**Departmental Seminar, March 2005**

**Andreas Penckwitt**

# Intelligent Finance

A Convergence of Mathematical
Finance with
Technical and Fundamental Analysis

First International Workshop on Intelligent Finance
held in Melbourne, December 13-14, 2004

# Session 1: Social Economic Perspectives of Finance

- Intelligent Finance - An Introduction
  Heping Pan, Didier Sornette and Kenneth Kortanek
- The Financial/Economic Dichotomy
  Robert R. Prechter and Wayne D. Parker, The Socionomics Foundation, USA

# Session 2: Fundamental Analysis and Econometrics

- Warren Buffett: Investment Genius or Statistical Anomaly?
  John Price, The Conscious Investor, Australia, and Edward Kelly, University of Dublin, Trinity College, Ireland
- Credit Risk Evaluation Through Stock Price Fluctuations and Their Correlations
  Naoto Oshiro and Yasufumi Saruwatari, University of Tsukuba, Financial Technology Research Institute, Japan
- How Long Is the Long Run? Evidence from the Foreign Exchange Market
  Kenneth Clements, Yihui Lan, University of Western Australia

# Session 3: Technical Analysis and Trading Strategies

- A Test of Momentum Trading Strategies in Foreign Exchange Markets: Evidence from the G7
  Robert J. Bianchi, Michael E. Drew and John Polichronis, Queensland University of Technology, Australia
- Simulating Profitable Stock Trading Strategies with an Evolutionary Artificial Neural Network
  Serge Hayward, Ecole Supérieure de Commerce de Dijon, France

# Session 3 … continued

- On the Representation of Trading Strategies and Financial Products
  Stefan Dirnstorfer, Technical University Munich, Germany
- The Predictive Ability of Simple Technical Indicators: Australian Evidence
  Maurice Peat, Max Stevenson and Daniel Maroney, University of Sydney, Australia

# Session 4: Stochastic Process Models

- Non-stochastic Uncertainty Approaches to Prediction in Finance
  Kenneth Kortanek, University of Pittsburgh, USA
- Pricing Barrier Options with Local Volatility Surface for Advantage
  Zili Zhu, CSIRO Mathematical & Information Sciences, Australia
- ~~Dynamic Optimal Recovery to Credit Risk~~
  ~~Jianhui Huang, University of Alberta, Canada~~
- Karhunen-Loève Approximations of Wiener Processes and Solutions of SDEs
  Deborah Downes and Stephen Lucas, University of South Australia

# Session 7: Game Theory and Intelligent Agents

- A Mechanism for Pockets of Predictability in Complex Adaptive Systems
  Jørgen Vitting Andersen and Didier Sornette, CNRS, France, UCLA, USA
- ~~Minority Games in Financial Markets~~
  ~~Damien Challet, Oxford University, UK (presentation only)~~
- ~~Strategic Updating of Threshold Response in An Agent-based Market Model~~
  ~~François Ghoulmie, University of Paris, France~~
- Phase Transition of Dynamical Herd Behaviors in Financial Markets
  Kyungsik Kim and Seong-Min Yoon, Pukyong National University, Korea
- ~~Strategic Alliance: Absorptive Capacity and Search~~
  ~~Julian Lowe and Munirul Haque Nabin~~

# Session 8: Chaos Theory and Econophysics

- Dependence Structures in Financial Time Series: A Chaos-Theoretic Approach
  Rodney C Wol, Queensland University of Technology, Australia
- A Mean-Field Approach of Predicting the Future of the Income Distributions of Companies
  Hideki Takayasu, Takayuki Mizuno and Misako Takayasu, Sony Computer Science Laboratories, Japan
- Characterization of Temporal Behavior of Foreign Exchange Markets
  Misako Takayasu, Takaaki Ohnishi, Takayuki Mizuno and Hideki Takayasu, Tokyo Institute of Technology, Japan
- ~~Statistical Analysis of Detrended Stock Market Indices~~
  ~~Boon Leong Lan, Monash University, Malaysia~~

# Session 9: Quantitative Analysis and Portfolio Management

- Calculating the Optimal Exercise Boundary of American Put Options with An Approximation Formula
  Song-Ping Zhu, University of Wollongong, Australia
- Phase Transitions in an Equity-Ranking Predictor
  Jerey Satinover, University of Nice, France

# Session 9 … continued

- Compound Models of High-Low Speculative Prices: A Cointegration-based Approach
  Nagaratnam Jeyasreedharan, University of Tasmania, Australia
- Relationships between Different Term Structures of Australian Interest Rate Swap Market
  Musa Mammadov and John Yearwood, University of Ballarat

# Session 10: Computational Intelligent Finance Systems

- Algorithmic Trade Execution and Market Impact
  Richard Coggins, Marcus Lim and Kevin Lo, University of Sydney, Australia
- The Components of the Bid-Ask Spread: An Ability-Based Model
  Paochung Hsu, Providence University, Taiwan, Republic of China
- An Investigation of the Uses of Depth of Field and Stochastic Concepts in Fine Tuning Strategic Plays in the Australian Stock Market and Its Impact on Systems Development
  Barry O’Gray, Curtin University of Technology, Australia

# Session 11: Intelligent Finance Theories

- ~~Why Stock Markets Crash - Critical Events in Complex Financial Systems~~
  ~~Didier Sornette, University of California LA and CNRS, University of Nice, France~~
- A Swingtum Theory of Finance for Swing Trading and Momentum Trading
  Heping Pan, University of Ballarat

# Intelligent Finance - An Introduction

Heping Pan

Intelligent finance emerging convergence of several distinct disciplines:

- Fundamental Analysis
- Technical Analysis
- Quantitative Analysis
- Strategic Analysis
  - Art of trading and active speculation either passively exploiting market-inequilibria or actively with conscious intention to affect market
  - Game theory and intelligent agents

