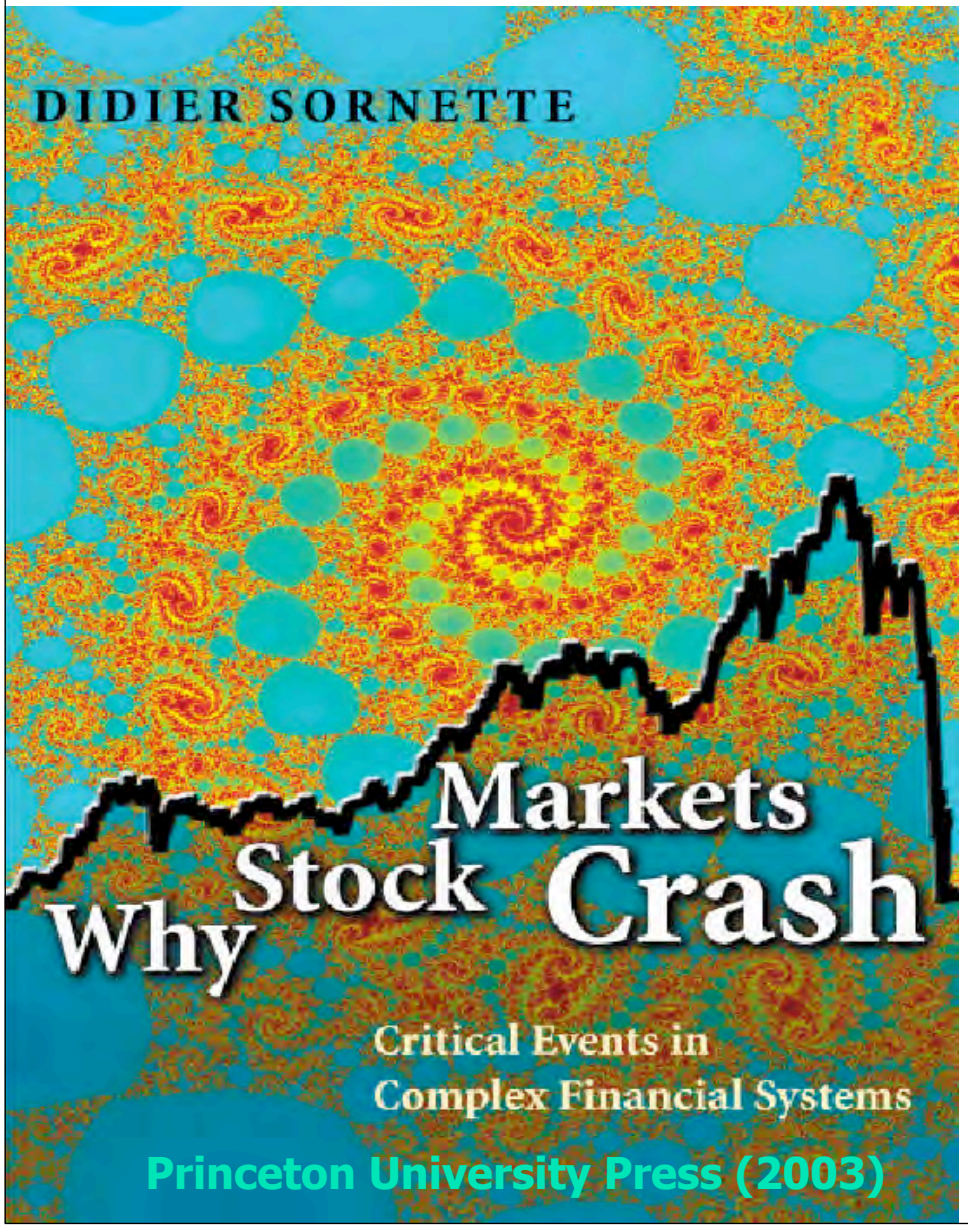
Physics and Financial Economics (1776-2011)

Inter-breeding, Discoveries and Open Problems



D. Sornette

Professor of Entrepreneurial Risks at ETH Zurich

Professor of Finance at the Swiss Finance Institute

Director of the Financial Crisis Observatory

Founding member of the Risk Center at ETH Zurich (June 2011) (www.riskcenter.ethz.ch)

Professor of Geophysics associated with the Department of Earth Sciences (D-ERWD), ETH Zurich

Professor of Physics associated with the Department of Physics (D-PHYS), ETH Zurich

Education

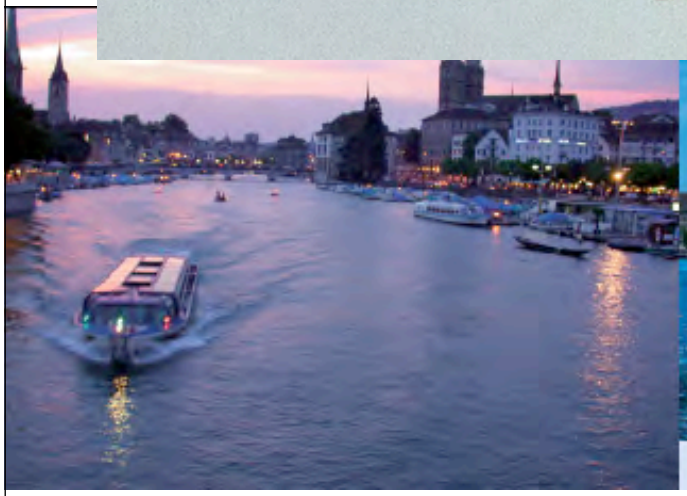
16,342 students
3,507 doctoral students
41 master programs

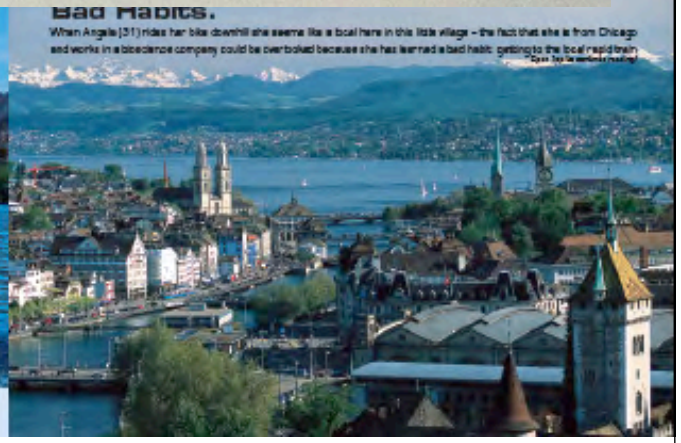
Research

16 departments
413 professors
4,500 scientists
Over 80 nationalities

Knowledge/ Technology Transfer

> 100 spin-offs since 2006
> 60 patents (2010)
> 60 license agreements
300 cooperation treaties





ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

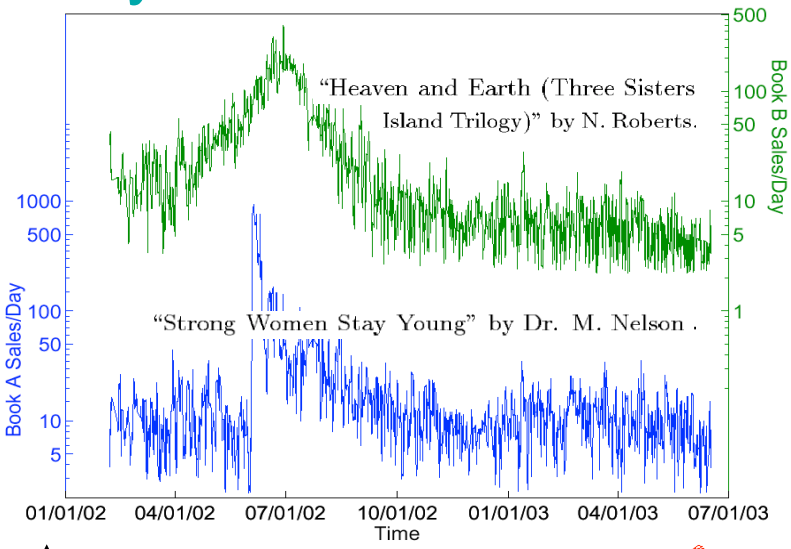
ETH Zurich, an academic attraction

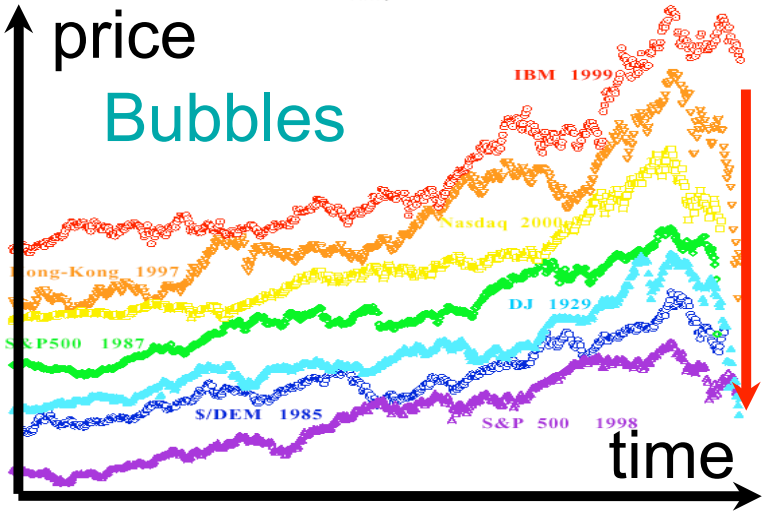
Number of students steady rising

		2006	2010	Growth
Education	Students	12 826	16 342	27 %
	New entries engineering studies	1065	1733	63 %
Research	Scientific staff	3858	4479	16 %
	Professors	359	413	15 %
Knowledge transfer	Spin-offs (2006 to 2010)	104		

- Collective dynamics and organization of social agents (Commercial sales,YouTube, Open source softwares, Cyber risks)
- Agent-based models of bubbles and crashes, credit risks, systemic risks
- Prediction of complex systems, stock markets, social systems
- Asset pricing, hedge-funds, risk factors…
- Human cooperation for sustainability
- Natural and biological hazards (earthquakes, landslides, epidemics, critical illnesses…)

Dynamics of success





(3 guest-professors, 5 foreign associate professors,
3 post-docs, 3 senior researchers, 12 PhD students, ~12 Master students/year)

ECONOMICS

Adam Smith "Inquiry into the Nature and Causes of the Wealth of Nations" (1776)

•Francis Edgeworth and Alfred Marshall (1890) develop the concept of equilibrium

•"everything in the economy affects everything else"

•Vilfredo Pareto (1897): power law distribution of incomes

•Louis Bachelier (1900): random walk model of Paris stock market and solution of diffusion equation

•Benoit Mandelbrot (1963) proposes heavy-tailed distributions (Levy stable laws) for the pdf of cotton returns

•initially supported by Merton Miller, Eugene Fama, and Richard Roll (Chicago), Paul Samuelson (MIT), and Thomas Sargent (Carnegie Mellon), but opposition from Paul Cootner and Clive Granger;

•distributions of returns are becoming closer to the Gaussian law at timescales larger than one month.

PHYSICS

•Isaac Newton Philosophiae Naturalis Principia Mathematica (1687) [(novel at the time) notion of causative forces]

•Clerk Maxwell and Ludwig Boltzmann (1871-1875): equilibrium in gases

•mean-field theory or self-consistent effective medium methods

•distribution of event sizes (earthquakes, avalanches, landslides, storms, forest fires, solar flares, commercial sales, war sizes, ...)

•Einstein (1905): theory of Brownian motion

•Benoit Mandelbrot (1977): Fractals

•Much of the efforts in the econophysics (1993-2000s) refined the Levy hypothesis into

$$\mathrm{pdf}(r) \sim 1/r^3$$

ECONOMICS

PHYSICS

Adam Smith (1776)
"Inquiry into the Nature and Causes of the Wealth of Nations"

Isaac Newton (1687)

Philosophiae Naturalis Principia Mathematica

notion of causative forces

(novel at the time)

ECONOMICS		PHYSICS
Francis Edgeworth and Alfred Marshall (1890) develop the concept of equilibrium	←	Clerk Maxwell and Ludwig Boltzmann (1871-1875) equilibrium in gases
"everything in the economy affects everything else"	↔	mean-field theory or self-consistent effective medium methods

Equilibrium

ECONOMICS

PHYSICS

Vilfredo Pareto (1897)
power law distribution of incomes

distribution of event sizes (earthquakes, avalanches, landslides, storms, forest fires, solar flares, commercial sales, war sizes, ...)

Non-Gaussian heavy tailed distributions

ECONOMICS

PHYSICS

Louis Bachelier (1900)
random walk model of
Paris stock market and
solution of diffusion
equation

Einstein (1905)
theory of Brownian motion

Theory of random walks and diffusion equation

ECONOMICS

Benoit Mandelbrot (1963)
Heavy-tailed distributions (Levy stable laws) for the pdf of cotton returns

initially supported by Merton Miller, Eugene Fama, and Richard Roll (Chicago), Paul Samuelson (MIT), and Thomas Sargent (Carnegie Mellon), but opposition from Paul Cootner and Clive Granger

distributions of returns are becoming closer to the Gaussian law at timescales larger than one month.

PHYSICS

Benoit Mandelbrot (1977)
Fractals

Much of the efforts of econophysicists (1993-2000s) refined the Levy hypothesis into

$$\mathrm{pdf}(r) \sim 1/r^3$$

self-similarity

ECONOMICS

-Paul Krugman (1996)
"Self-organizing economy"
-Brian Arthur (1992)
Induction, out-of-equilibrium
-Santa Fe Institute (1994-...)

PHYSICS

P. W. Anderson (1957)
"More is different" (1972)
-Out-of-Equilibrium
-frozen heterogeneity
(spinglasses, glasses, proteins)

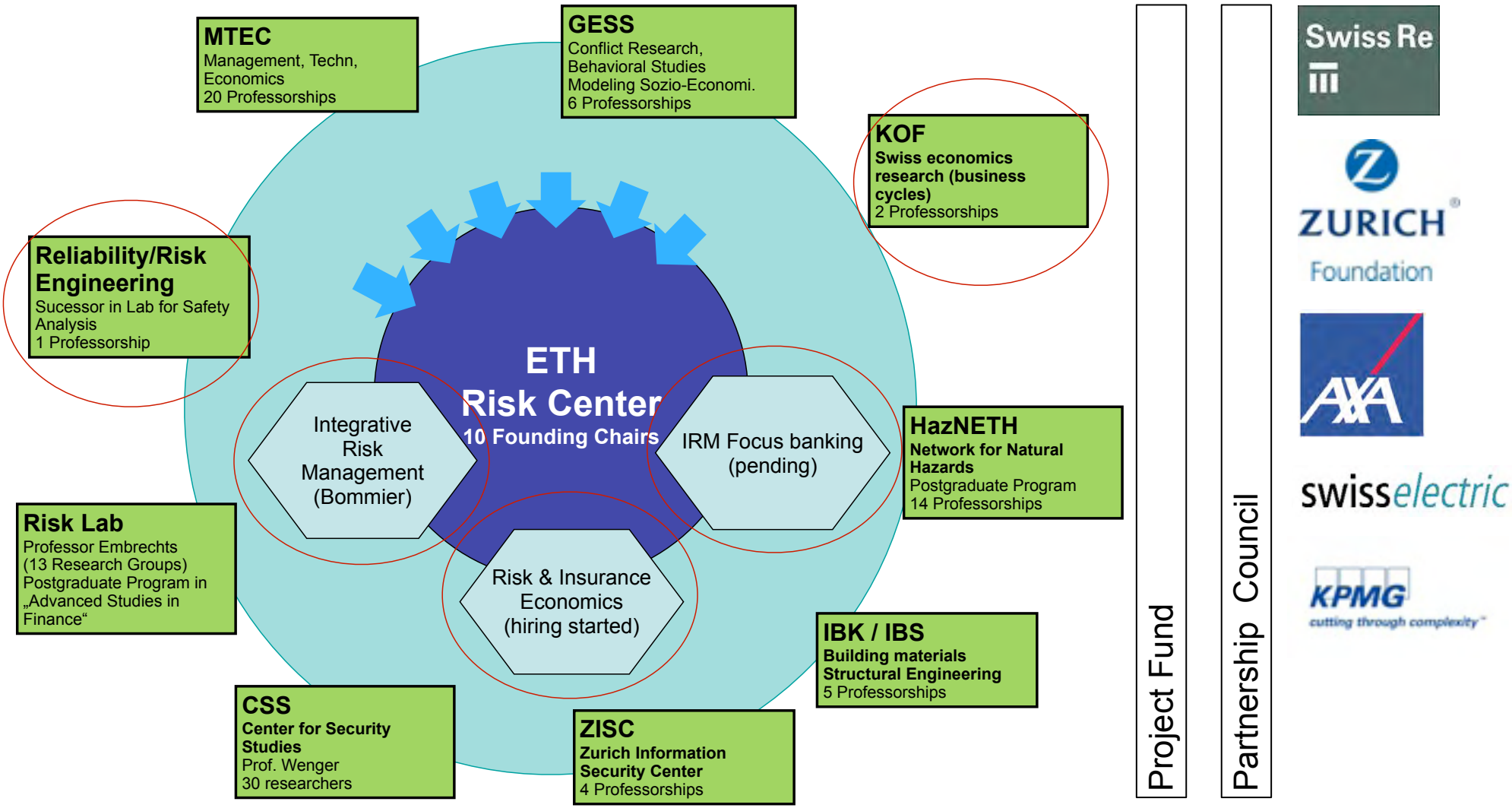
Out-of-equilibrium, frozen heterogeneity,
Self-organization, phase transitions ....

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

ETH Foundation Zürich

ETH Risk Initiative

Vision: World-leading, inspiring nucleus for integrative risk research and teaching



THE EXPERTISE OF TEN PROFESSORS FROM FIVE DEPARTMENTS

PROF. DR. WOLFGANG KRÖGER
Managing Director
Former Head of Laboratory for Safety Analysis, Founding Rector of the International Risk Governance Council

D-MTEC

DEPARTMENT OF MANAGEMENT, TECHNOLOGY AND ECONOMICS

D-BAUG

DEPARTMENT OF CIVIL, ENVIRONMENTAL AND GEOMATIC ENGINEERING

D-GESS

DEPARTMENT OF HUMANITIES, SOCIAL AND POLITICAL SCIENCES

D-MATH

DEPARTMENT OF MATHEMATICS

D-UWIS

DEPARTMENT OF ENVIRONMENTAL SCIENCES

D-BAUG

PROF. DR. KAY AXHAUSEN
Founding Member
Institute for Transport Planning and Systems

D-MTEC

PROF. DR. ANTOINE BOMMIER
Founding Member / Steering Commitee
Chair of Integrative Risk Management and Economics

D-GESS

PROF. DR. LARS-ERIK CEDERMAN
Founding Member
Chair of International Conflict Research

D-MATH

PROF. DR. PAUL EMBRECHTS
Founding Member / Steering Commitee
Professor of Mathematics

D-MTEC

PROF. DR. HANS GERSBACH
Founding Member
Chair of Macroeconomics: Innovation and Policy

D-UWIS

PROF. DR. H.R. HEINIMANN
Founding Member / Chair of Steering Commitee
Chair of Forest Engineering

D-GESS

PROF. DR. DIRK HELBING
Founding Member / Steering Commitee
Chair of Sociology, specialization in Modeling and Simulation

D-BAUG

PROF. DR. HANS J. HERRMANN
Founding Member / Steering Commitee
Chair of Computational Physics

D-MTEC

PROF. DR. FRANK SCHWEITZER
Founding Member
Chair of Systems Design

D-MTEC

PROF. DR. DIDIER SORNETTE
Founding Member
Chair of Entrepreneurial Risks

ETH RISK CENTER

A partial lists of achievements of Econophysics

- scaling laws, “universality”
- agent-based models, induction, evolutionary models [1, 9, 11, 21],
- minority games [8],
- option theory for incomplete markets [4, 6],
- “string theory” of interest rate curves [5, 38],
- theory of Zipf law and its economic consequences [12, 13, 27],
- theory of large price fluctuations [14],
- theory of bubbles and crashes [17, 22, 40],
- random matrix theory applied to covariance of returns [20, 36, 37],
- methods and models of dependence between financial assets [25, 43].

