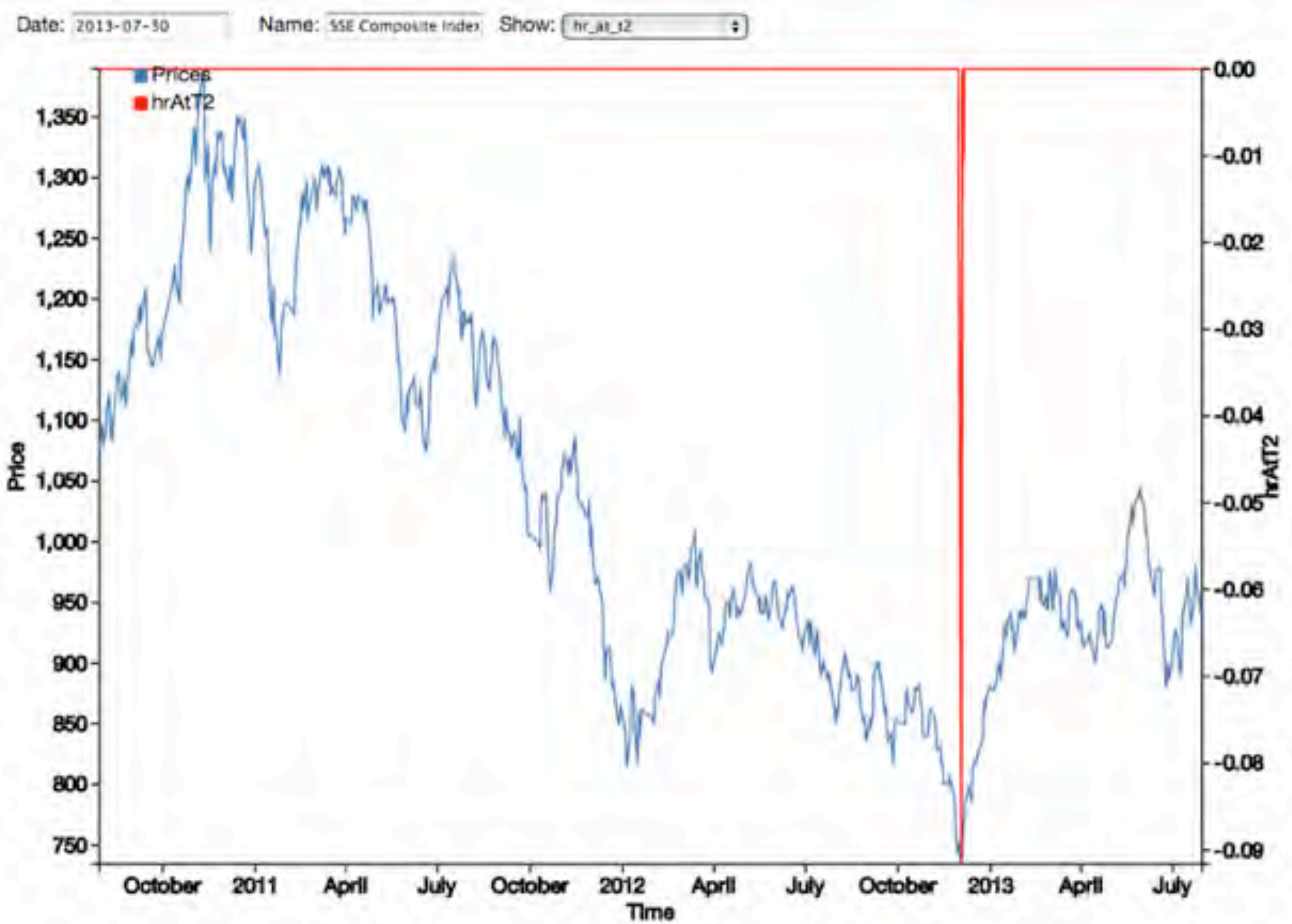

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