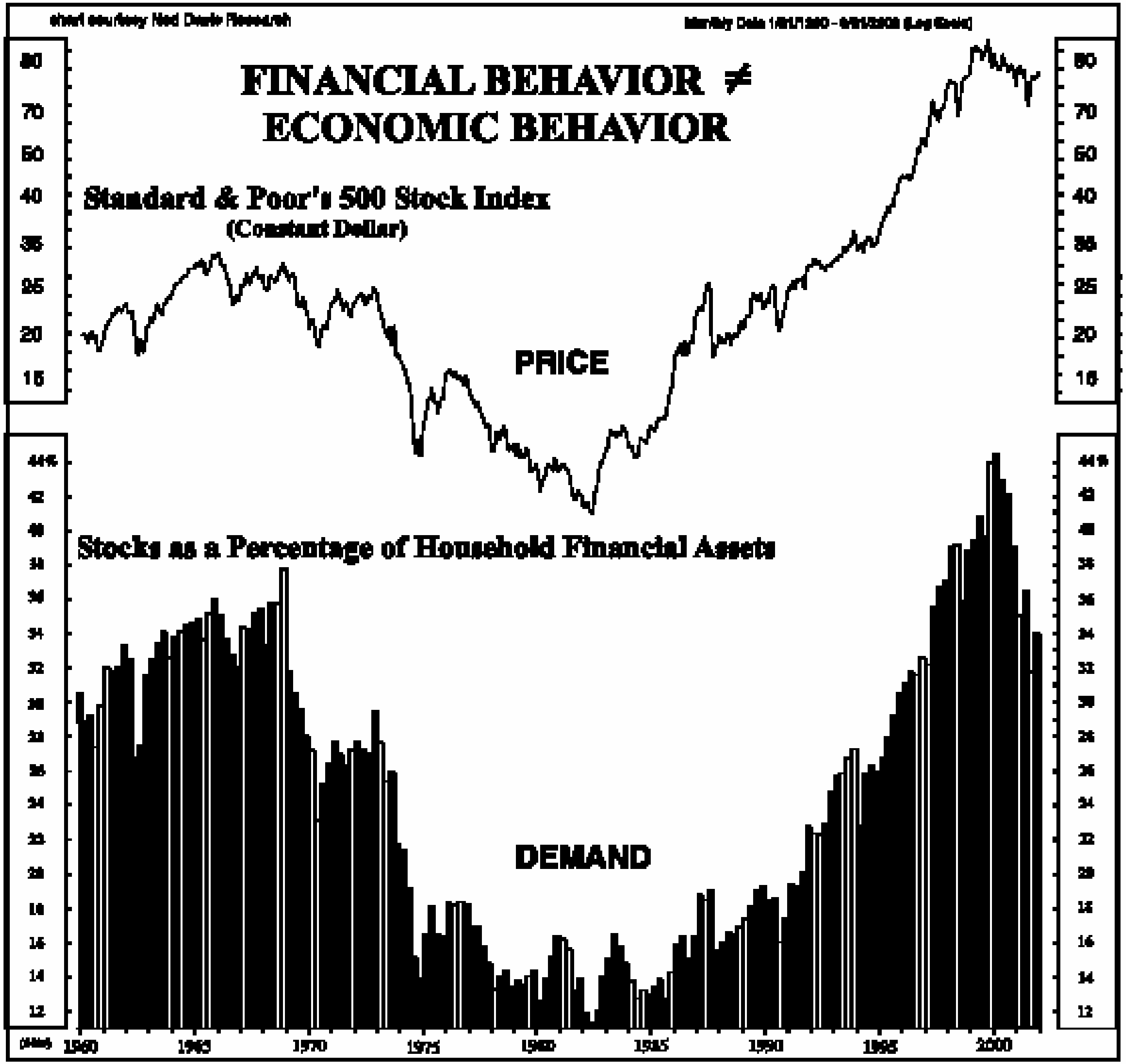
# Characteristics of Intelligent Finance

- **Objective:** gain consistently absolute positive and nontrivial returns of investing and trading in selected financial markets
- **Approach:** exploit complete information about the selected markets
- **Methodology:** manage the very last risk - the incompleteness of a standalone trading system

# The Financial/Economic Dichotomy

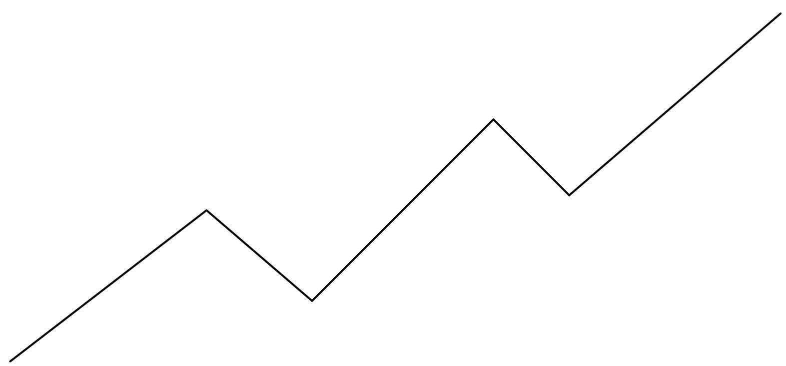
Robert R. Prechter

- Dramatic Anomalies:
  - 1976-1980: quaterly GPD growth, but stock market went down
  - 1980-now: Inflation leads to money supply tripled, but gold prize went down
  - 9/11: market closed for 6 days, slight drop for six days, but went up following six month
  - etc.
- Knowing news one day ahead does not help to predict financial markets


FINANCIAL BEHAVIOR ≠ ECONOMIC BEHAVIOR
Standard & Poor's 500 Stock Index
(Constant Dollar)
PRICE
Stocks as a Percentage of Household Financial Assets
DEMAND
1960
1965
1970
1975
1980
1985
1990
1995
2000