G. Daniel and D. Sornette, Econophysics: historical perspectives, in the Encyclopedia of Quantitative Finance, edited by Rama Cont (www.wiley.com/go/eqf), Section: History of Quantitative Modeling (1st section out of 21), edited by Perry Mehrling and Murad Taqqu (http://arXiv.org/abs/0802.1416)

A partial lists of achievements of Econophysics

Need for econophysics results and insights to be known

Strategy: team up with economists to develop rigorous statistical approachs and publish in top financial or economic journals

Reach beyond physics and marry with other disciplines

Physics is no-more the Queen of sciences.

Examples: role of financial firms to influence the rest of the economy; networks of networks and fragility versus robustness; critical phenomena...

FOUR EXAMPLES

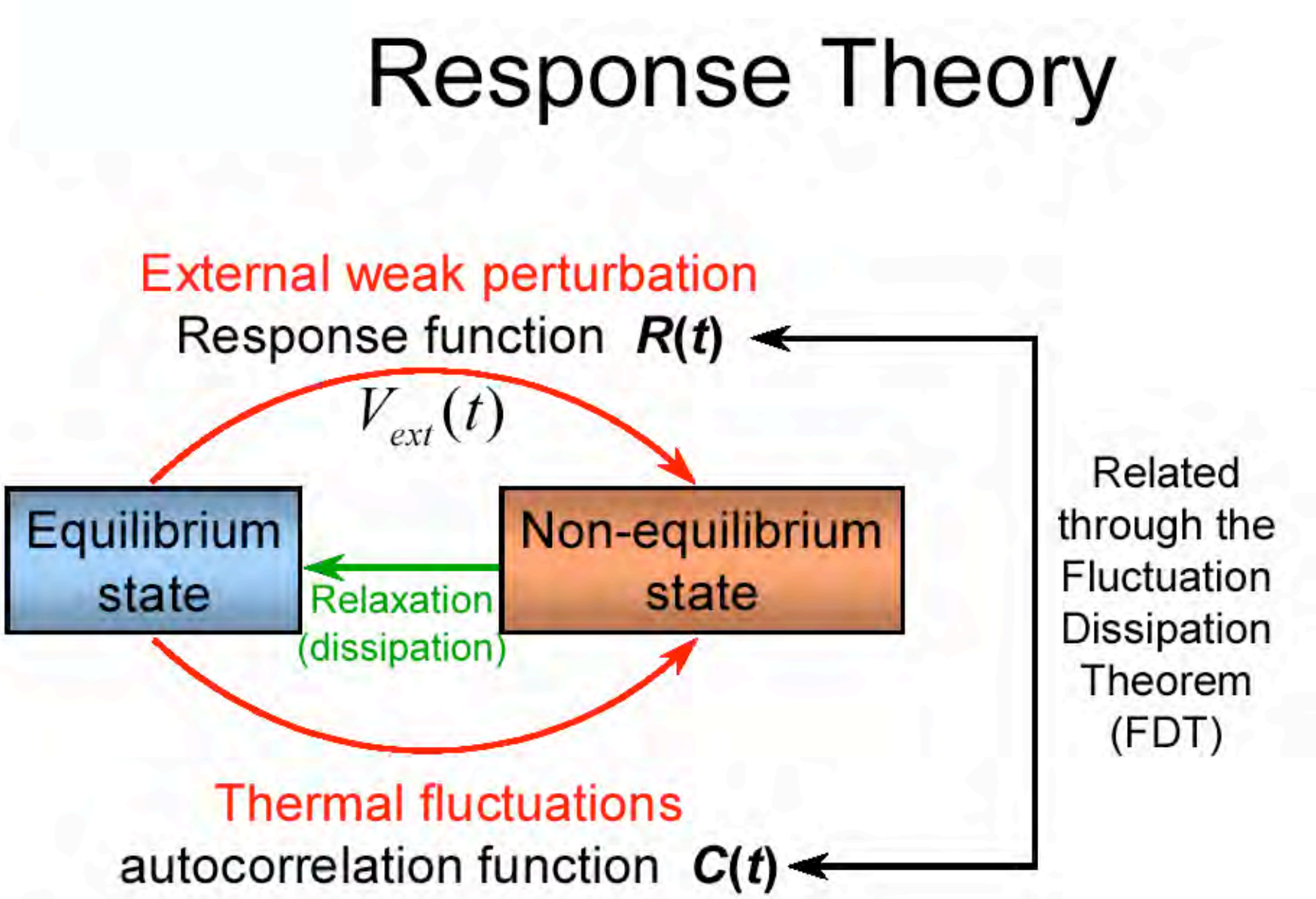
(i) the fluctuation-susceptibility theorem transforms into a remarkable classification of financial volatility shocks (endogenous versus exogenous),

(ii) the Ising model of phase transitions can be generalized to model the stylized facts of financial markets,

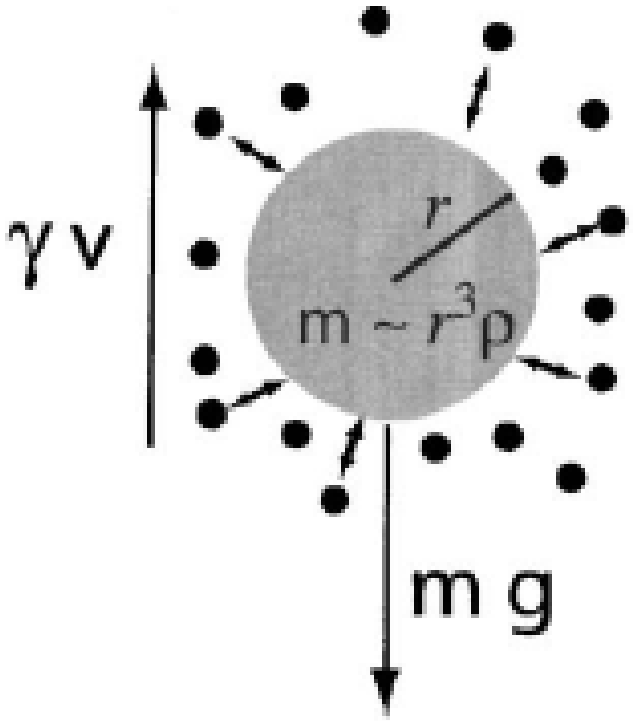
(iii) the concepts of collective phenomena and phase transitions (with spontaneous symmetry breaking) help understand financial bubbles and their following crashes,

(iv) the mathematics of quantum physics provides a new quantum decision theory solving the known paradoxes.

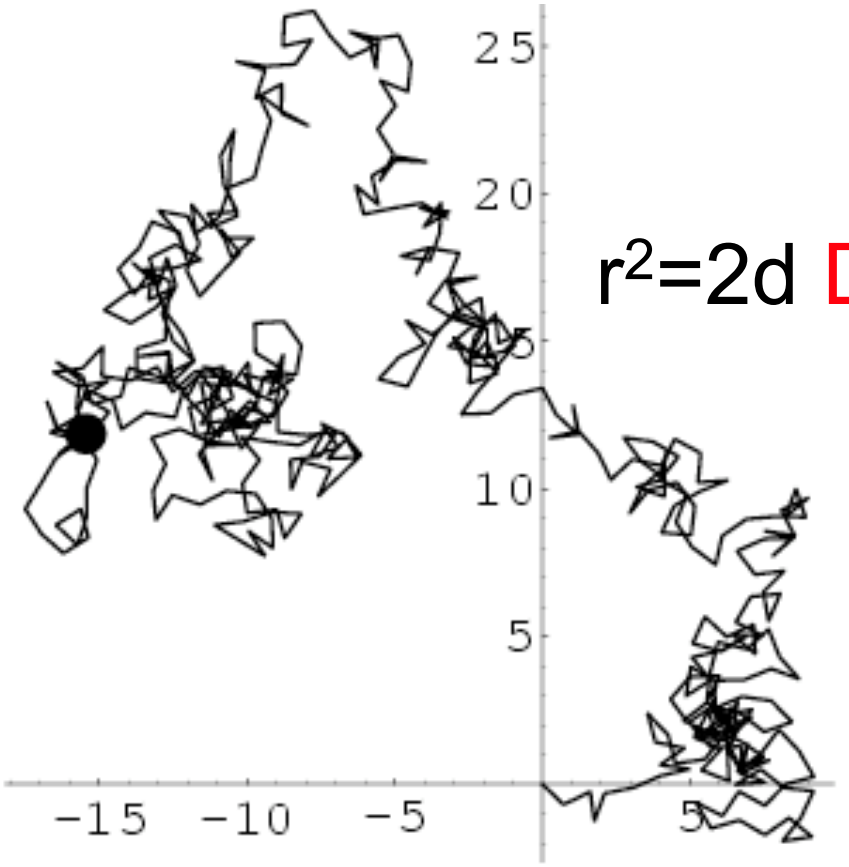
Guidelines from Physics: perturb and study the response



EXO:Drag resistance
under an external force



ENDO: Random walk



$r^2=2d\,Dt$

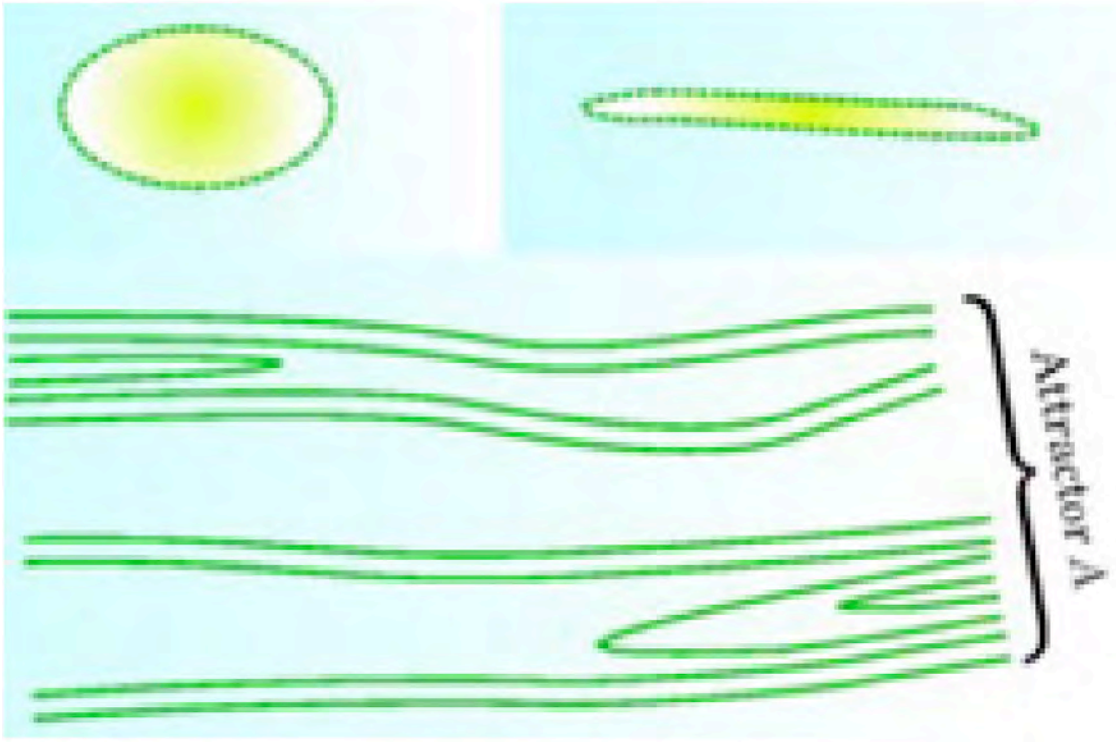
$$D=k_BT/\gamma$$

(Einstein, 1905)

Fluctuation-dissipation theorem far from equilibrium is not expected to hold

- Externally imposed perturbations may be different from spontaneous fluctuations (external fluctuations lie outside the complex attractor)

- Attractor of dynamics may exhibit bifurcations



D. Ruelle, Physics Today, May 2004

The method of critical events in economics and social sciences

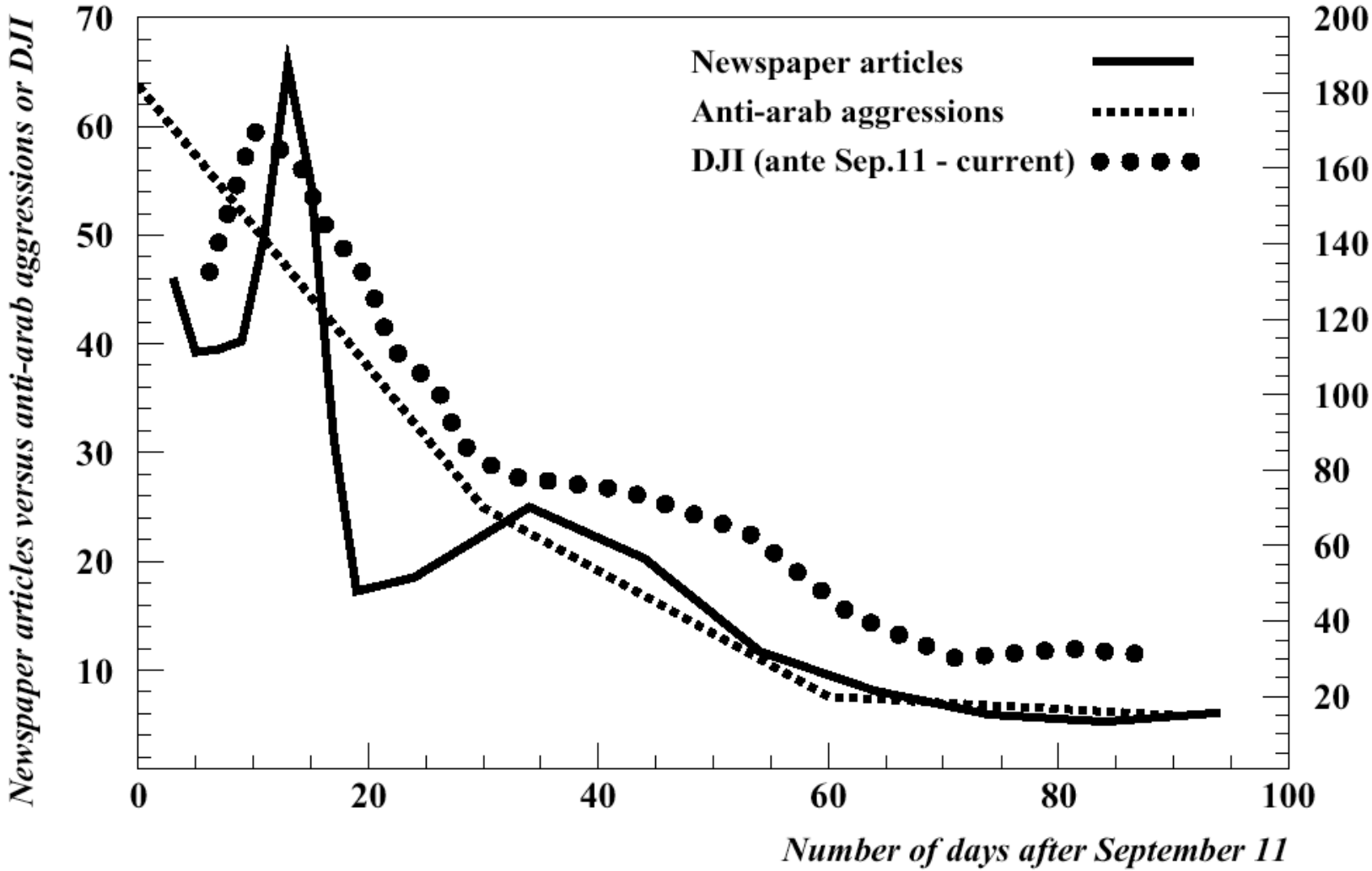
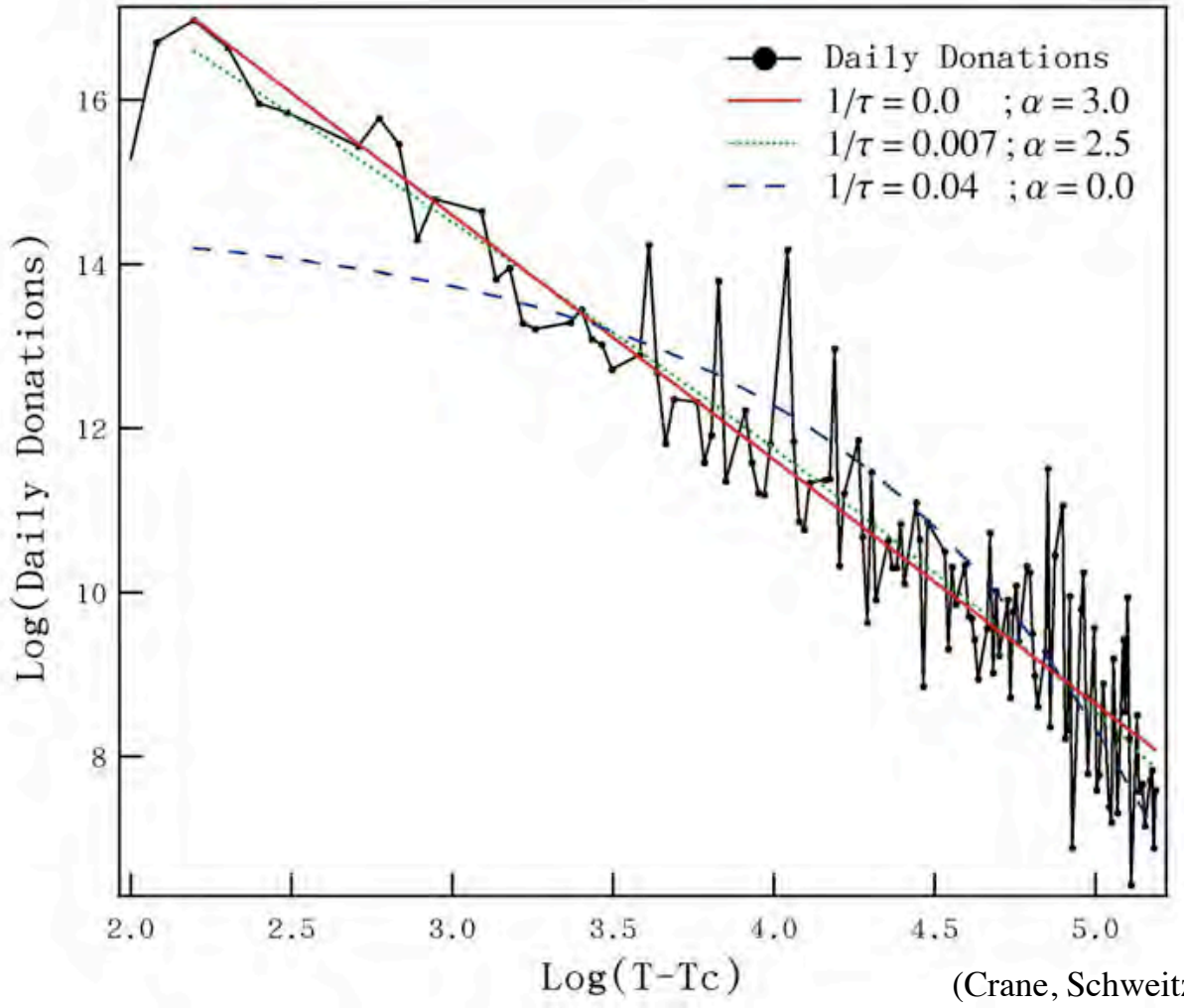


Fig.2: Relaxation curves after the shock of September 11. The solid line curve is the same as in Fig.1 but over a larger time interval; the broken line (scale on the right-hand side) shows the number of anti-arab aggressions in California in the three months after September 11; the dotted line shows the changes in the level of the Dow Jones Index with respect to its pre-Sep.11 level as given by the difference DJI(pre-9/11)-DJI(current). The tails of all three curves are well-approximated by power laws $\sim 1/t^{\alpha}$, with exponents α comprised between -1.4 and -2.2: $\alpha_1 = -1.8 \pm 0.7$ (newspaper articles), $\alpha_2 = -1.4 \pm 0.5$ (anti-arab agressions) and $\alpha_3 = -2.2 \pm 1.6$ (DJI).