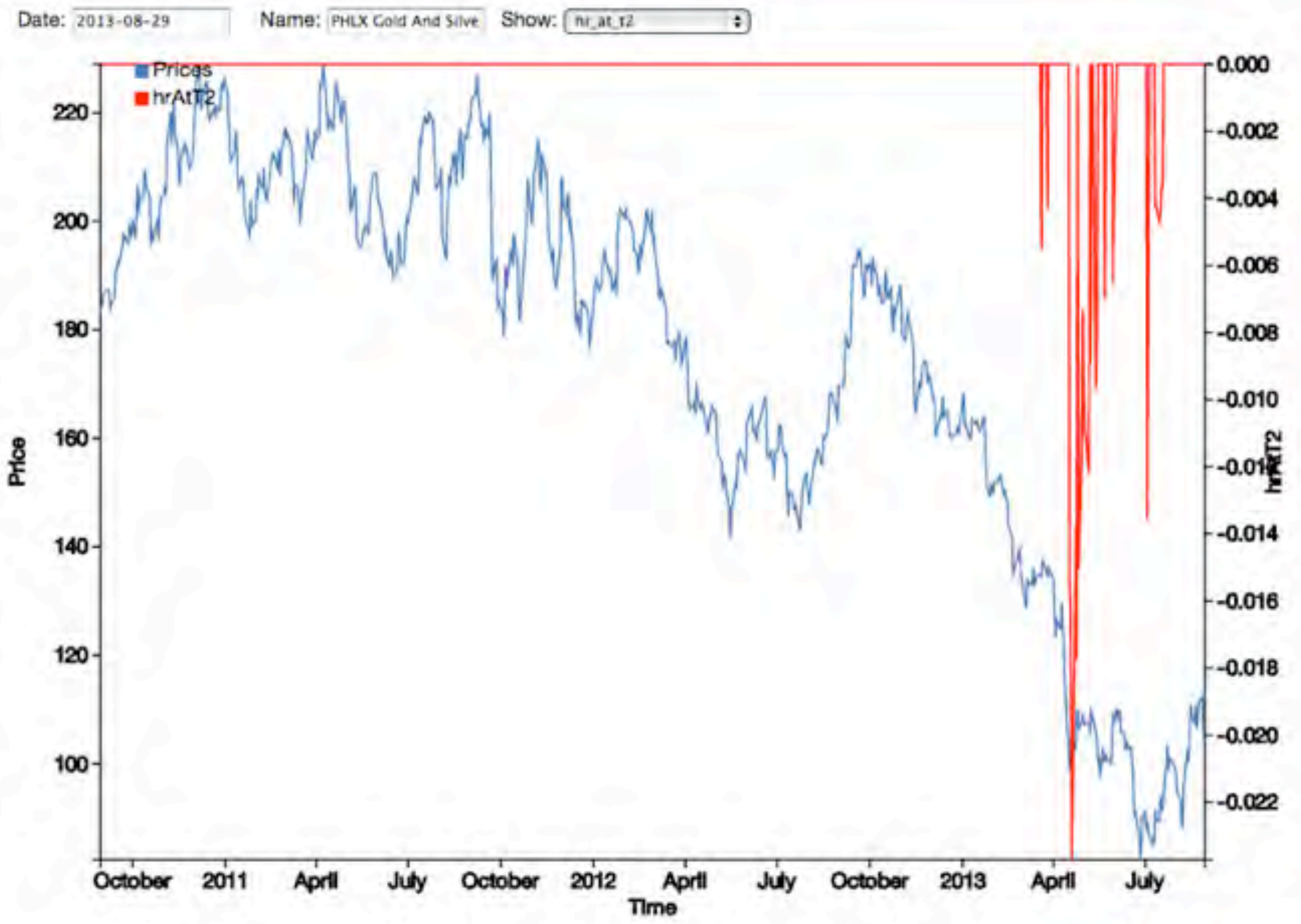
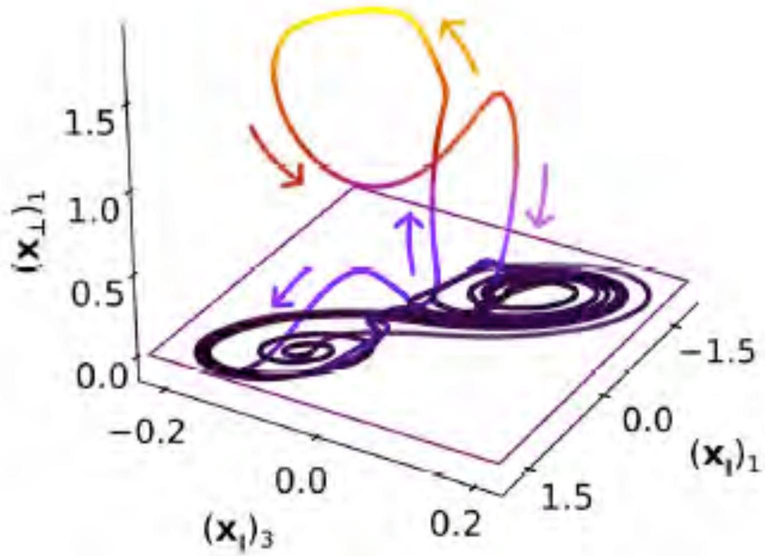