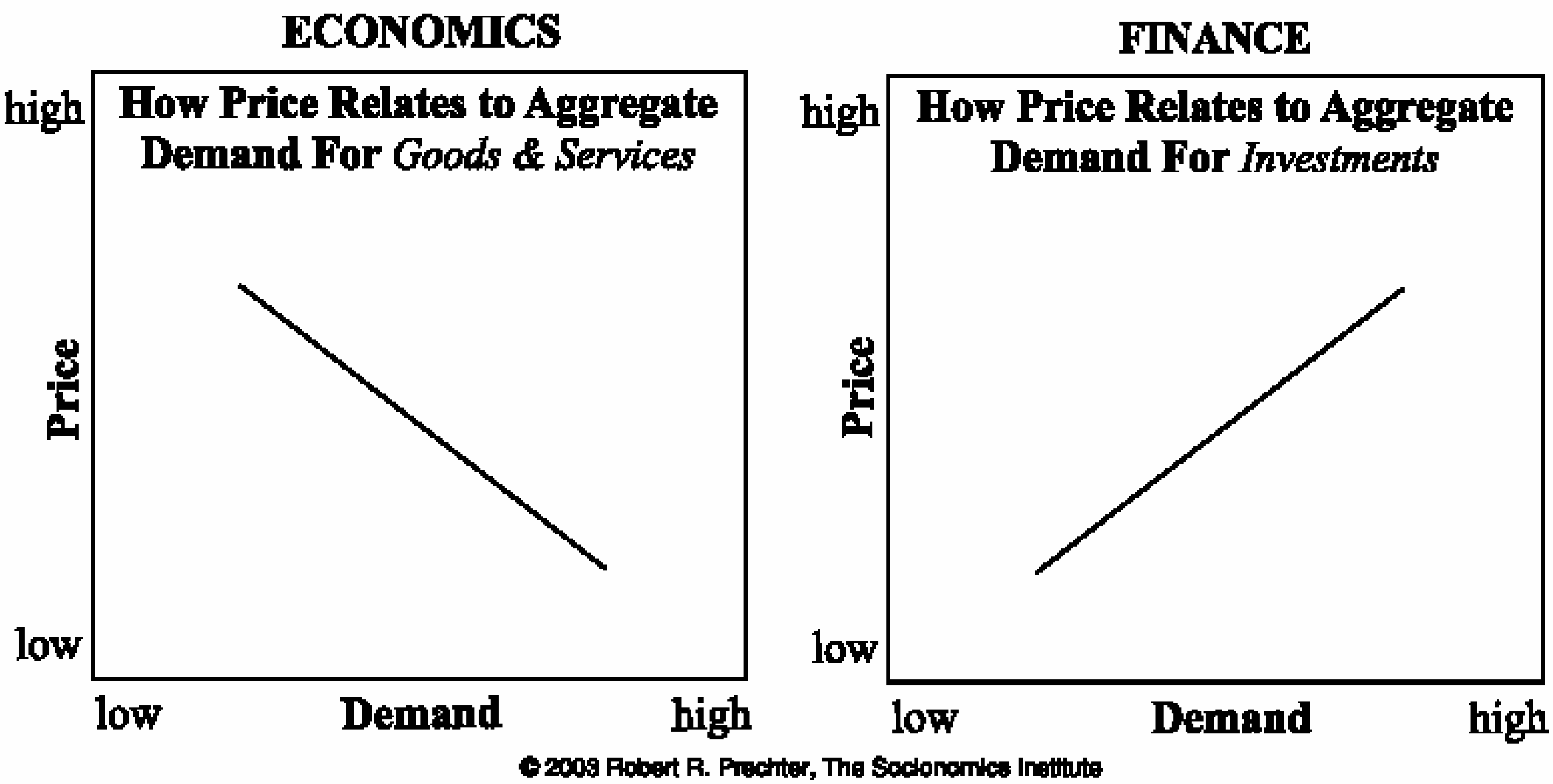
# Elliot Waves

- Stock market highly correlated to itself
- Natural growth pattern
- Simplest one is a basic Elliot Wave (1940)



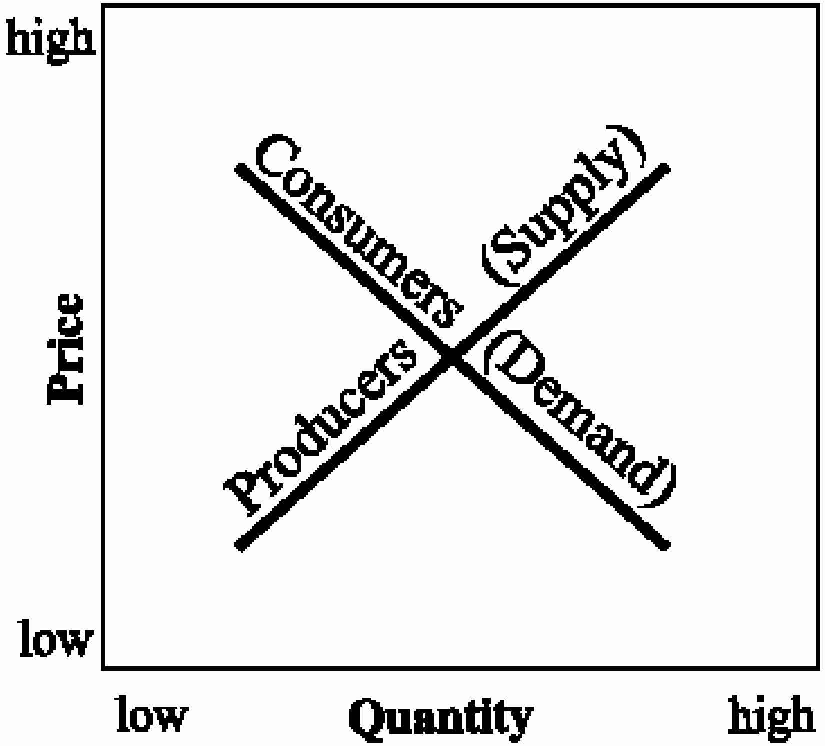
# Herding

- Herding when faced with uncertainty
- Notion that following the herd decreases risk (while risk actually increases)
- Herding creates patterns
- Rationalizing, not reasoning