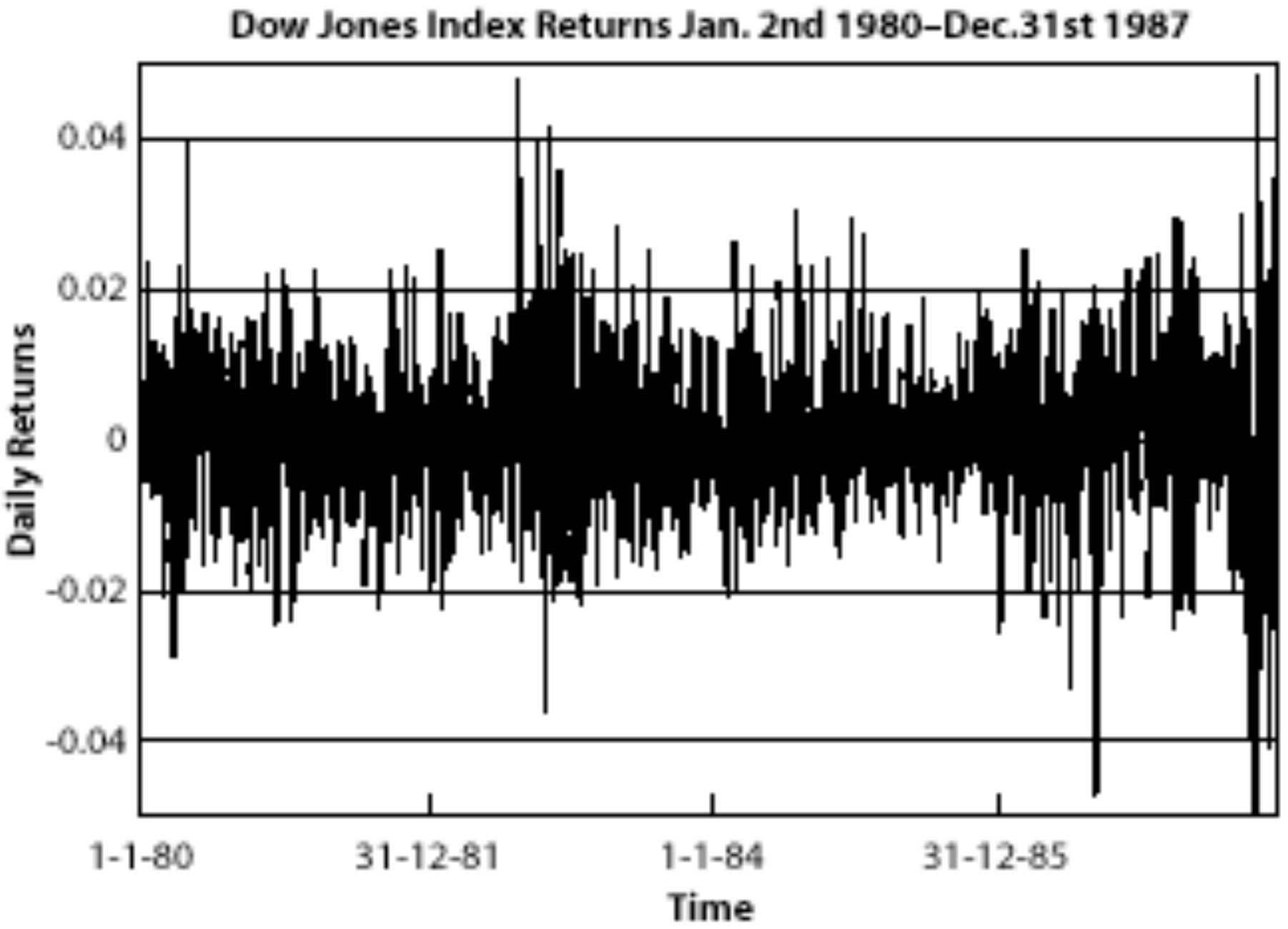
(Roehner and Sornette, 2004)

Daily number of donations following the Asian Tsunami of December 26, 2004



(Crane, Schweitzer and Sornette, 2009)

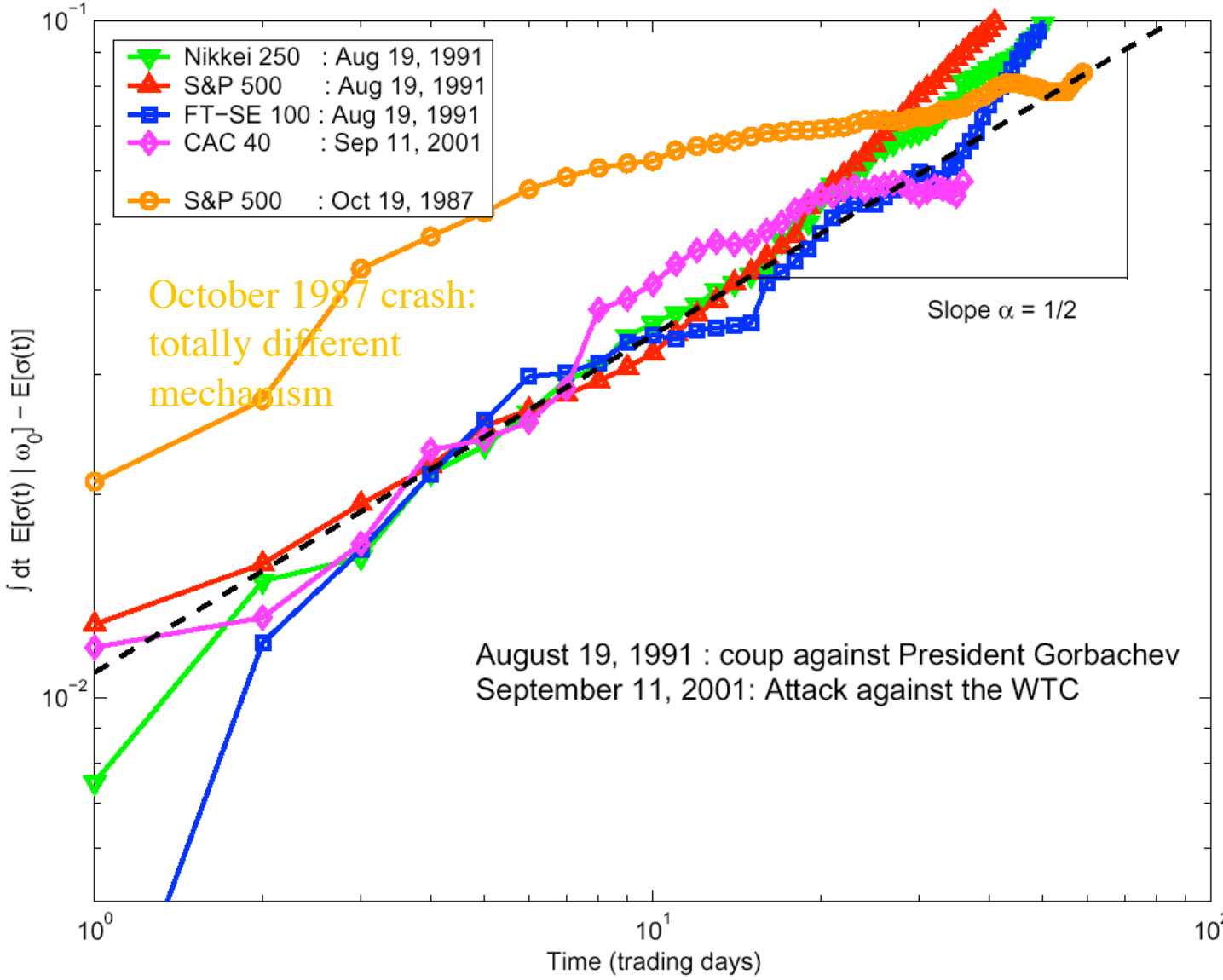
Volatility


Dow Jones Index Returns Jan. 2nd 1980–Dec.31st 1987
0.04
0.02
0
-0.02
-0.04
Daily Returns
1-1-80
31-12-81
1-1-84
31-12-85
Time

Linear response to an external shock

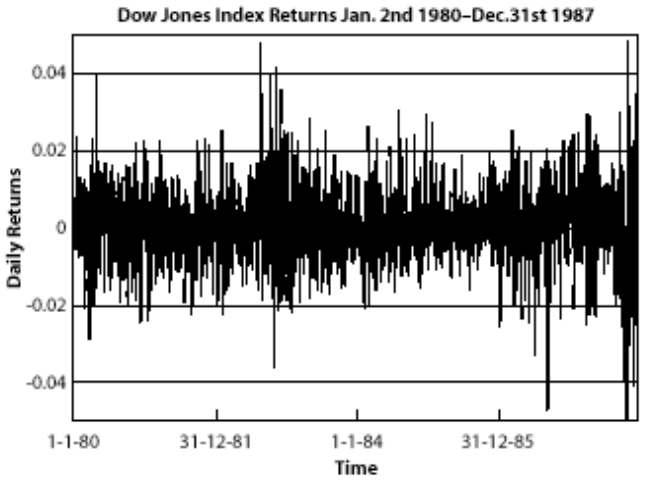
(Multifractal Random Walk model)

$$\mathrm{E}_{\mathrm{exo}}[\sigma^2(t) \mid \omega_0] - \overline{\sigma^2(t)} \propto e^{2K_0 t^{-1/2}} - 1 \approx \frac{2K_0}{\sqrt{t}}$$



D. Sornette, Y. Malevergne and J.F. Muzy Volatility fingerprints of large shocks: Endogeneous versus exogeneous, Risk Magazine (http://arXiv.org/abs/cond-mat/0204626)

“Conditional response” to an endogeneous shock



Interplay between
-long memory
-exponential

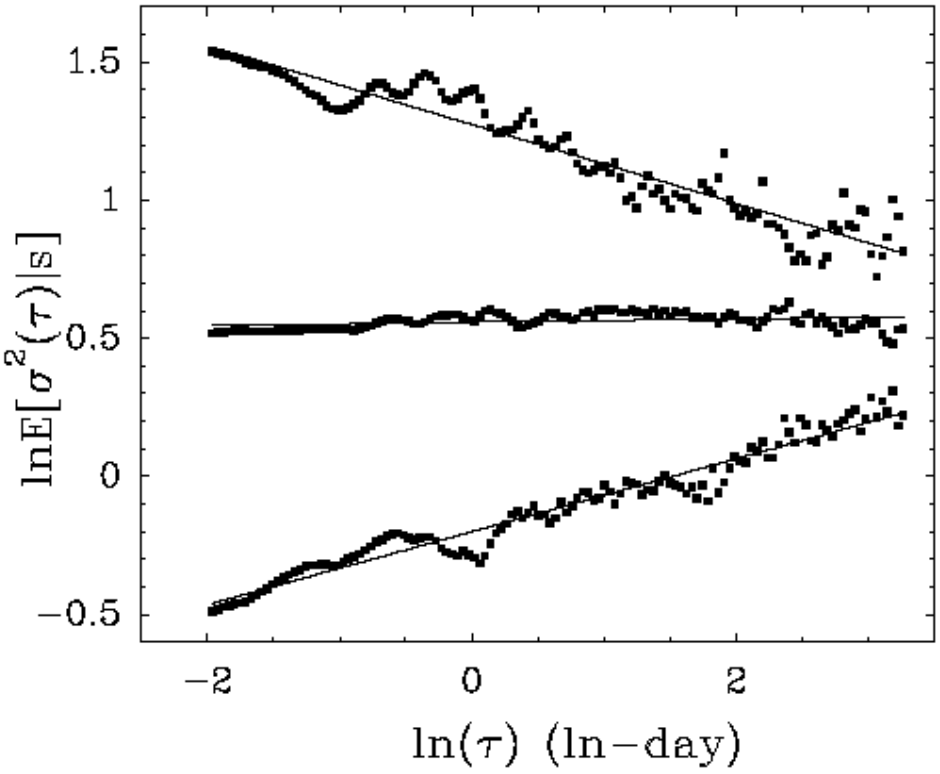
$$\mathrm{E}_{\mathrm{endo}}[\sigma^2(t) \mid \omega_0] \sim t^{-\alpha(s)}$$

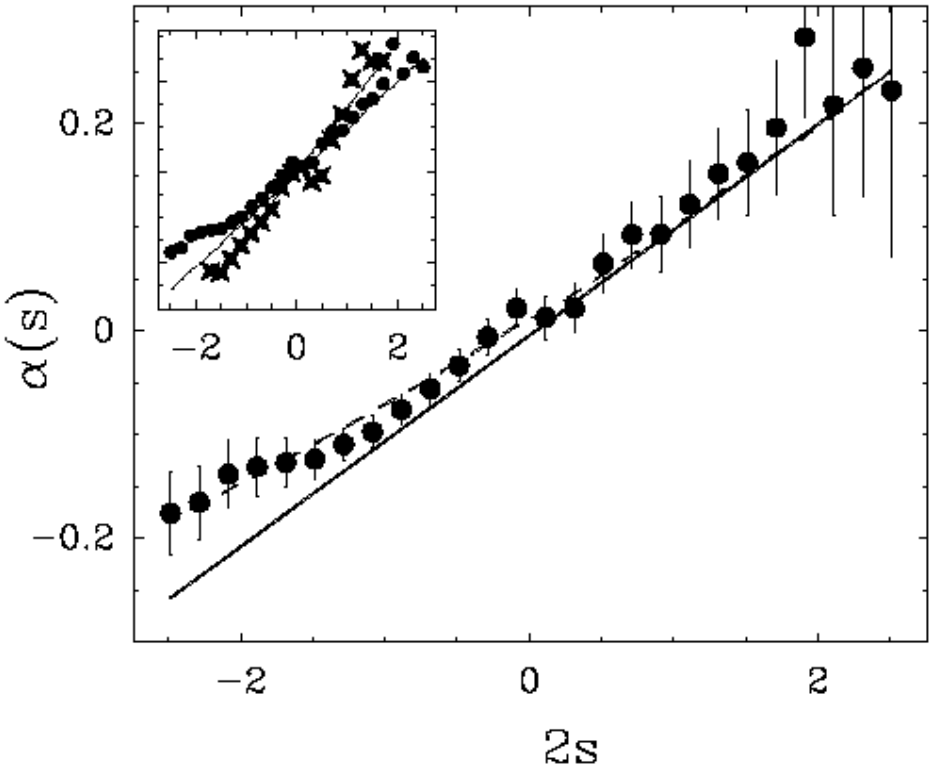
where $\alpha(s) = \dfrac{2s}{\ln(\frac{Te^{3/2}}{\Delta t})}$

D. Sornette, Y. Malevergne and J.F. Muzy, Volatility fingerprints of large shocks: Endogeneous versus exogeneous, Risk 16 (2), 67-71 (2003) (http://arXiv.org/abs/cond-mat/0204626)

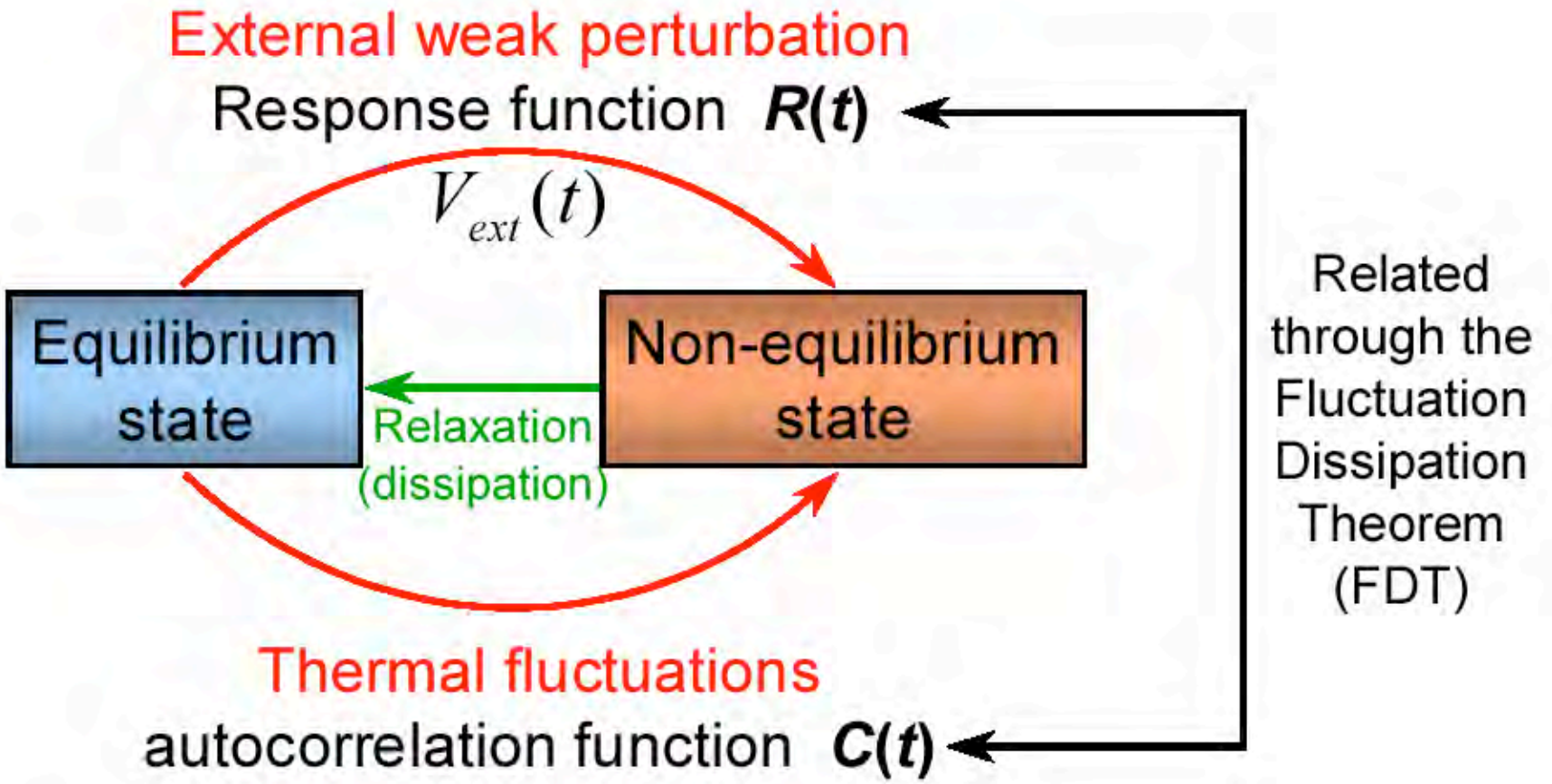
Real Data and Multifractal Random Walk model

$$\mathrm{E}_{\mathrm{endo}}[\sigma^2(t) \mid \omega_0] \sim t^{-\alpha(s)}$$





Response Theory



Endogenous versus Exogenous

Extinctions

- -meteorite at the Cretaceous/Tertiary KT boundary
- -volcanic eruptions (Deccan traps)
- -self-organized critical events

Discoveries

- -serendipity
- -maturation

Financial crashes

- -external shock
- -self-organized instability

Volatility bursts in financial time series

- -external shock
- -cumulative effect of "small" news

Earthquakes

- -tectonic driving
- -triggering

Immune system

- -external viral or bacterial attack
- - " internal" (dis-)organization

Parturition

- -mother/foetus triggered?
- -mother-foetus complex?

Brain (learning)

- -external inputs
- -internal self-organization and reinforcements (role of sleep)

Aviation industry recession

- -September 11, 2001
- -structural endogenous problems

Commercial success and sales

- -Ads
- -epidemic network

Recovery after wars?

- -internally generated (civil wars)
- -externally generated

Social unrests

- -triggering factors
- -rotting of social tissue

FOUR EXAMPLES

(i) the fluctuation-susceptibility theorem transforms into a remarkable classification of financial volatility shocks (endogenous versus exogenous),

(ii) the Ising model of phase transitions can be generalized to model the stylized facts of financial markets,

(iii) the concepts of collective phenomena and phase transitions (with spontaneous symmetry breaking) help understand financial bubbles and their following crashes,

(iv) the mathematics of quantum physics provides a new quantum decision theory solving the known paradoxes.