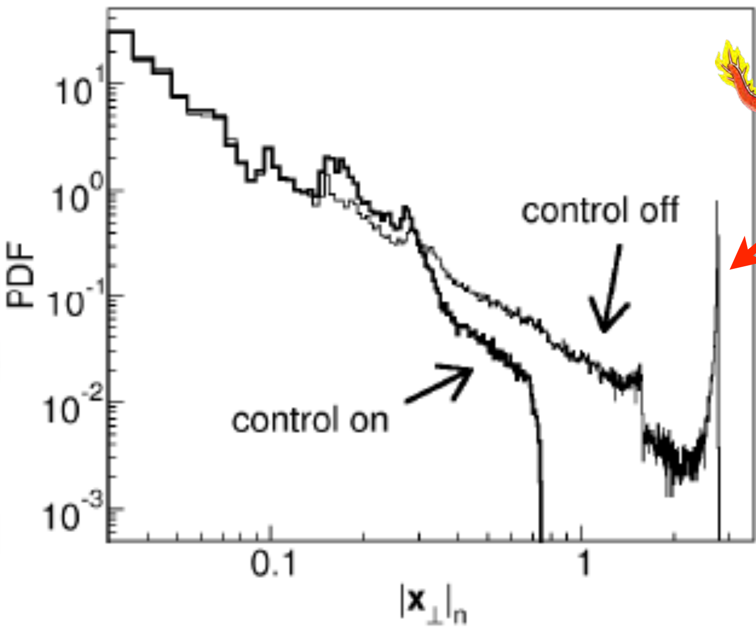
Slaying dragon-kings

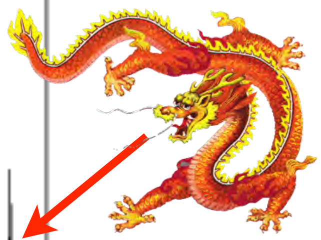
predictability and control of extreme events in complex systems



possibility to control by small targeted perturbations







Hugo L. D. de S. Cavalcante, Marcos Oriá, Didier Sornette, and Daniel J. Gauthier (2013)

Big problems are piling up...

Suggested solutions:

- Study history ("this time is different", really?)
- Recognition that crises are the norms rather than the exception
- Understand underlying mechanisms (positive feedbacks are grossly under-estimated)
- Diagnostic: fundamental vs proximal
- Weak signal, advance warning and collective processes
- Monitoring and forecasting (managing and governing needs predicting)
- Decouple and diversify
- Fiduciary principle; principled ethical behavior; reassessment of expectations; risk monitoring
- Incentives + human cognitive biases + individual resilience

Further Reading

D. Sornette, Dragon-Kings, Black Swans and the Prediction of Crises, International Journal of Terraspace Science and Engineering 2(1), 1-18 (2009) (http://arXiv.org/abs/0907.4290) and http://ssrn.com/abstract=1470006)

D. Sornette and G. Ouillon, Dragon-kings: mechanisms, statistical methods and empirical evidence, Eur. Phys. J. Special Topics 205, 1-26 (2012) (http://arxiv.org/abs/1205.1002 and http://ssrn.com/abstract=2191590)

D. Sornette and G. Ouillon, editors of the special issue of Eur. Phys. J. Special Topics on ``Discussion and debate: from black swans to dragon-kings - Is there life beyond power laws?'', volume 25, Number 1, pp. 1-373 (2012). http://www.springerlink.com/content/d5x6386kw2055740/?MUD=MP

D. Sornette and R. Woodard Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis, in Proceedings of APFA7 (Applications of Physics in Financial Analysis), "New Approaches to the Analysis of Large-Scale Business and Economic Data," M. Takayasu, T. Watanabe and H. Takayasu, eds., Springer (2010) (http://arxiv.org/abs/0905.0220))

D. Sornette and P. Cauwels, The Illusion of the Perpetual Money Machine, Notenstein Academy White Paper Series (Dec. 2012) http://arxiv.org/abs/1212.2833 and http://ssrn.com/abstract=2191509)

Didier Sornette, Why Stock Markets Crash (Critical Events in Complex Financial Systems) Princeton University Press, January 2003

Y. Malevergne and D. Sornette, Extreme Financial Risks (From Dependence to Risk Management) (Springer, Heidelberg, 2006).