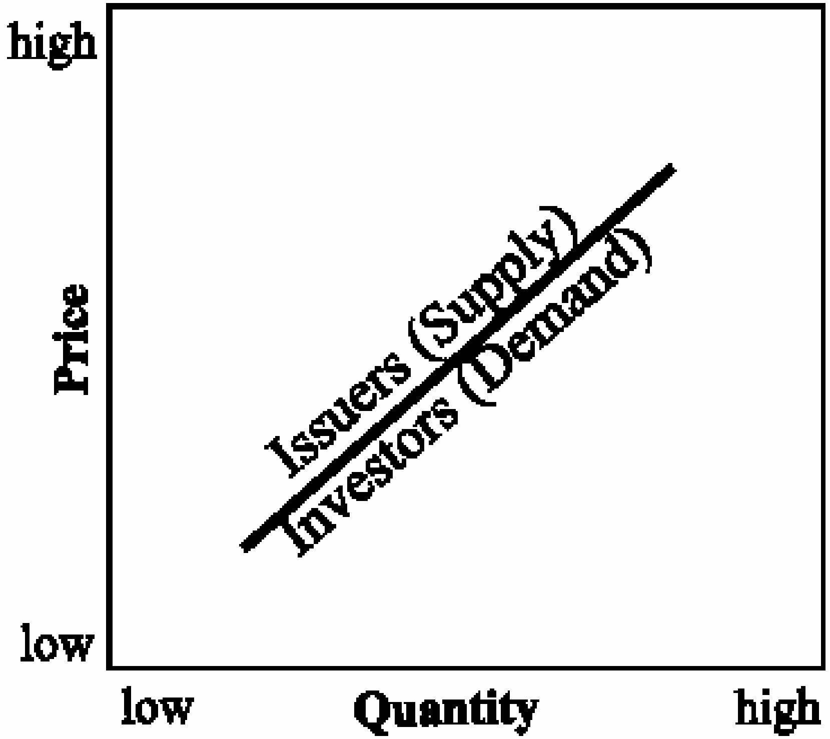



| | |
|---|---|
| Motivation (goal): Survive and Thrive | Motivation (goal): Survive and Thrive |
| Means: Maximizing Utility | Means: Herding |
| Mechanism: Conscious Reason | Mechanism: Unconscious Reason |
| Result: Survive and Thrive | (Ultimate Result) Result: Losses |

**The Law of Supply & Demand in Utilitarian Economics**




**Herding Impulse in Finance**






Features: Rational Valuation
Equilibrium
Objective Values
Aggregate Governor: The Invisible Hand

Features: Pre-Rational (Impulsive) Valuation
Dynamism
Subjective Values
Aggregate Governor: The Wave Principle

# Socionomics

- Economic behaviour results from major mood trends
- Stock market is leading, not lagging
- Stock market as major sociometer
- Elliot waves of social mood

## ***Contrasting Models of Finance***

| EMH (Economic) Model | WP (Socionomic) Model |
|---|---|
| 1. Objective, conscious, rational decisions to maximize utility determine financial values. | 1. Subjective, unconscious, pre-rational impulses to herd determine financial values. |
| 2. Financial markets are random. | 2. Financial markets are patterned. |
| 3. Financial markets are unpredictable. | 3. Financial markets are probabilistically predictable. |
| 4. Financial markets "tend toward equilibrium" and "revert to the mean." | 4. Financial markets are dynamic and do not revert to anything. |
| 5. Investors in financial markets typically use information to reason. | 5. Investors in financial markets typically use information to rationalize emotional imperatives. |
| 6. Investors' decisions are based on knowledge and certainty. | 6. Investors' decisions are fraught with ignorance and uncertainty. |
| 7. Changing events presage changes in the values of associated financial instruments. | 7. Changing values of financial instruments presage changes in associated events. |
| 8. Economic principles govern finance. | 8. Socionomic principles govern finance. |

# Minority Game (MG)

- Multi-agent system
- Addresses interaction between agents and information
- No optimal strategy
- Inductive reasoning
- Cooperation without direct interaction
- Critical transition (collective behaviour qualitatively different from single agent)

# Minority Game

- N agents with memory length m and a set of s strategies (randomly assigned)
- At each time step, agents take action

  $$a_i^{\mu_m}(t) = \pm 1$$

  based on common information

  $$\mu_m(t) = \{\frac{1 + \text{sign}[A^{\mu}(k)]}{2}; k = t - m + 1, ..., t\}$$

  where $A^{\mu}(k) = \sum_i a_i^{\mu}(k)$ excess demand

# Minority Game

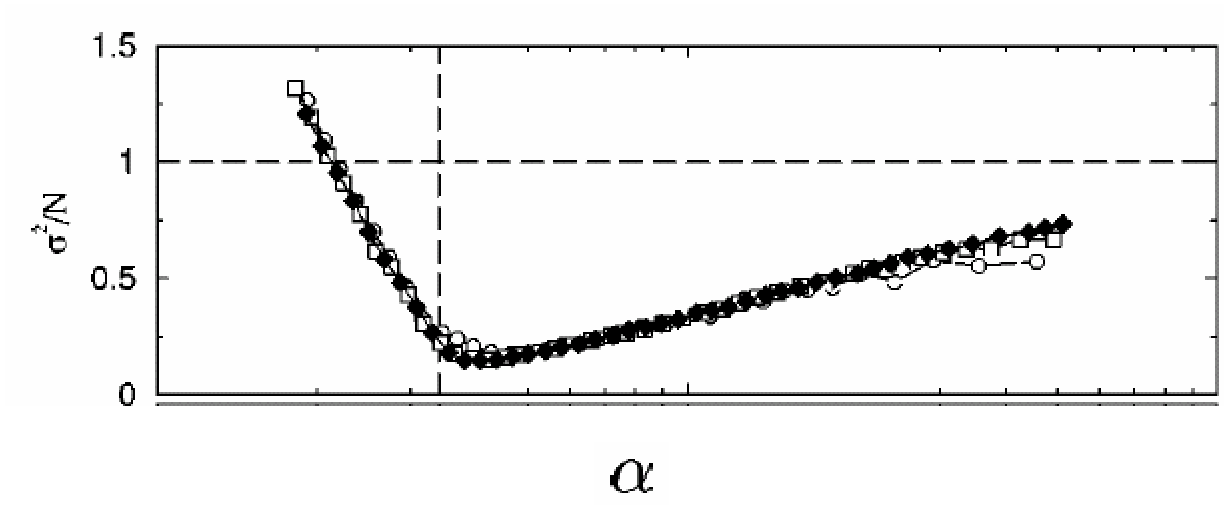
- Action based on best strategy, where a strategy is a mapping of $2^m$ possible histories onto two possible decisions
- In standard minority game s = 2
- Payoff $g_j(t) = -a_j(t)A(t)$ (standard MG)