Imitation

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.

-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

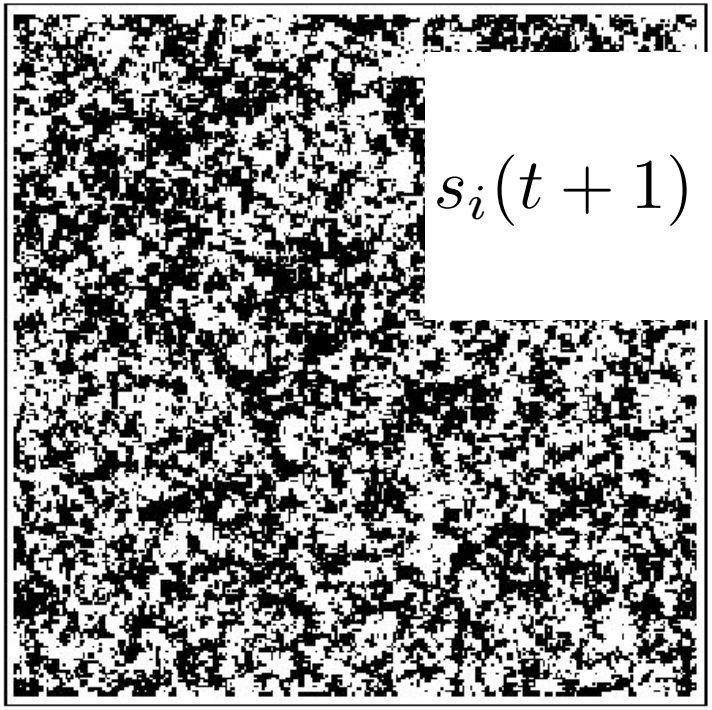
HARRISON HONG, JEFFREY D. KUBIK, and JEREMY C. STEIN*

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.

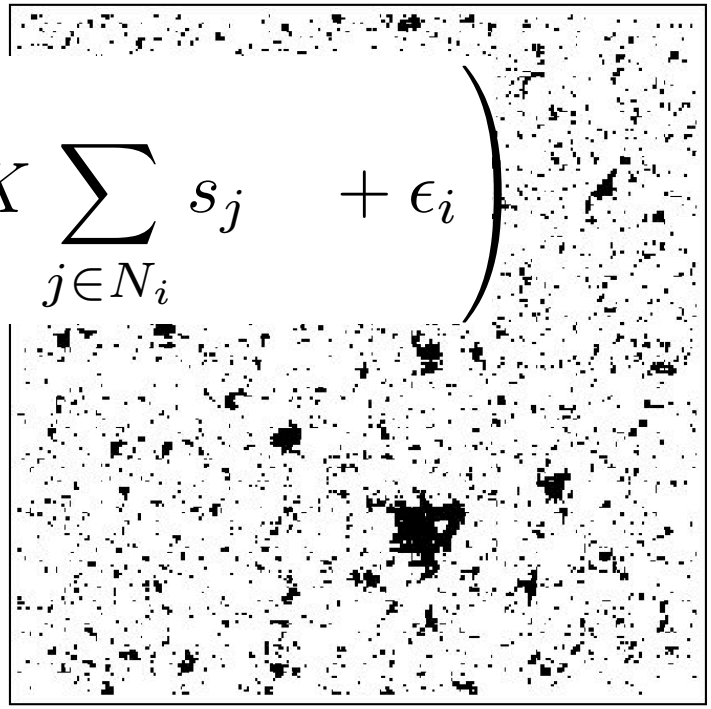
THE JOURNAL OF FINANCE • VOL. LX, NO. 6 • DECEMBER 2005

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)



$$s_i(t+1) = \text{sign}\left(K \sum_{j \in N_i} s_j \quad + \epsilon_i \right)$$

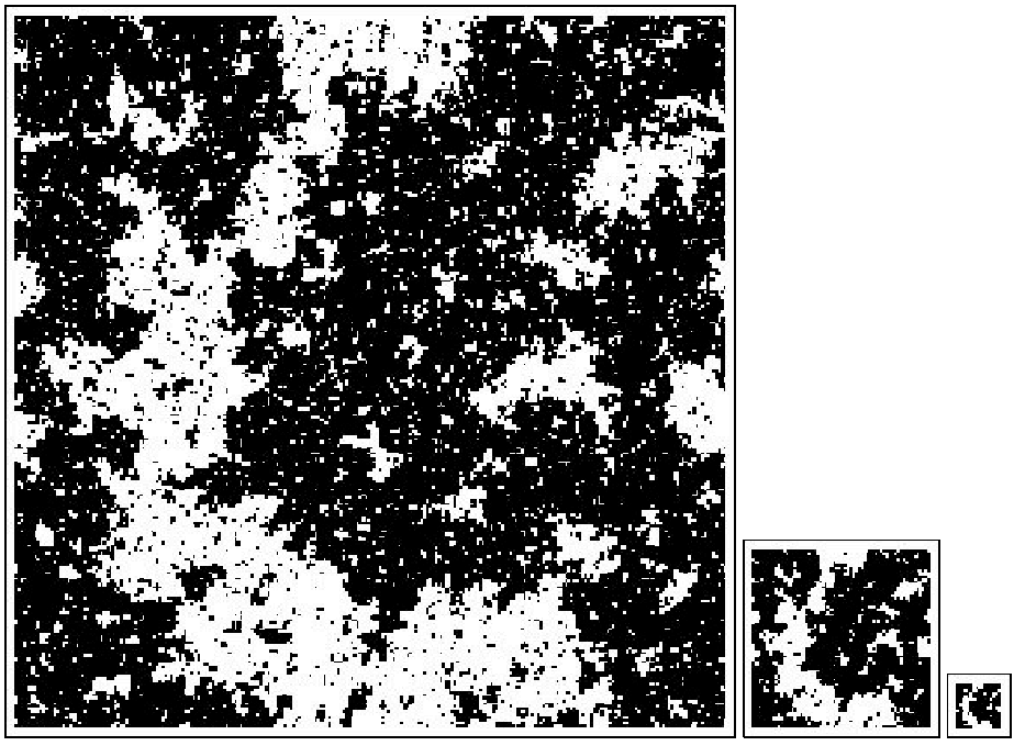


Order
K large

Disorder : K small

Renormalization group:
Organization of the description scale by scale

Critical:
K=critical value



Importance of Positive Feedbacks and Over-confidence in a Self-Fulfilling Ising Model of Financial Markets

$$s_i(t) = \mathrm{sign}\left[\sum_{j\in\mathcal{N}} K_{ij}(t)\mathrm{E}[s_j](t) + \sigma_i(t)G(t) + \epsilon_i(t)\right]$$

Imitation **News** **Private information**

$$K_{ij}(t) = b_{ij} + \alpha_i K_{ij}(t-1) + \beta r(t-1)G(t-1)$$

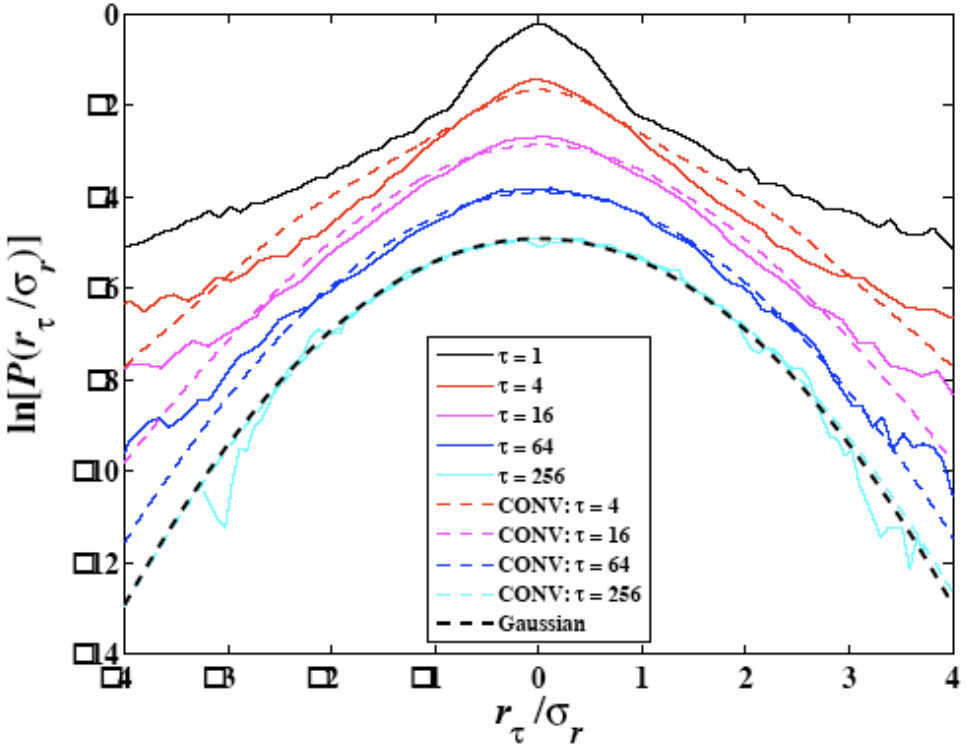
(generalizes Carlos Pedro Gonçalves, who generalized Johansen-Ledoit-Sornette)

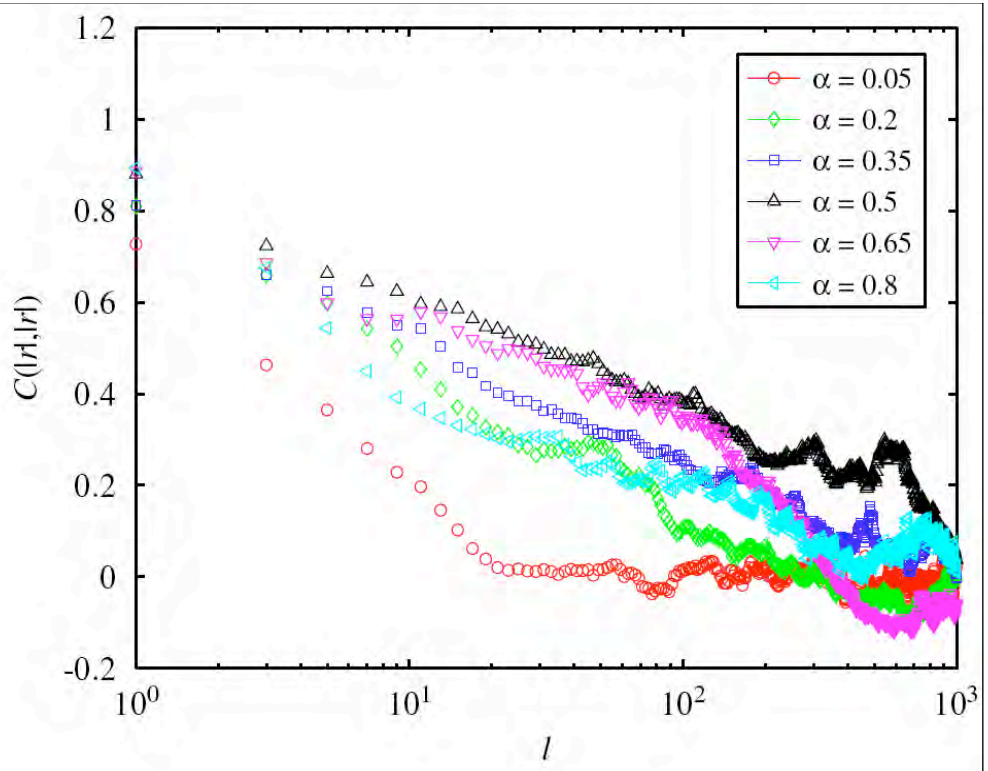
β: propensity to be influenced by the felling of others

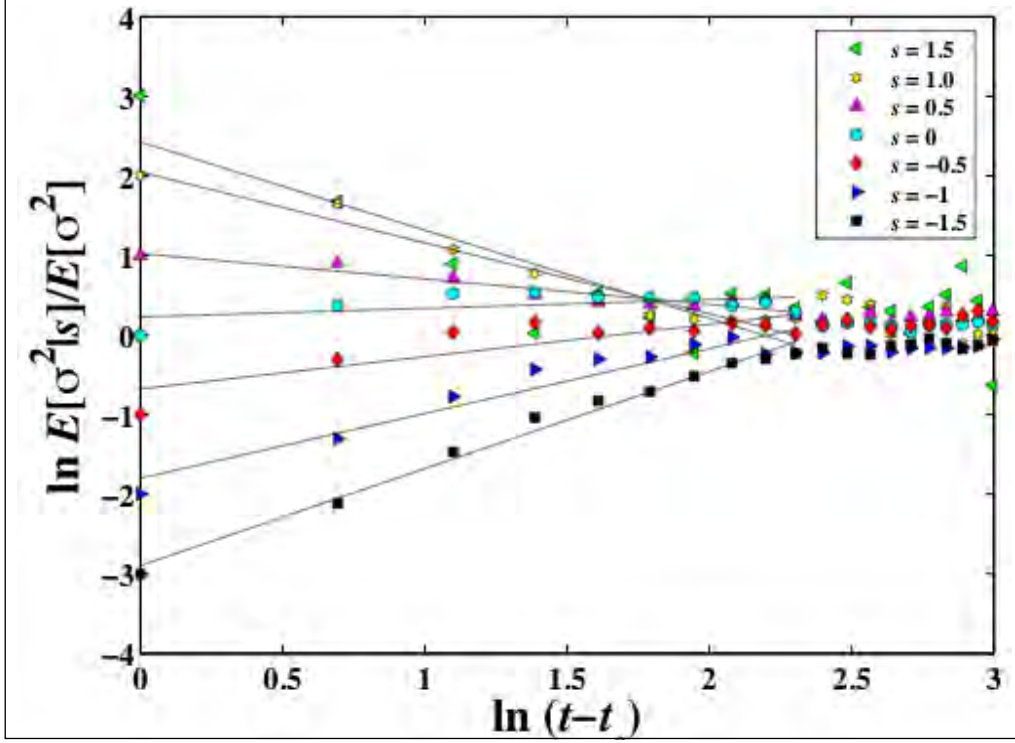
1. **β<0: rational agents**

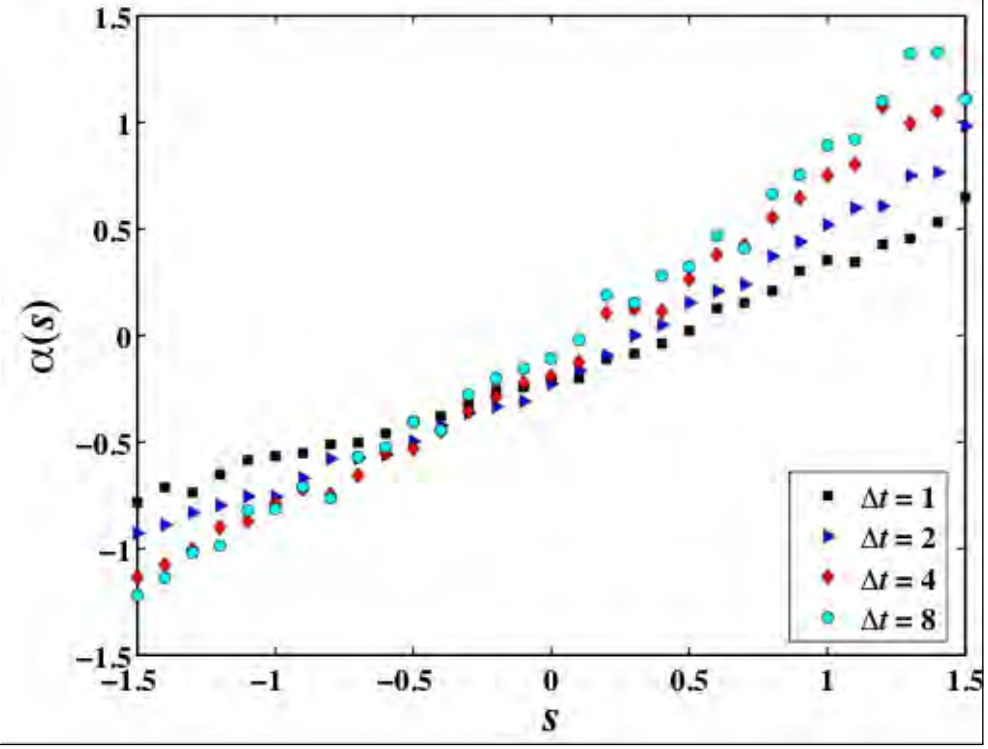
- **β>0: over-confident agents**

Didier Sornette and Wei-Xing Zhou, Physica A 370 (2), 704-726 (2006)


ln[P(r_τ/σ_r)]
r_τ/σ_r
τ = 1
τ = 4
τ = 16
τ = 64
τ = 256
CONV: τ = 4
CONV: τ = 16
CONV: τ = 64
CONV: τ = 256
Gaussian

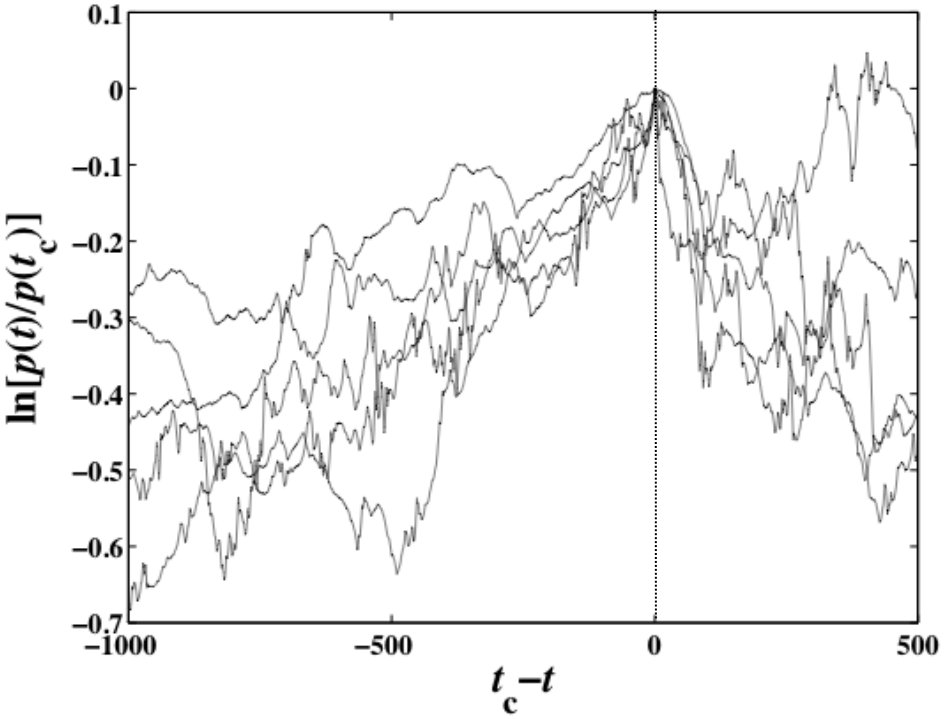

C(|r|,|r|)
l
α = 0.05
α = 0.2
α = 0.35
α = 0.5
α = 0.65
α = 0.8


ln E[σ²|s]/E[σ²]
ln (t−t')
s = 1.5
s = 1.0
s = 0.5
s = 0
s = −0.5
s = −1
s = −1.5


α(s)
s
Δt = 1
Δt = 2
Δt = 4
Δt = 8

Bubbles and crashes

Fig. 15. Five price trajectories showing bubbles preceding crashes that occur at the shifted time 0. The five time series have been translated so that the time of their crash is placed at the origin $t = 0$.



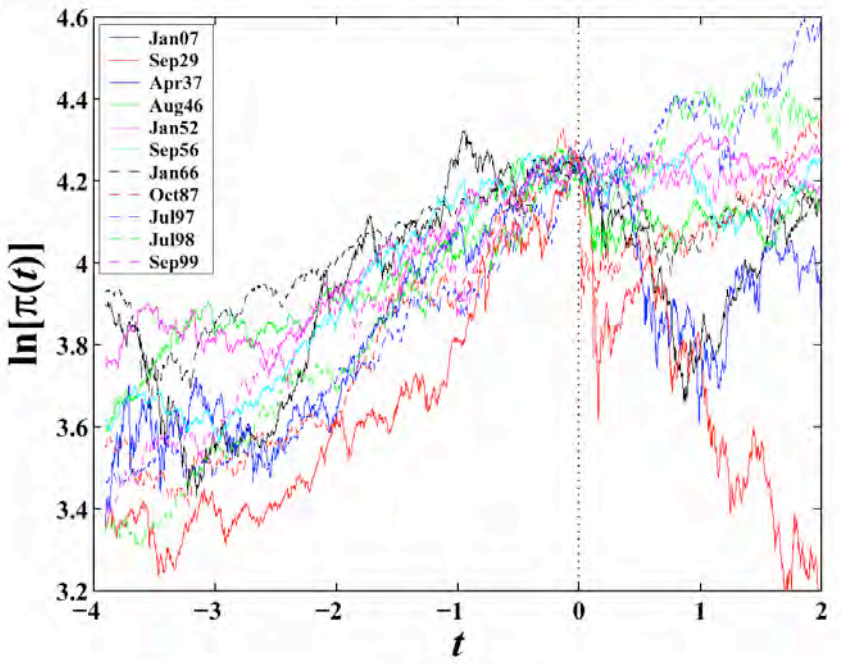


Figure 4: (Color online) Superposed epoch analysis of the 11 time intervals, each of 6 years long, of the DJIA index centered on the time of the maxima of the 11 predictor peaks above $AI = 0.3$ of the alarm index shown in Fig. 3.

D. Sornette and W.-X. Zhou
Predictability of Large Future Changes in major financial indices,
International Journal of Forecasting 22, 153-168 (2006)

Aggregation of information

The aggregated information of agent *i* is:

$$info_i(t) = c_{1i} \cdot \sum_{j=1}^{J} k_{ij} E_i[s_j(t)] + c_{2i} \cdot u(t) \cdot news(t) + c_{3i} \cdot \epsilon_i(t)$$

imitation term — news term — idiosyncratic term

$$c_{1/2/3} \sim UD \in [0, c_{1/2/3\,max}]$$

personal susceptibility to the different sources of information

$$\epsilon_i \sim N(0,1)$$

Gaussian noise

$$news(t) \sim N(0,1)$$

$$k_{ij}(t) = \alpha \cdot k_{ij}(t-1) + r(t-1) \cdot E_i[s_j(t-2)] \cdot \frac{1-\alpha}{\sigma_r}$$

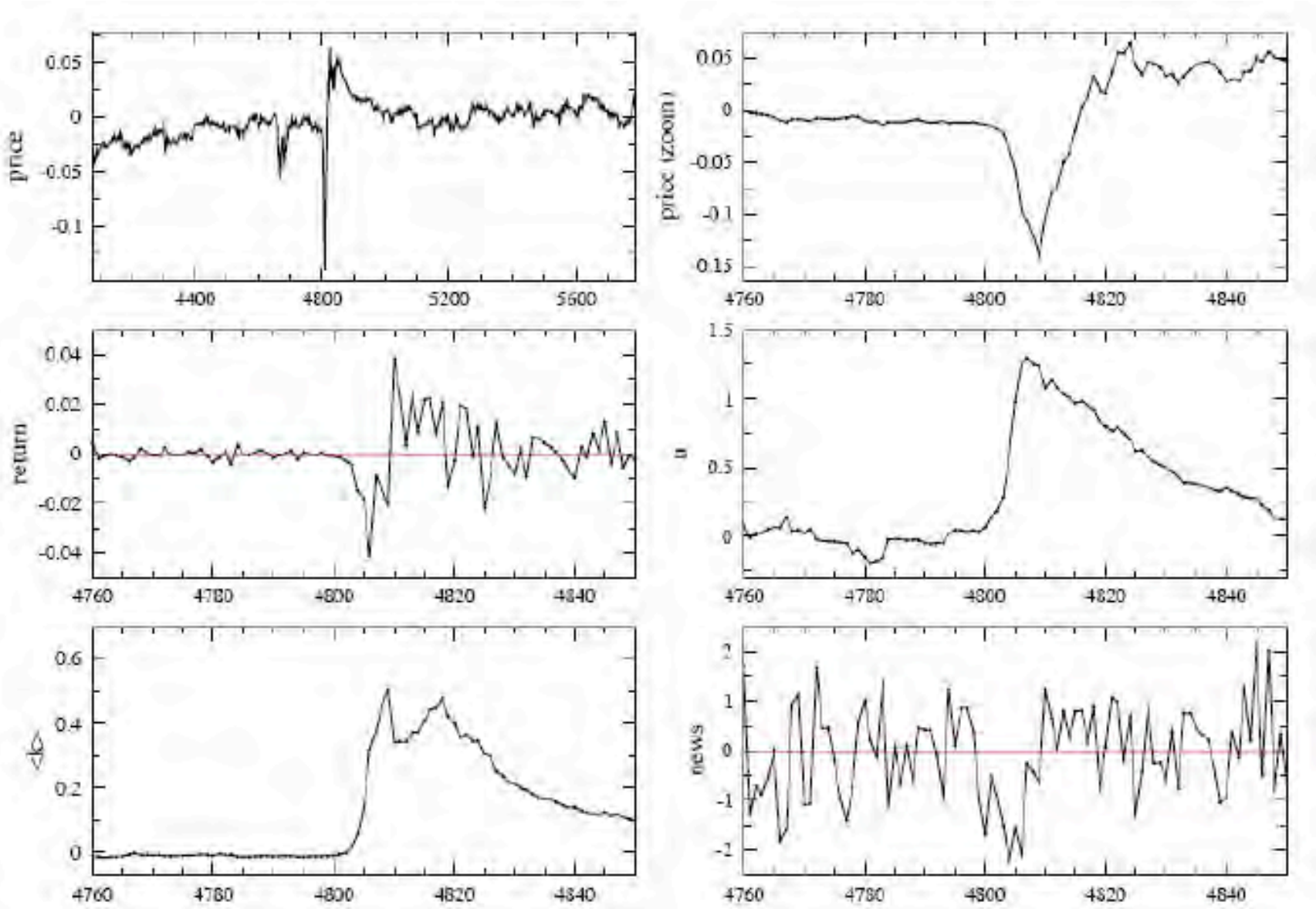
past neighbour j performance

$$u(t) = \alpha \cdot u(t-1) + r(t-1) \cdot news(t-2) \cdot \frac{1-\alpha}{\sigma_r}$$

past news performance

G. Harras and D. Sornette, Endogenous versus exogenous origins of financial rallies and crashes in an agent-based model with Bayesian learning and imitation, J. Economic Behavior and Organization (2008) (http://arXiv.org/abs/0806.2989

News impact



Impact of the news to some values, generated with $C_1 = C_2 = C_3 = 1.0$.

FOUR EXAMPLES

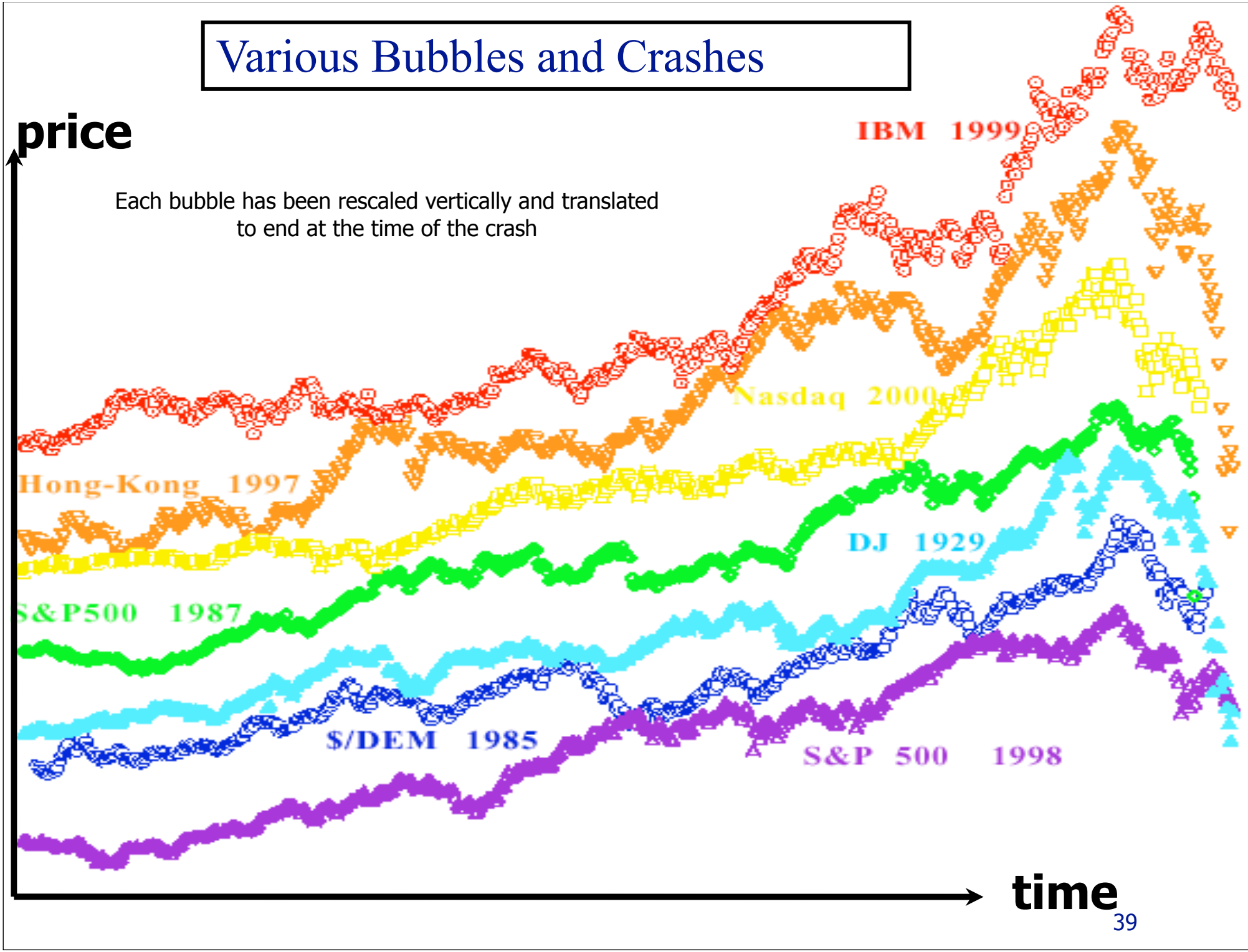
(i) the fluctuation-susceptibility theorem transforms into a remarkable classification of financial volatility shocks (endogenous versus exogenous),

(ii) the Ising model of phase transitions can be generalized to model the stylized facts of financial markets,

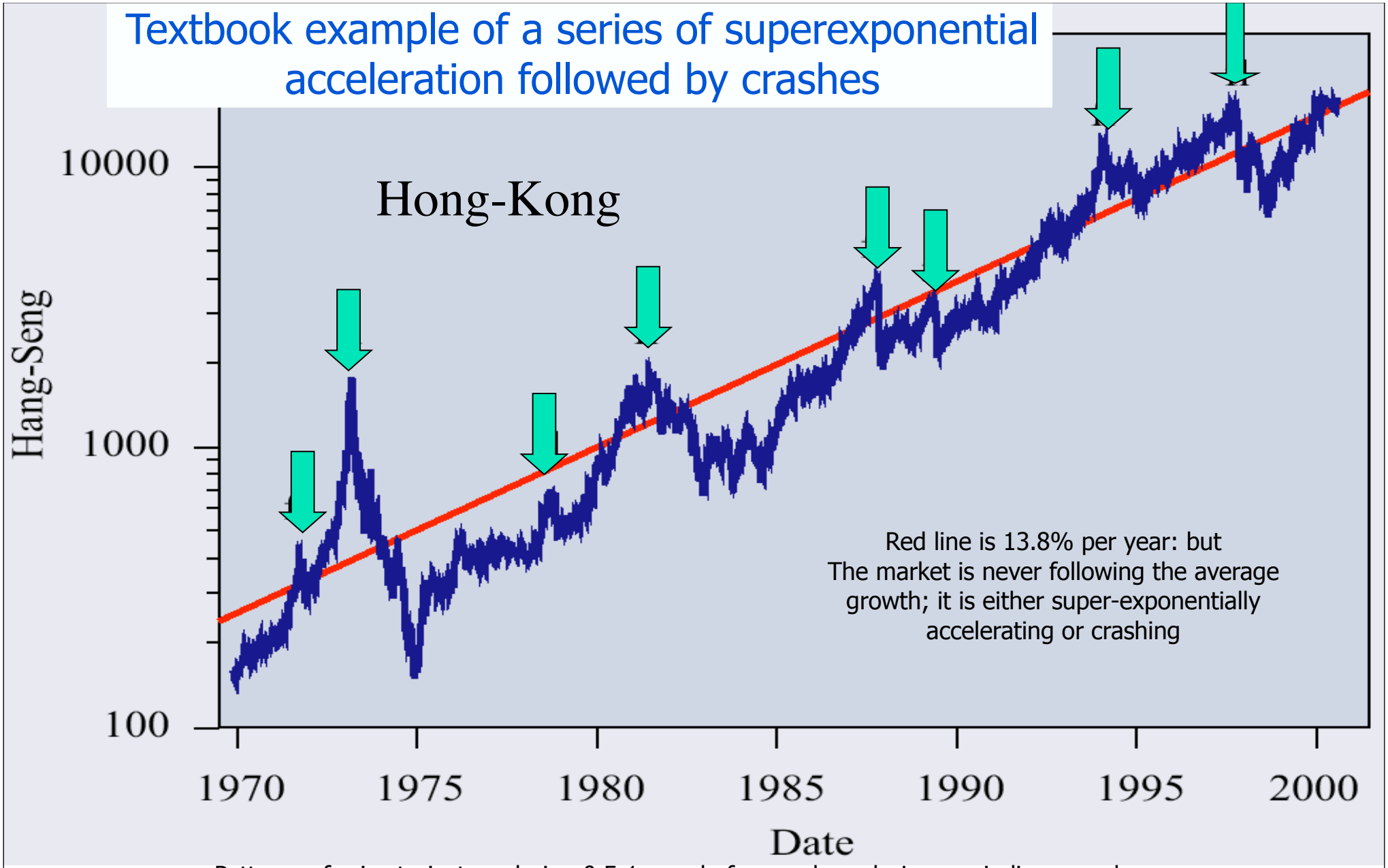
(iii) the concepts of collective phenomena and phase transitions (with spontaneous symmetry breaking) help understand financial bubbles and their following crashes,

(iv) the mathematics of quantum physics provides a new quantum decision theory solving the known paradoxes.

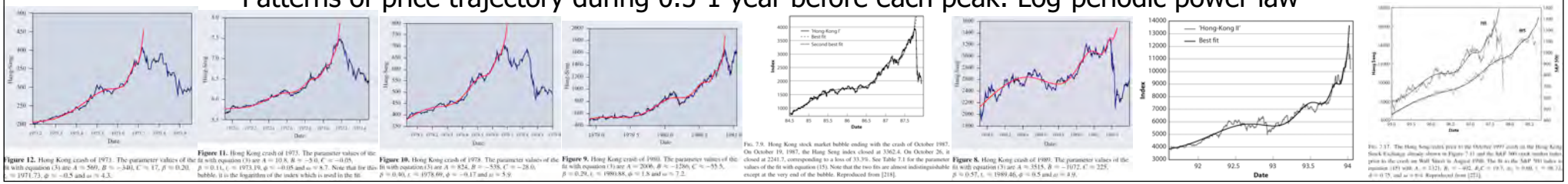
Various Bubbles and Crashes



Textbook example of a series of superexponential acceleration followed by crashes



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



Positive feedbacks and finite-time singularity

Conjecture: Many systems exhibit transient FTS as "ghost-like" solutions that the system follows for a while before being attenuated.
Analogous to exponential sensitivity to initial condition with reinjection → chaos **but** here FTS blow-up.

$$\frac{dp}{dt} = rp(t)[K - p(t)]$$

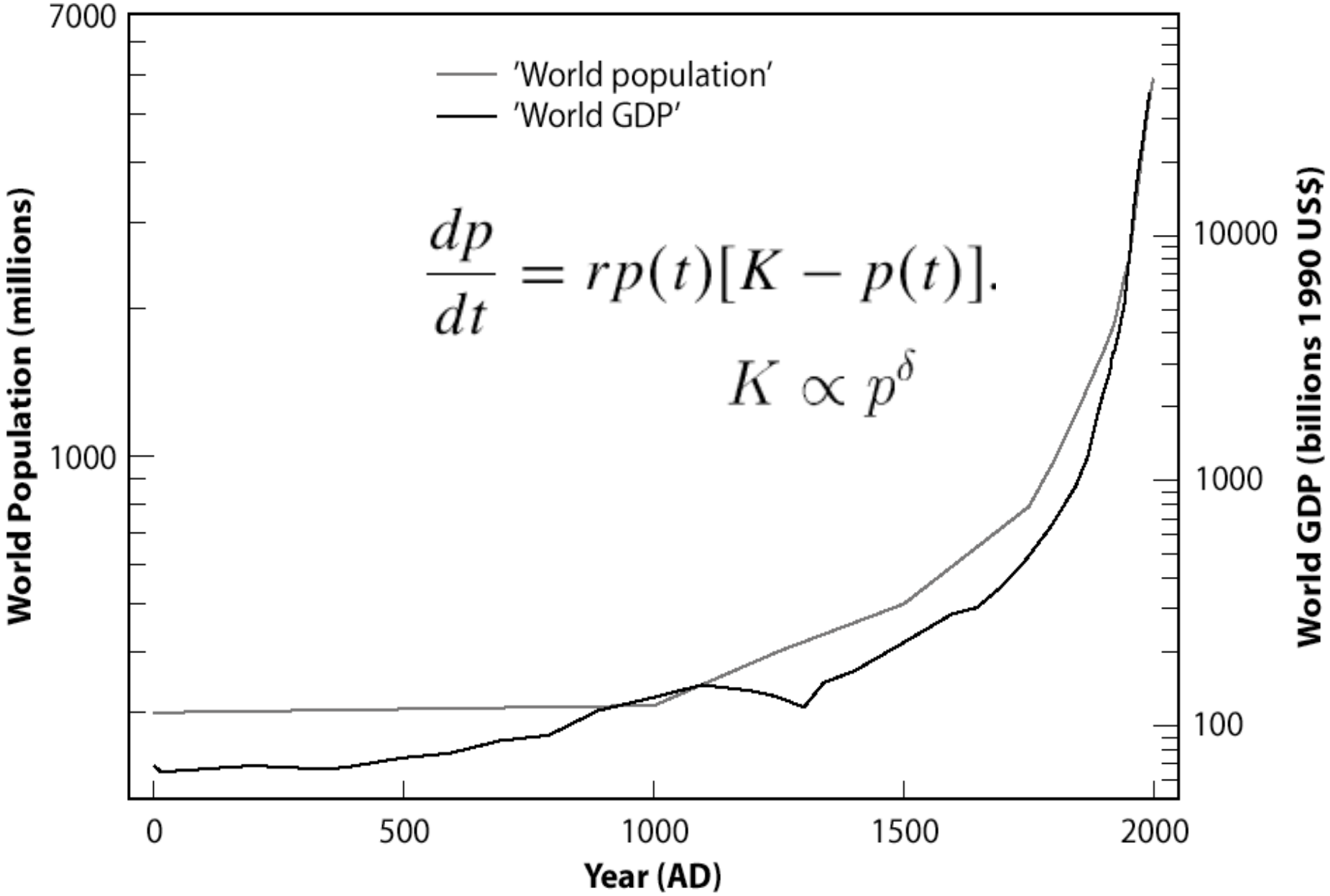
$$\frac{dp}{dt} = r[p(t)]^{1+\delta}$$

with $K \propto p^{\delta}$

$$p(t) \propto (t_c - t)^z, \text{ with } z = -\frac{1}{\delta} \text{ and } t \text{ close to } t_c.$$