- Other payoff functions lead to different mechanisms, e.g. $g_j(t) = a_j(t-1)A(t)$ ($ game)

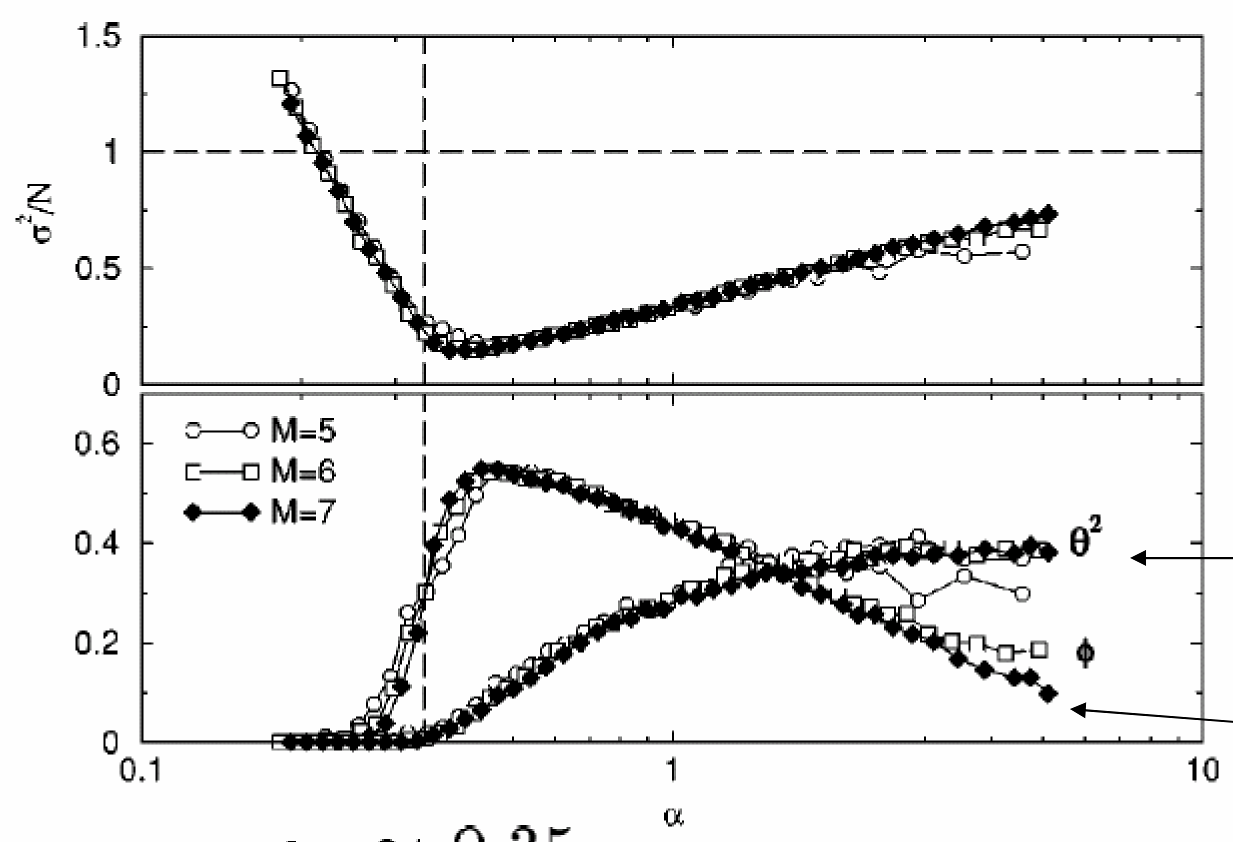
# Phase transition

- Fluctuations of A(t) depend only on ratio

$$\alpha \equiv 2^m / N$$




Crowded Coordination Random




Measure of predictability

Ratio of agents with frozen strategy

$\alpha_c \approx 0.35$

symmetric phase

unpredictable

asymmetric phase

predictable

# Other interesting results

- Possibility to extract sufficient information on strategies from collective action A(t)
- Behaviour becomes very predictable just before a crash
- Only if agents account for their market impact, Nash equilibrium is reached (in standard MG agents play against A(t), not each other)

# A Mechanism for Pockets of Predictability in Complex Adaptive Systems

Jørgen Vitting

- Found pockets of predictability in MG
- Some strategies might be decoupled
  For example