Multi-dimensional generalization: multi-variate positive feedbacks

Super-exponential growth



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)

DISCRETE HIERARCHY OF THE AGENT NETWORK

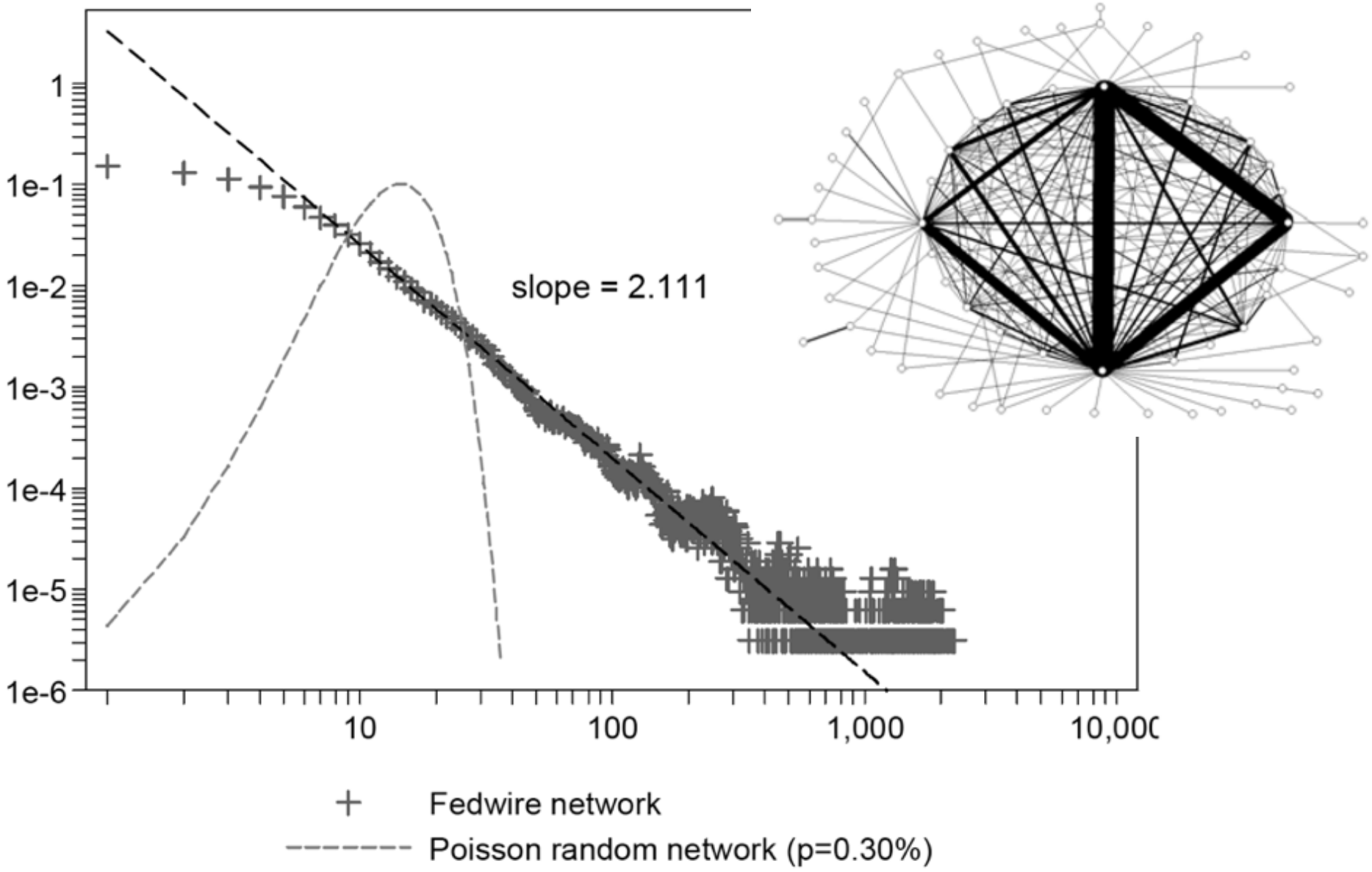
Presentation of three different mechanisms leading to discrete scale invariance, discrete hierarchies and log-periodic signatures

- Co-evolution of brain size and group size
  (Why do we have a big Brain?)

- Interplay between nonlinear positive and negative feedbacks and inertia

- Discrete scale invariance
  Complex fractal dimension
  Log-periodicity

network topology of the interbank payments transferred between commercial banks over the Fedwire® Funds Service

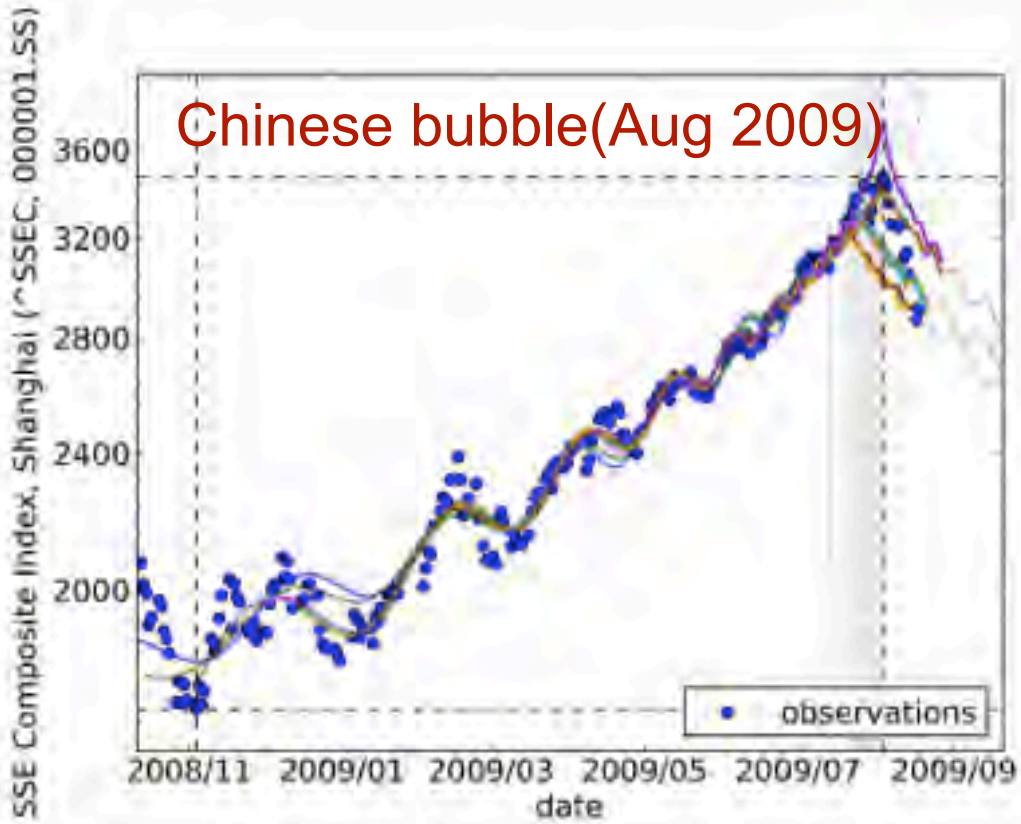


Kimmo Soramäki, Morten L. Bech, Jeffrey Arnold, Robert J. Glass, and Walter E. Beyeler, Physica A 379, 317-333 (2006)

FCO@ETH: Towards operational science of financial instabilities

Didier Sornette, Ryan Woodard, Peter Cauwels, Vladimir Filimonov, Wanfeng Yan, Qunzhi Zhang, Wei-Xing Zhou

- Main mission:
  - Identify bubbles
- Theory:
  - Positive feedback
- Deliverables
  - Weekly global bubble scan
  - Research, papers
  - Public forecasts
  - Digital timestamps



The Financial Bubble Experiment

advanced diagnostics and forecasts of bubble terminations

- ***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.**

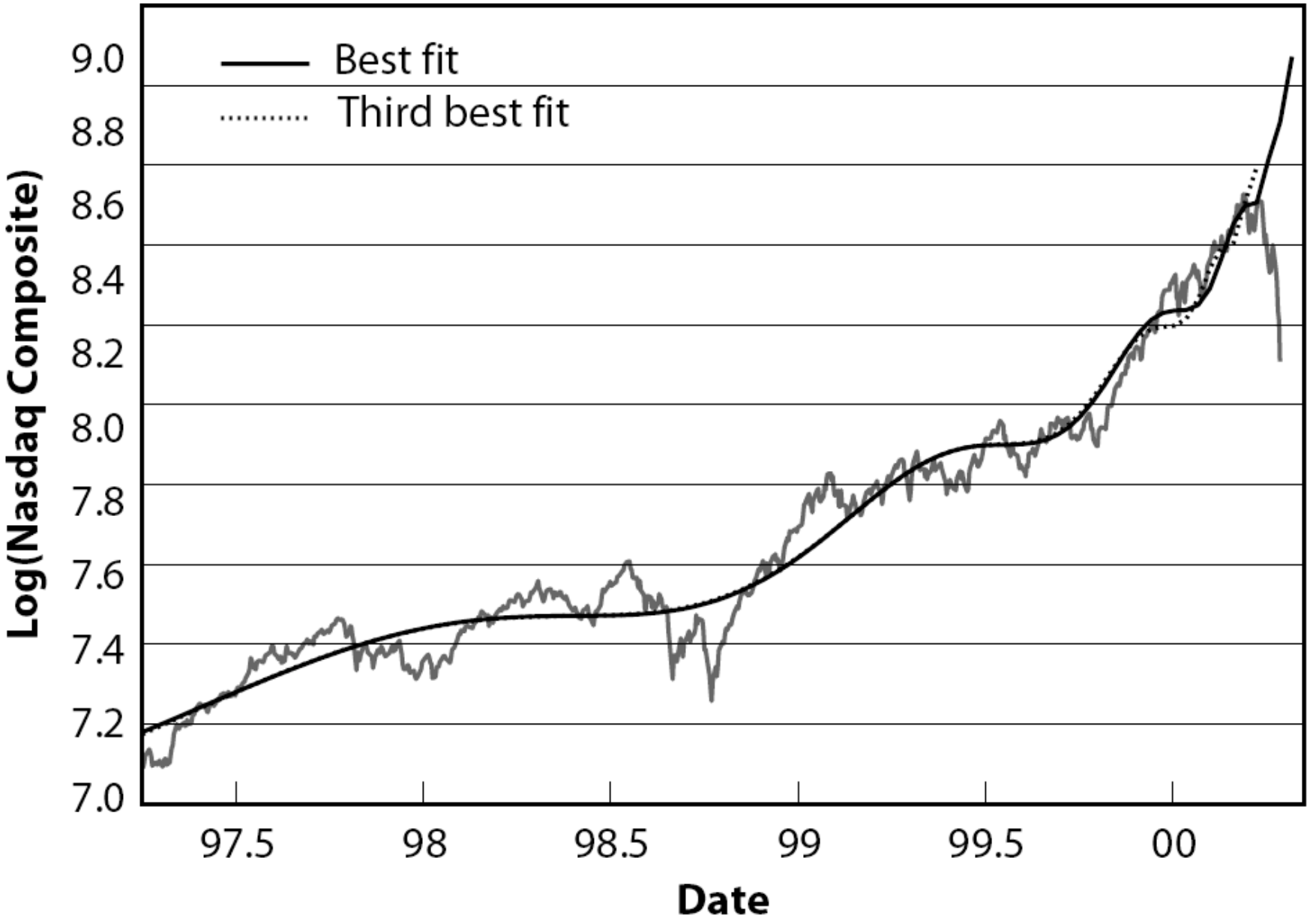
Methodology for diagnosing bubbles

- Positive feedbacks of higher return anticipation
  - ✳Super exponential price
  - ✳Power law “Finite-time singularity”

- Negative feedback spirals of crash expectation
  - ✳Accelerating large-scale financial volatility
  - ✳Log-periodic discrete scale-invariant patterns

THE NASDAQ CRASH OF APRIL 2000

"New Economy": ICT



Real-estate in the UK

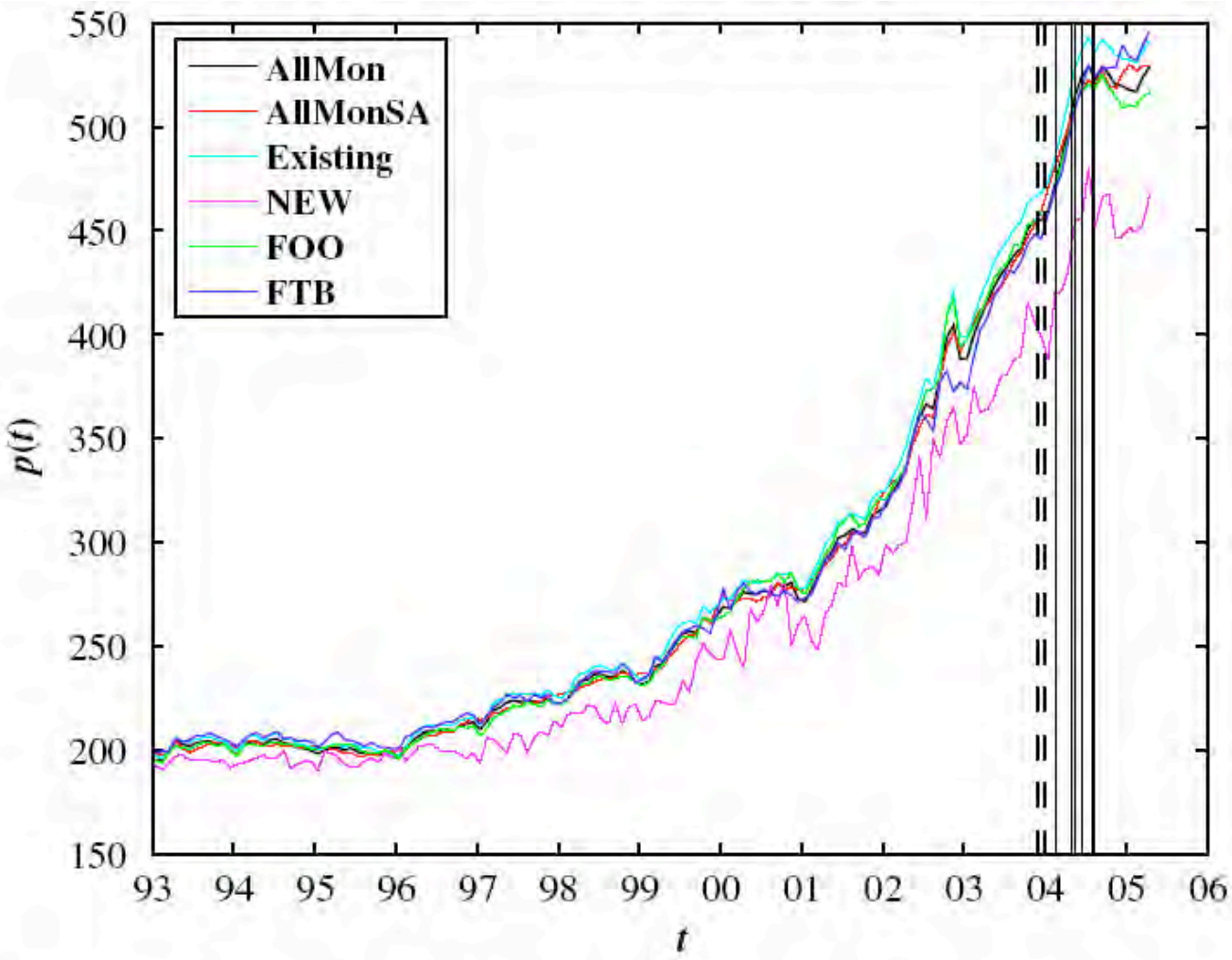


Fig. 1. (Color online) Plot of the UK Halifax house price indices from 1993 to April 2005 (the latest available quote at the time of writing). The two groups of vertical lines correspond to the two predicted turning points reported in Tables 2 and 3 of [1]: end of 2003 and mid-2004. The former (resp.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

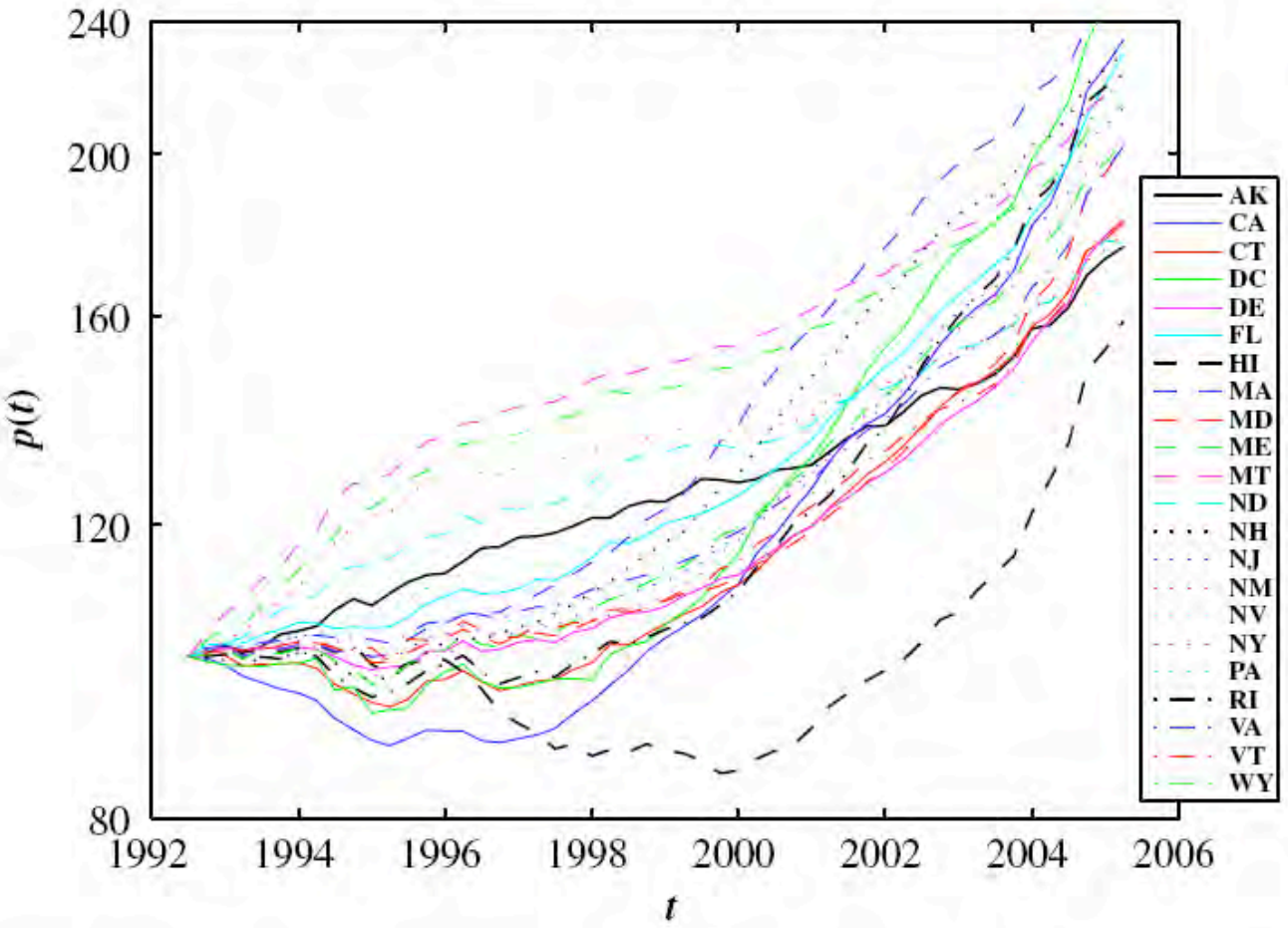
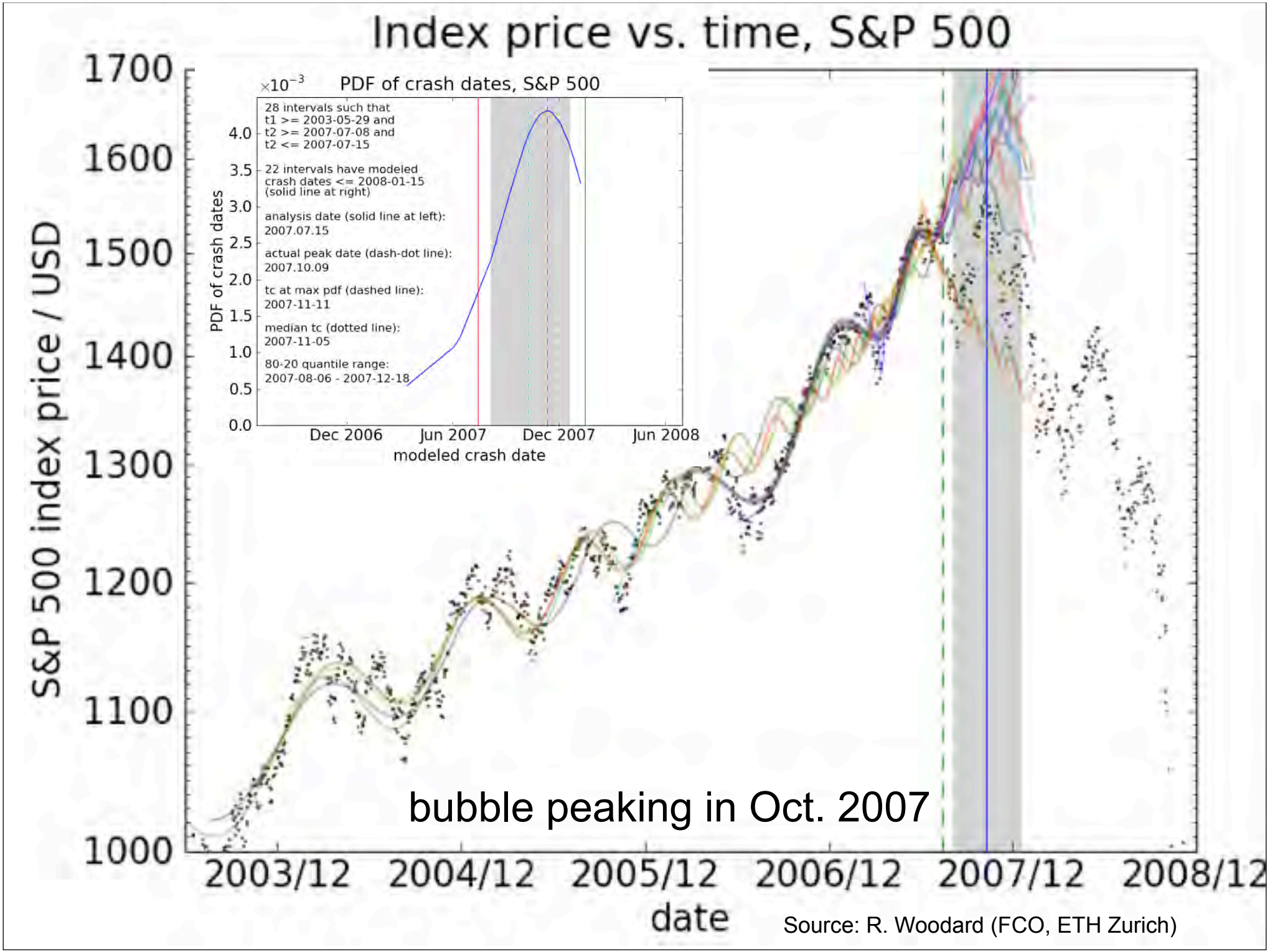


Fig. 5. (Color online) Quarterly average HPI in the 21 states and in the District of Columbia (DC) exhibiting a clear upward faster-than-exponential growth. For better representation, we have normalized the house price indices for the second quarter of 1992 to 100 in all 22 cases. The corresponding states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

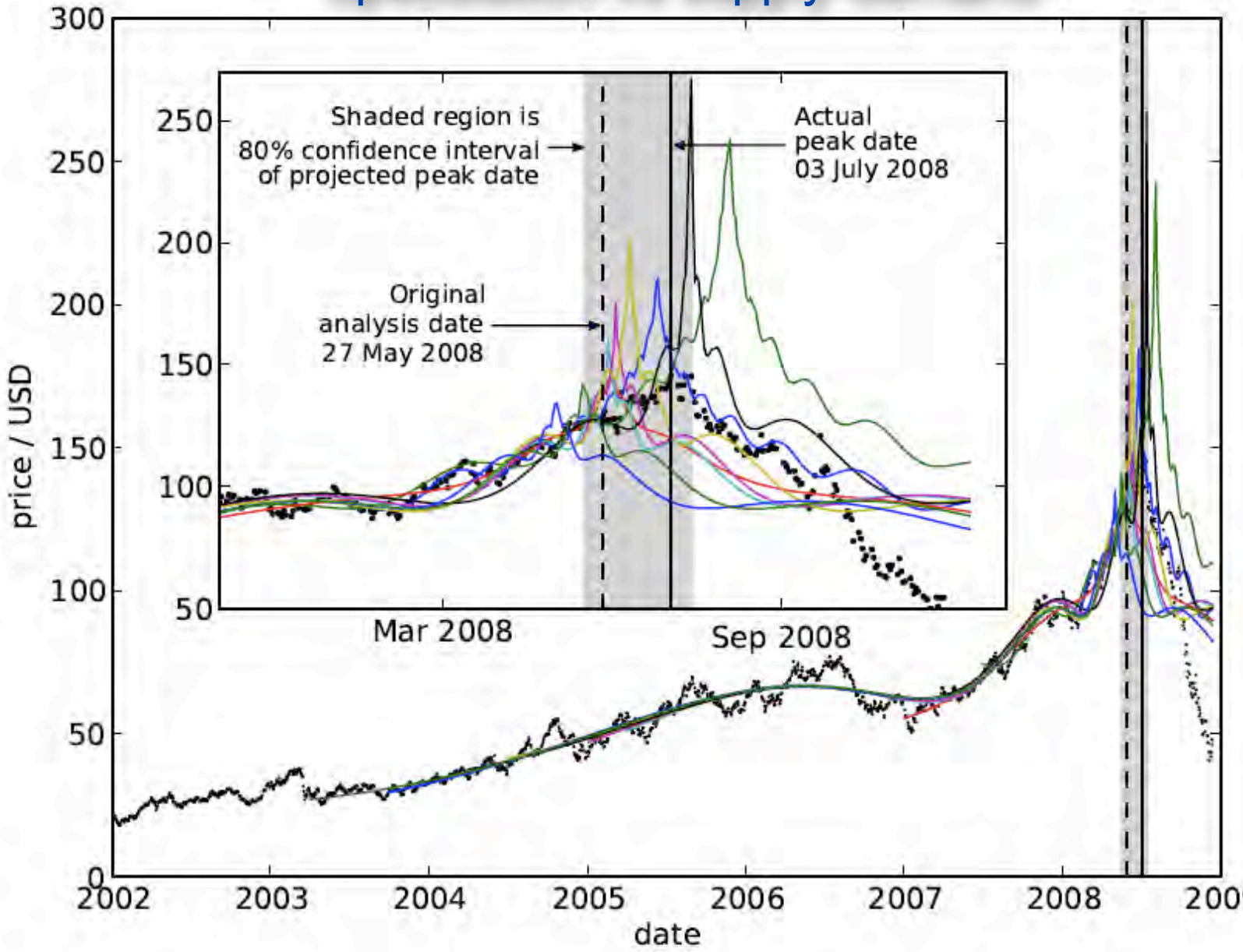
W.-X. Zhou, D. Sornette / Physica A 361 (2006) 297–308



Source: R. Woodard (FCO, ETH Zurich)

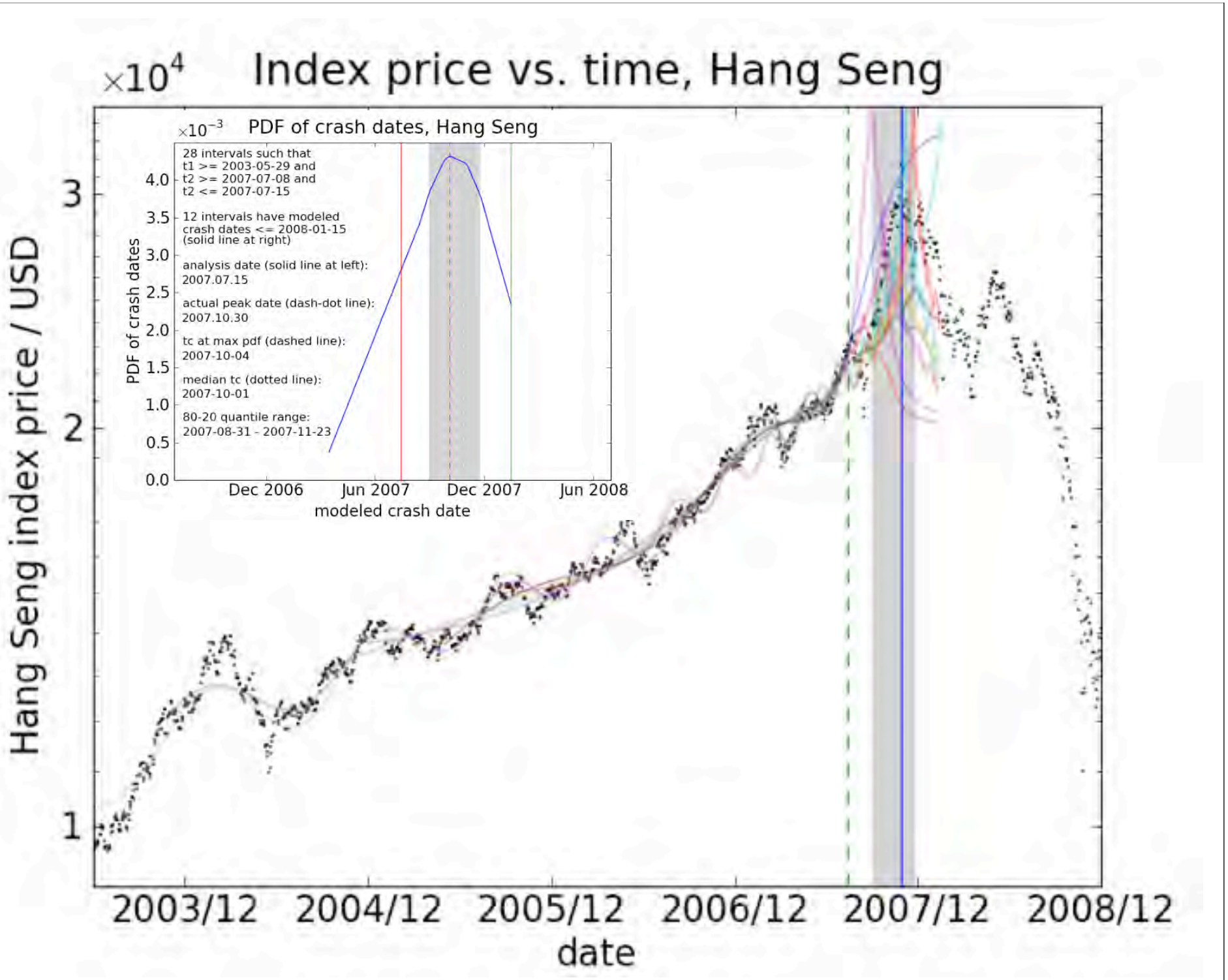
2006-2008 Oil bubble

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.


Index price vs. time, Hang Seng
×10^4
Hang Seng index price / USD
1
2
3
2003/12
2004/12
2005/12
2006/12
2007/12
2008/12
date
PDF of crash dates, Hang Seng
×10^-3
PDF of crash dates
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
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
Dec 2006
Jun 2007
Dec 2007
Jun 2008
modeled crash date

FOUR EXAMPLES

(i) the fluctuation-susceptibility theorem transforms into a remarkable classification of financial volatility shocks (endogenous versus exogenous),

(ii) the Ising model of phase transitions can be generalized to model the stylized facts of financial markets,

(iii) the concepts of collective phenomena and phase transitions (with spontaneous symmetry breaking) help understand financial bubbles and their following crashes,

(iv) the mathematics of quantum physics provides a new quantum decision theory solving the known paradoxes.

Partial list of problems with standard Utility theory

- Allais paradox (Compatibility violation: Several choices are not compatible with utility theory)
- Ellsberg paradox (uncertainty aversion)
- Kahneman-Tversky paradox (invariance violation)
- Rabin paradox (payoff size effects)
- Disjunction effect (violation of the sure-thing principle)
- Conjunction fallacy (violation of probability theory)

“Bounded rationality”

- In 1957, Herbert Simon described the principle of “bounded rationality” - Nobel Prize in 1978:

  “The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problem whose solution is required for objectively rational behavior in the real world, or even for a reasonable approximation to such objective rationality.”

PARMENIDES FOUNDATION

FutureWorld FOUNDATION

What to do?

1. Realistic problems are complicated, consisting of many parts.

2. Different parts of a problem interact and interfere with each other.

3. Several thoughts of mind can be intricately interconnected (entangled).

Life is complex!

=>Towards a fundamental theory of human decision making

(triune brain: reptilian, emotional, rational)

Quantum Decision Theory?

V.I. Yukalov and D. Sornette
Processing Information in Quantum Decision Theory,
Entropy 11, 1073-1120 (2009)

V.I. Yukalov and D. Sornette
Entanglement Production in Quantum Decision Making,
Physics of Atomic Nuclei 73 (3), 559-562 (2010).

Quantum Decision Theory

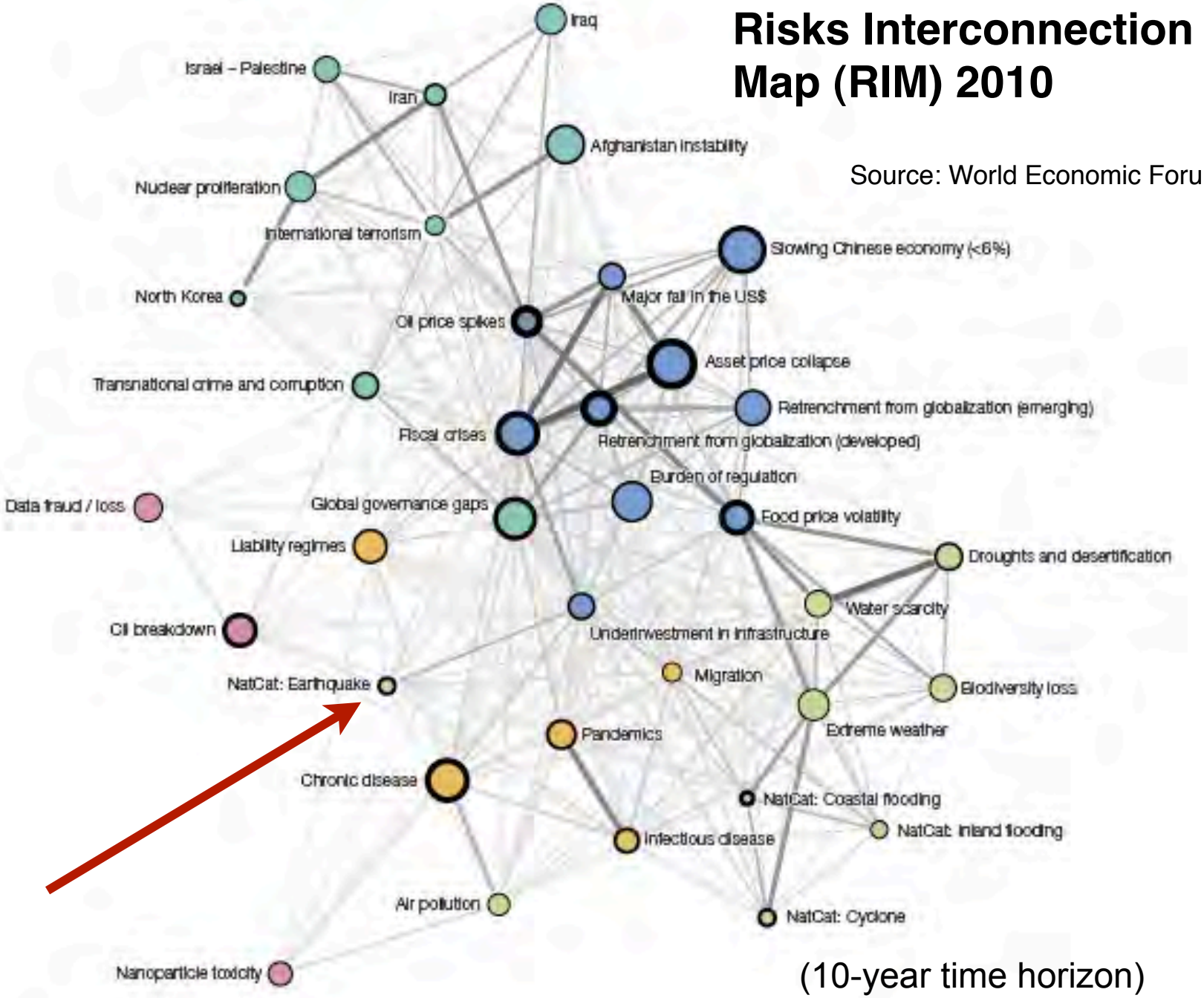
- Novel approach to decision making is developed based on a complex Hilbert space over a lattice of composite prospects.
- Risk of **loss and uncertainty** are taken into account.
- Decisions are probabilistic and depend on state of mind that can be changed or framed.
- Paradoxes of classical decision theory are explained.
- Good quantitative agreement with empirical data.
- Conjunction fallacy is a sufficient condition for disjunction effect.