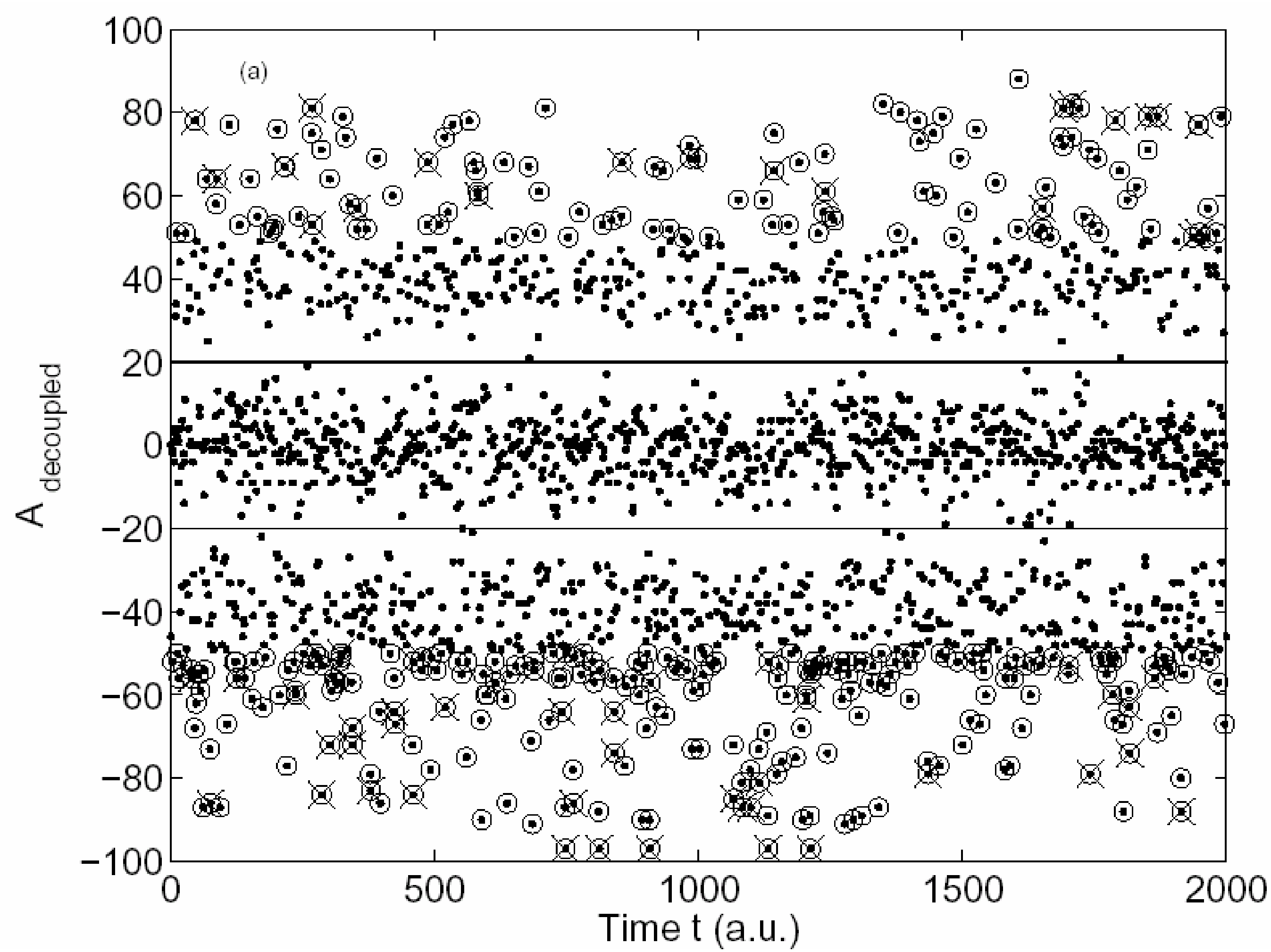
$$\{000 \to 0; 001 \to 0; 010 \to 1; 011 \to 0;$$
$$100 \to 1; 101 \to 0; 110 \to 1; 111 \to 0\}$$

  one time-step decoupled conditioned on
  $\mu_3(t) = 100$ or $\mu_3(t) = 000$

# Prediction days

- Possibility to predict with *certainty* future of global action if majority of agents use decoupled strategies which combine to a majority action
- Prediction days more frequent in statistically unpredictable regime ( $\alpha < \alpha_c$ )