Questions and Strategy for the future

"Nature" is more imaginative than mathematicians, economists or... econophysicists

Risks Interconnection Map (RIM) 2010

Source: World Economic Forum 2010



(10-year time horizon)

Likelihood (%)

1 5 10 20

Severity (Billion US$)

10 50 250 1000

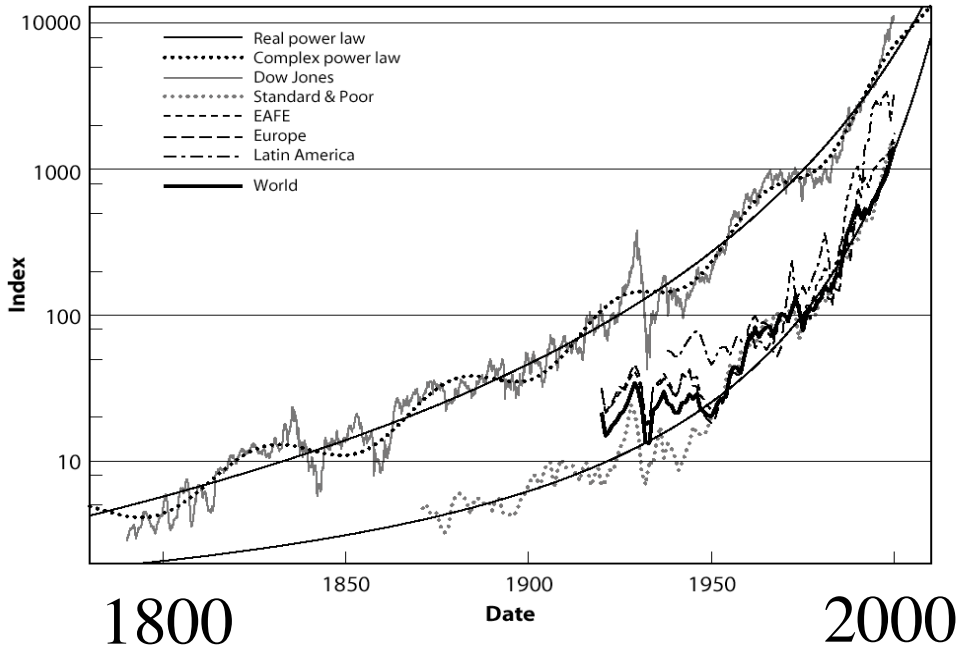
Domain

Economics | Geopolitics | Environment | Society | Technology

IMMENSE PROGRESS and INNOVATION

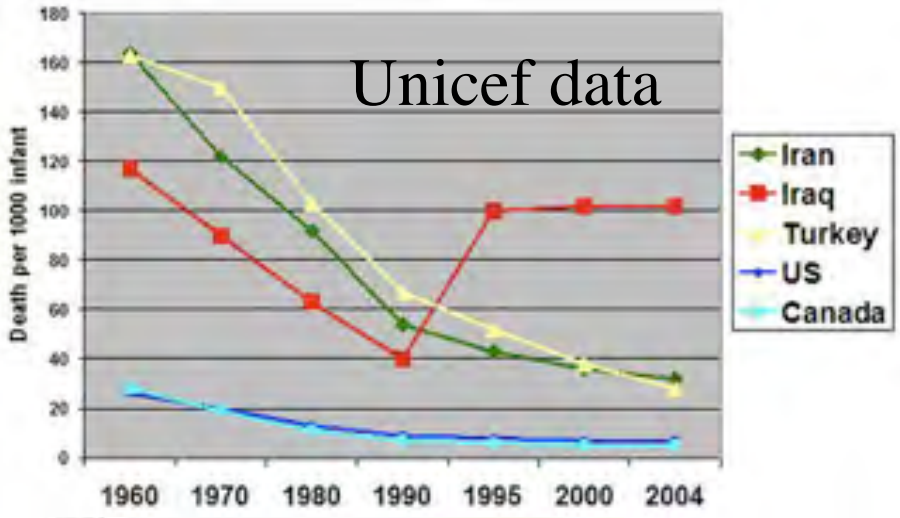
FINANCIAL SYSTEM

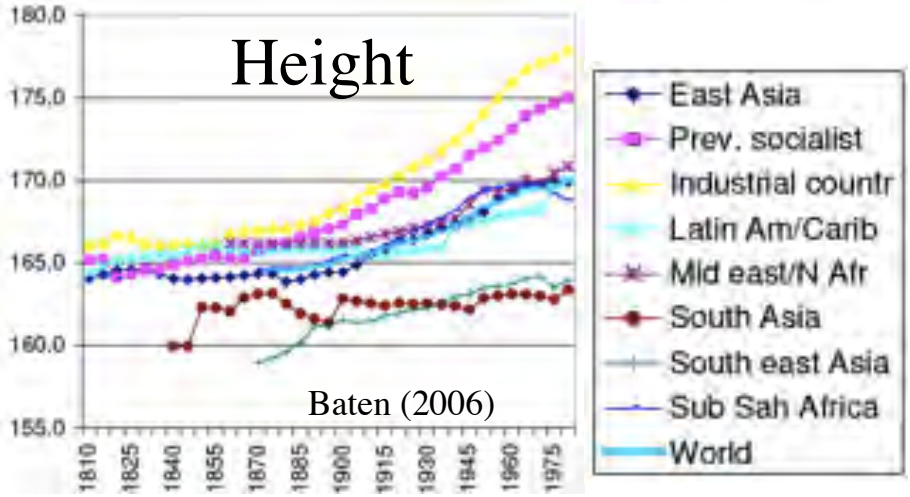
Financial innovations have fostered the use of capital for
- economic development,
- welfare,
- education...



FOOD AND HEALTHCARE

- Decrease of newborn and infant mortality
- Height as a proxy for health





CONFLICTS OF INTERESTS

FINANCIAL SYSTEM

Loss of "Fiduciary Principle"

'*no man can serve two masters*'
(J. Bogle, former CEO Vanguard group, JPM 2009)

"Legal relationship of confidence or trust between two parties"

The issue of "moral relativism"

Moral hazard

Incentives

FOOD AND HEALTHCARE

Loss of "Hippocratic oath"

'*nil nocere*'

Fundamental conflict of interest to keep us "marginally ill"

Maximizing share-holder value

Rational focus on short-term in the presence of large risks and uncertainties

HUMAN INTRINSIC WEAKNESSES

People simply fail to do what is best even for themselves, in the face of good, freely available information.

FINANCIAL SYSTEM

The illusionary quest of society-at-large, pensions funds, mutual funds... to gain more than 2% return in real terms (above inflation)

The "gambling society" (stardom culture, emphasis on "luck") vs work and risk management

The root cause of the crisis is our illusion on financial solution to growth (high returns, above GDP growth)

FOOD AND HEALTHCARE

The illusionary syndrome for "blue pills and red pills"...

Principle of least effort (Zipf, 1949)

Principle of immediate or short-term gratification (large "discount rate")

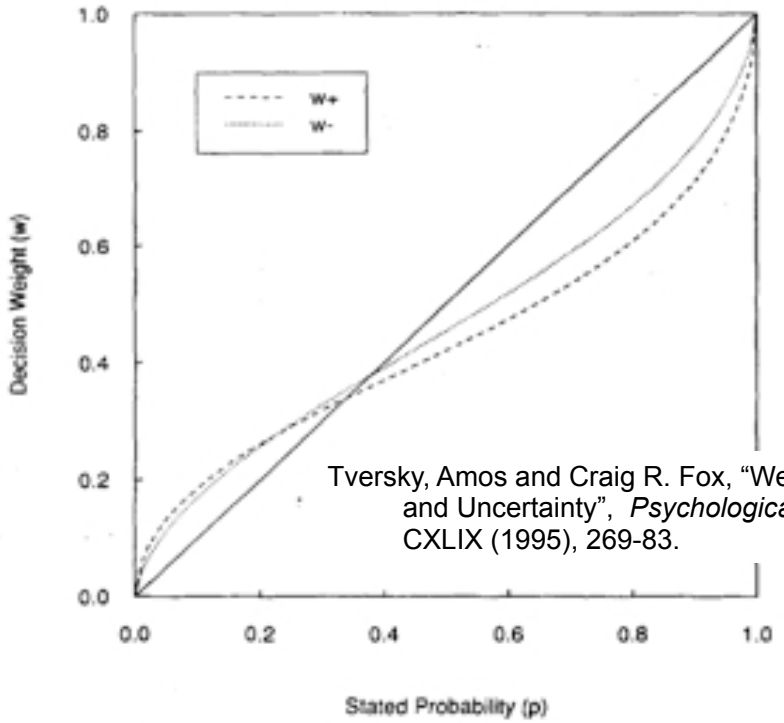
The root cause of the coming healthcare crisis is our illusion in technical / medical solutions.

HUMAN INTRINSIC WEAKNESSES

Fundamental failure to grasp the SYSTEM nature of the problems:
Instead, one problem => one proximate solution: THIS IS WRONG!

FINANCIAL SYSTEM

- Bankers are sellers of dreams.
- Bankers exploit our illusions and cognitive limitations... like casinos and lotteries...



Tversky, Amos and Craig R. Fox, "Weighing Risk and Uncertainty", *Psychological Review*, CXLIX (1995), 269-83.

FOOD AND HEALTHCARE

- The food industry exploits our weakness (addictive and/or compensatory nature of some foods).
- The pharmaceutical industry exploits our illusions for simple solutions to health problems.

Cooperation and coordination problems

- Public goods (individual cost for benefit to the group) (recycling, hybrid car, valor in combat, voting, donating blood,...)
- Tragedy of the commons (shared resource gives benefit to personal use and distributed losses) (cows in shared pastures, Air, Water, Scenery, global warming, pollution...)
  - Earth renewable services are exogenous to the economic costs and decision processes
- Externalities: pollution
- Market failures: asymmetric information

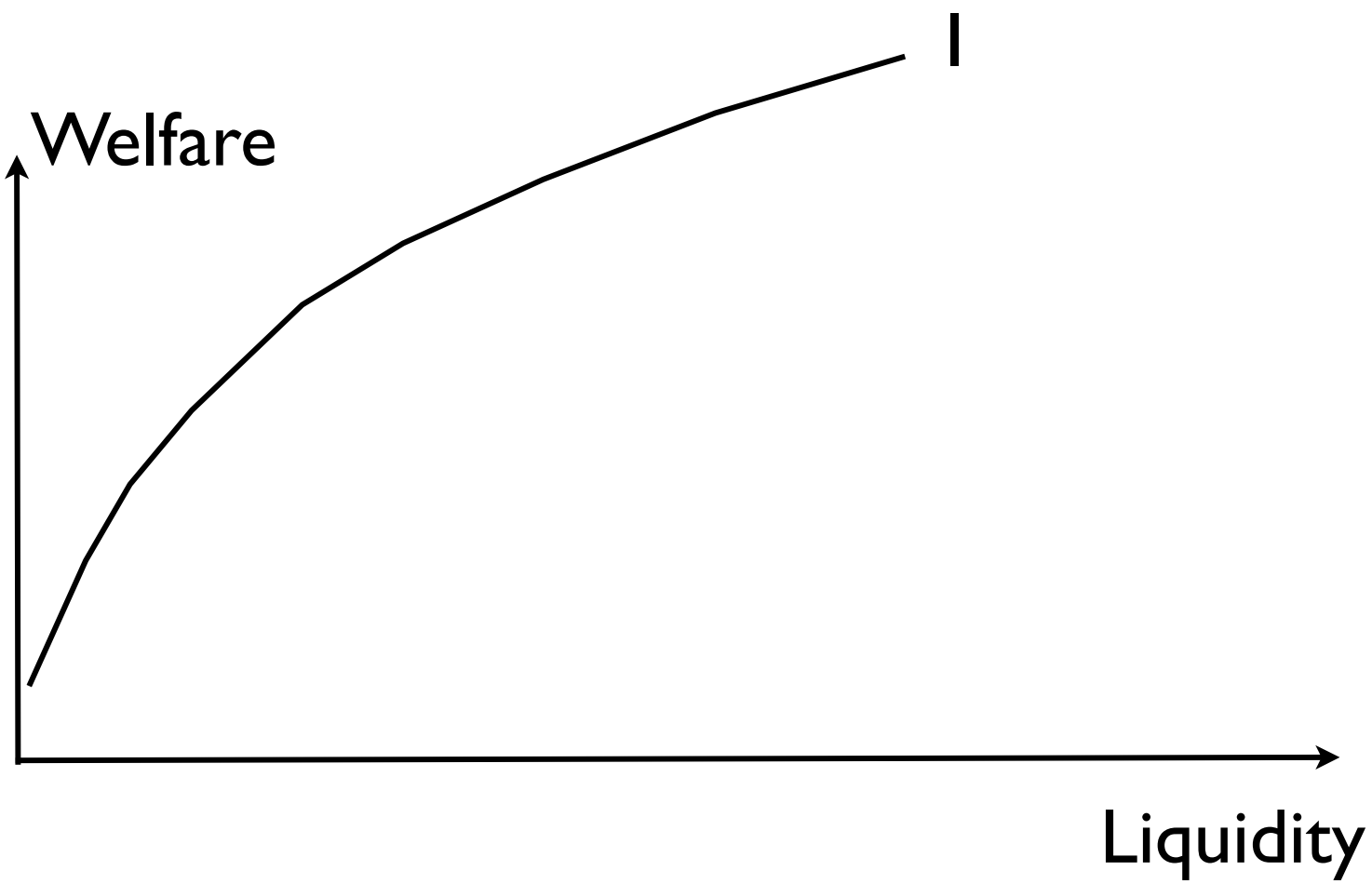
Theory and practice of human cooperation?

-Financial innovations, High Frequency Trading...
are justified by improved LIQUIDITY

=> do we need so much liquidity?

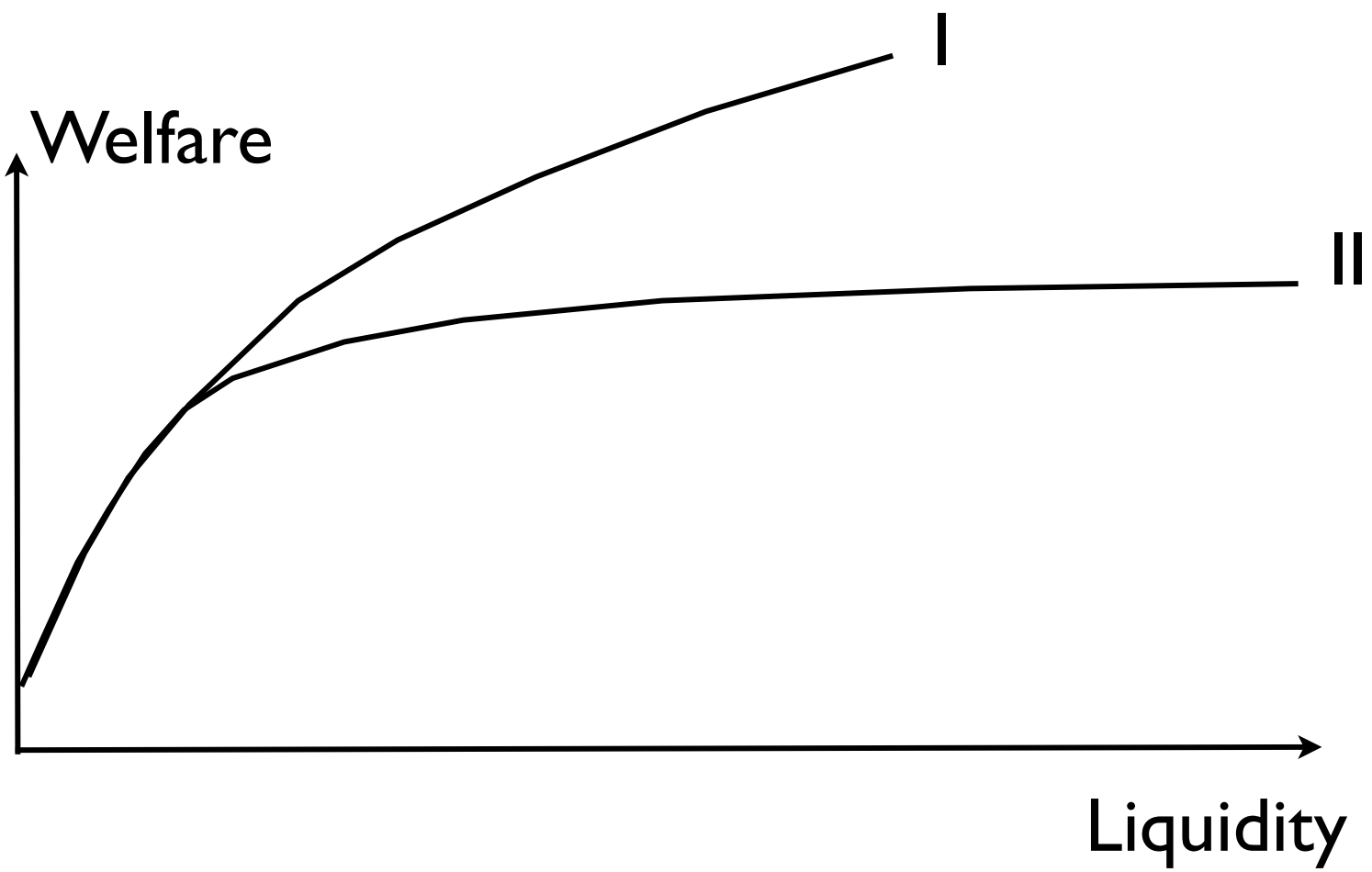
-Financial innovations, High Frequency Trading...
are justified by improved LIQUIDITY

=> do we need so much liquidity?



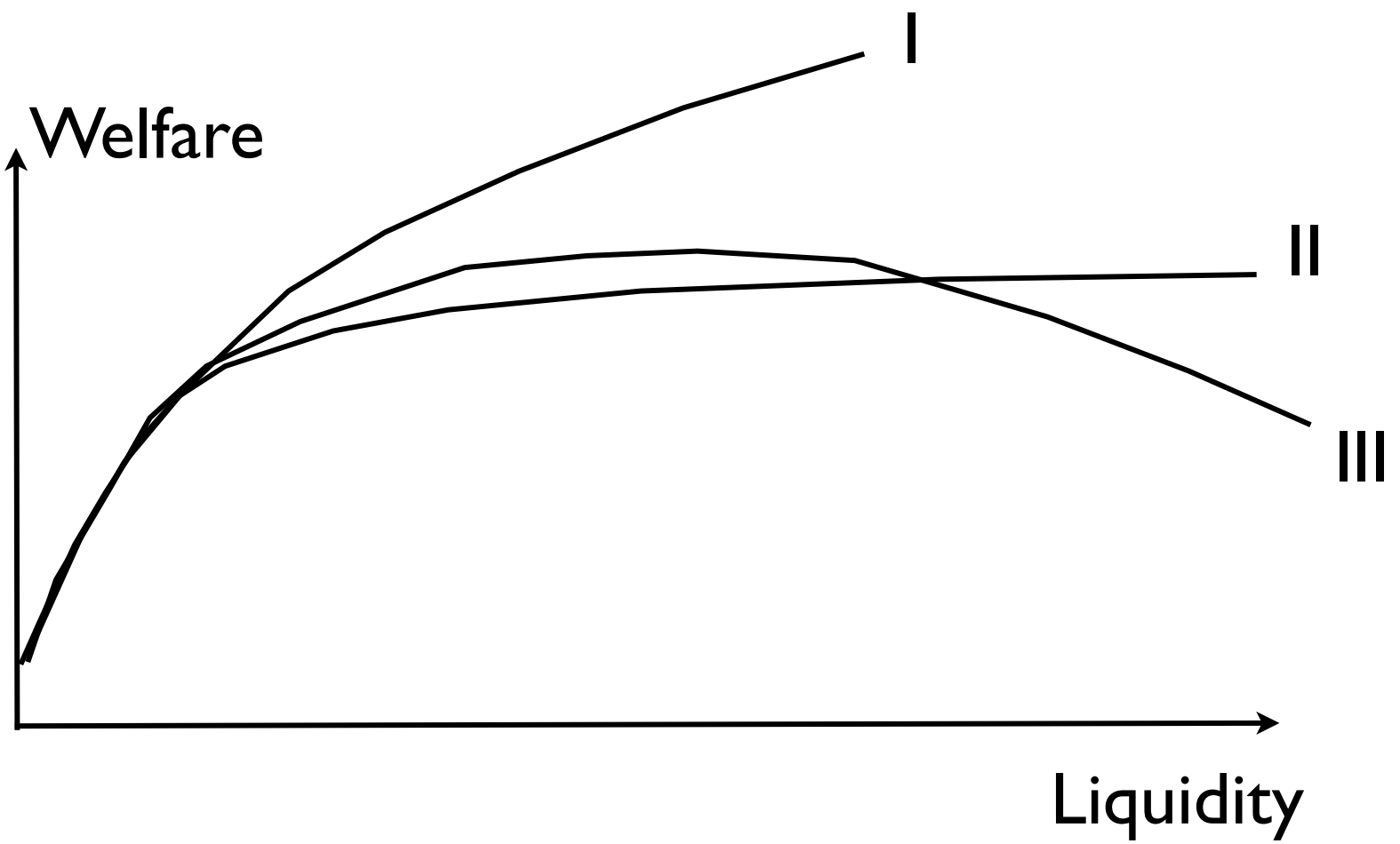
-Financial innovations, High Frequency Trading...
are justified by improved LIQUIDITY

=> do we need so much liquidity?



-Financial innovations, High Frequency Trading...
are justified by improved LIQUIDITY

=> do we need so much liquidity?



Questions and Strategy for the future

from post-mortem data analysis

to

real-time hand-on experiments,
trading and design

At present: most exciting progresses at the boundary between economics and the biological, cognitive, and behavioral sciences.

Physics has still a role to play as a unifying framework full of concepts and tools to deal with the complex.

The modeling skills of physicists explain their impressive number in investment and financial institutions (data-driven approach coupled with a pragmatic sense of theorizing)

KEY CHALLENGE:

true inter-disciplinarity by "marriage"

Entrepreneurial-Scientific spirit

"How many things are looked on as quite impossible until they have been actually effected?" (Pliny the Elder, 1st c. AD: Natural History, Book VII, section 6)

"It is impossible to produce a superior performance unless you do something different from the majority". Sir John Templeton.

Everybody knew it is impossible.
He/She did not know it.
He/She did it.