# Frequency of prediction days



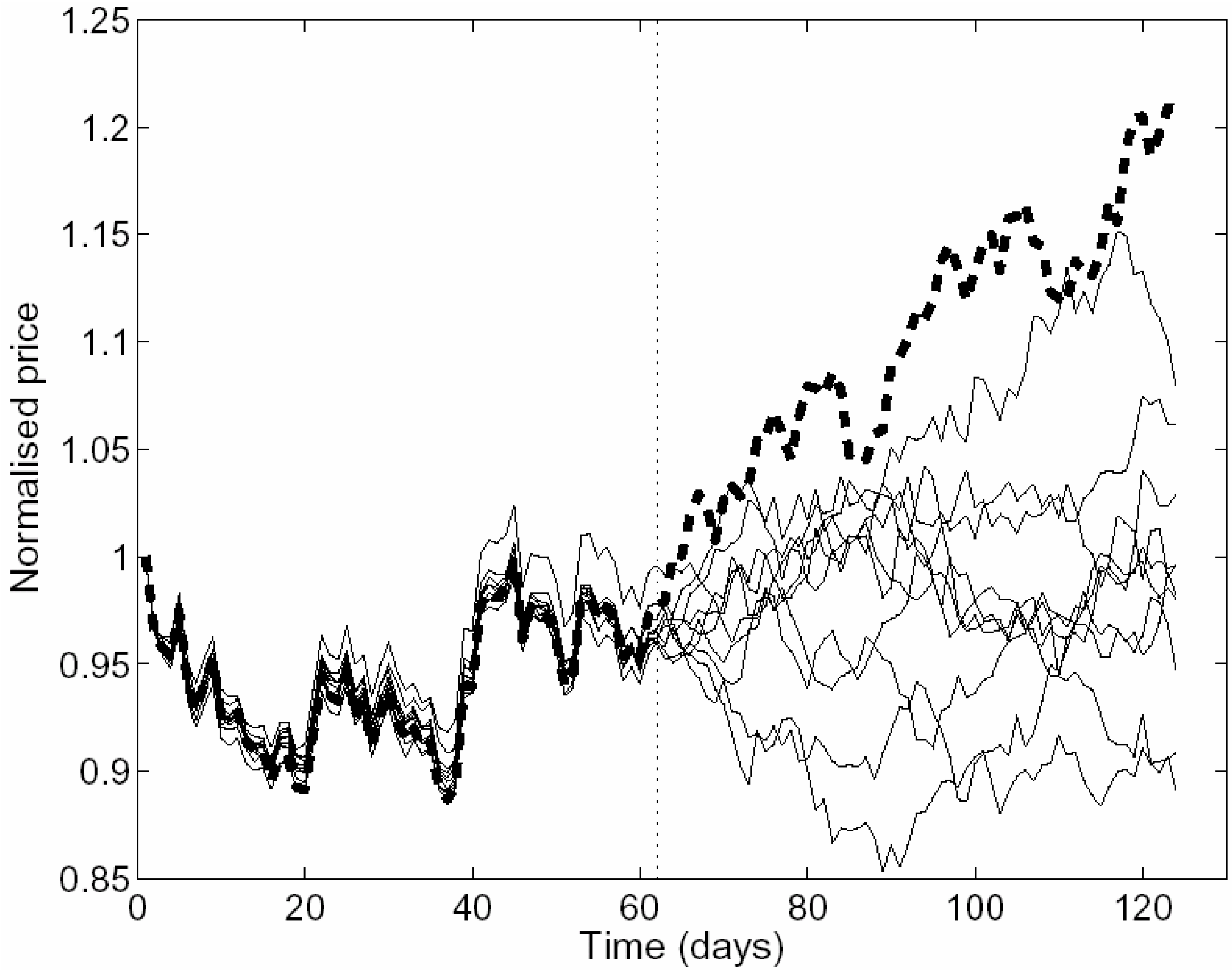

•one-step

× two-step

prediction days

random strategy

# Comparison to Nasdaq



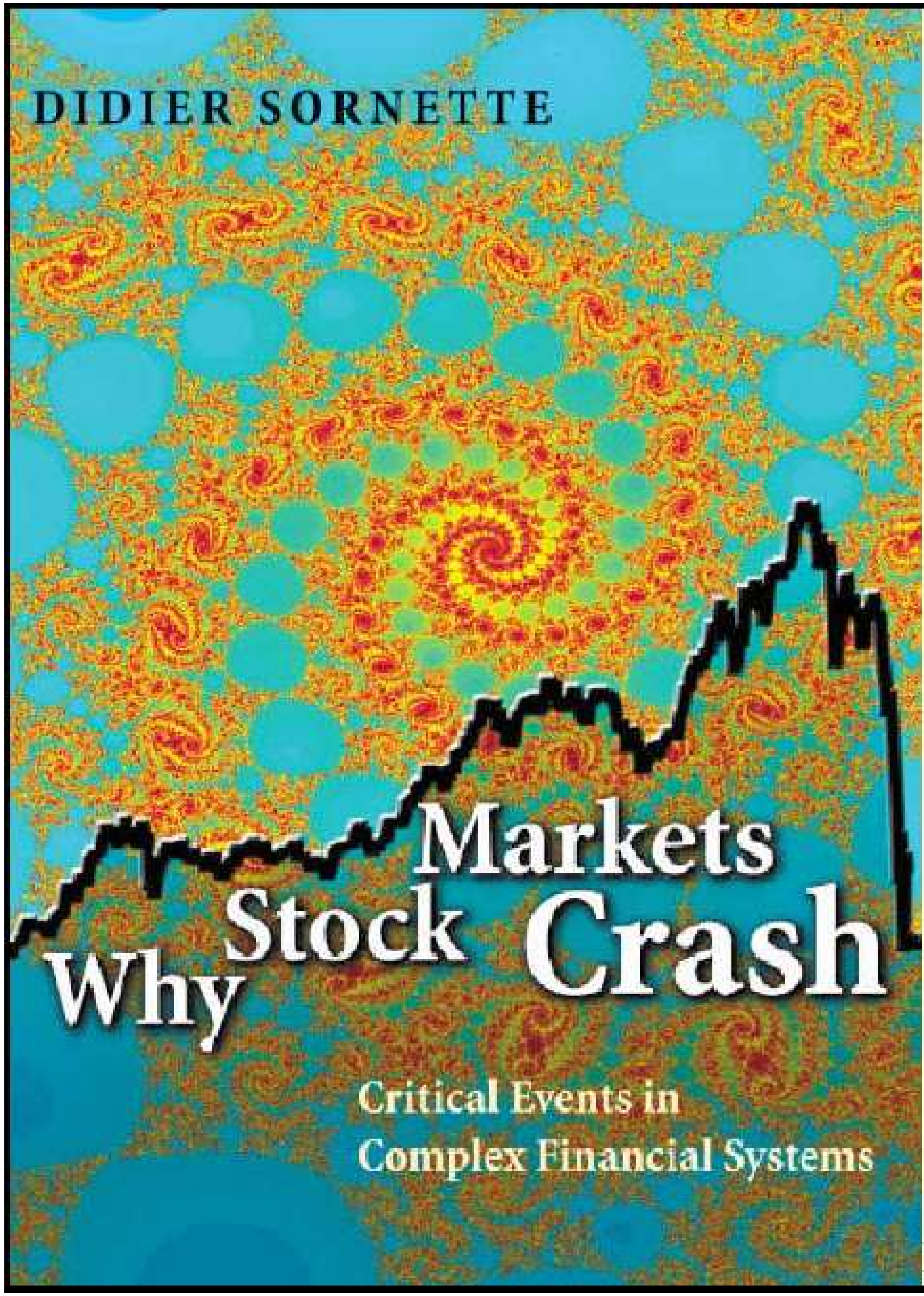

Poor job predicting prices

# Comparison to Nasdaq

- However, very good in predicting sign of change on prediction days

| $\|A\|$ | 0 | 0.5 | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 |
|---|---|---|---|---|---|---|---|---|---|---|
| % | 53 | 61 | 67 | 65 | 82 | 70 | 67 | 67 | 100 | 100 |
| Nb | 62 | 49 | 39 | 23 | 17 | 10 | 6 | 3 | 2 | 1 |

- On non-prediction days success rate not above 50%




# D. SORNETTE

**UCLA**
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Laboratoire de Physique de la Matière Condensée CNRS and Université des Sciences, Nice, FRANCE

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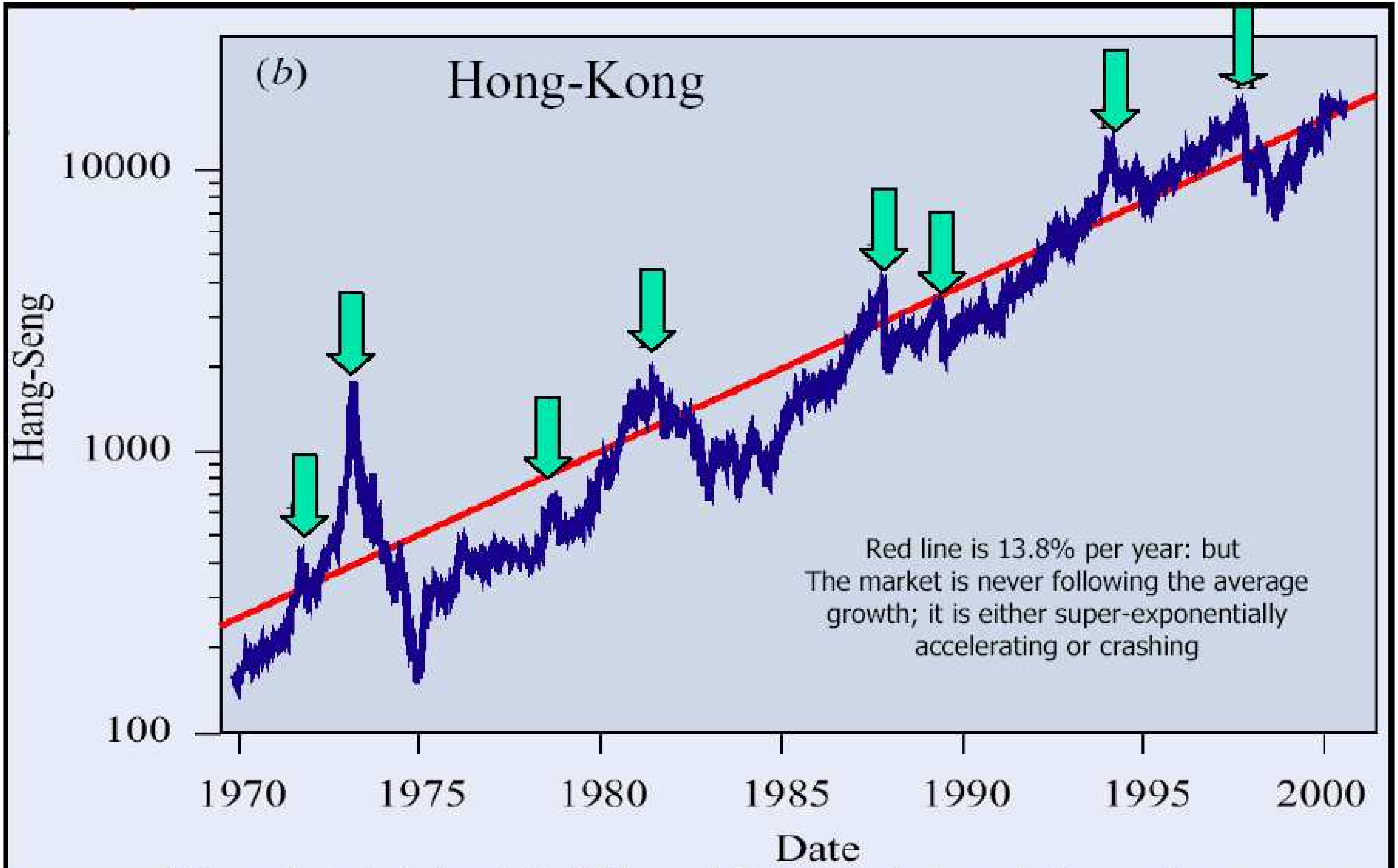
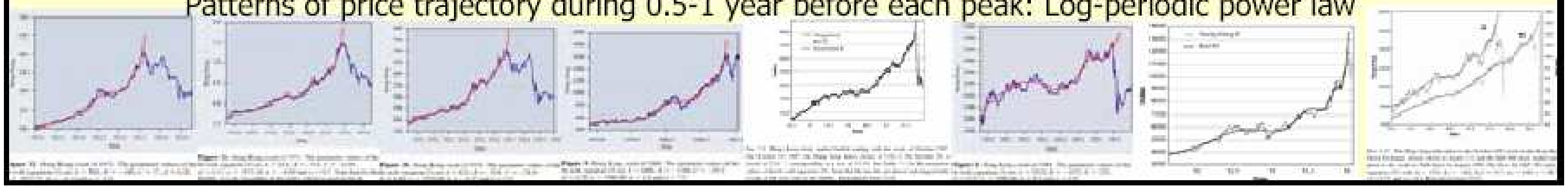
http://www.ess.ucla.edu/faculty/sornette/




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



# Universal Bubble and Crash Scenario

1. The bubble starts smoothly with some increasing production and sales (or demand for some commodity) in an otherwise relatively optimistic market.

2. The attraction to investments with good potential gains then leads to increasing investments, possibly with leverage coming from novel sources, often from international investors. This leads to price appreciation.

3. This in turn attracts less sophisticated investors and, in addition, leveraging is further developed with small downpayment (small margins), which leads to the demand for stock rising faster than the rate at which real money is put in the market.

4. At this stage, the behavior of the market becomes weakly coupled or practically uncoupled from real wealth (industrial and service) production.

5. As the price skyrockets, the number of new investors entering the speculative market decreases and the market enters a phase of larger nervousness, until a point when the instability is revealed and the market collapses.

# Complex Systems

-positive feedbacks

-non sustainable regimes

-rupture

# Mechanisms for positive feedbacks in the stock market

- Technical mechanisms
  1. Option hedging
  2. Insurance portfolio strategies
  3. Trend following investment strategies

- Behavioral mechanisms
  1. It is rational to imitate
  2. It is the highest cognitive task to imitate
  3. We mostly learn by imitation


JUST A NORMAL DAY AT THE NATION'S MOST IMPORTANT FINANCIAL INSTITUTION...
I'VE GOT A STOCK HERE THAT COULD REALLY EXCEL
REALLY EXCEL?
EXCEL?
SELL?
SELL?
SELL
SE
SELL!
SELL!
KAL
CARTOONISTS & WRITERS SYNDICATE http://CartoonWeb.com
SELL!
SELL!
ELL!
SELL!
THIS IS MADNESS! I CAN'T TAKE ANYMORE
GOOD BYE?
GOOD BYE!
Bye?
Buy?
BUY!
Buy!
BUY!!
Buy!
BUY!
I'VE GOT A STOCK HERE..

Kal

## Optimal strategy obtained under limited information

**Equation showing optimal imitation solution of decision in absence of intrinsic information and in the presence of information coming from actions of connected "neighbors"**

$$s_i(t-1) = \mathrm{sign}\left( K \sum_{j \in N_i} s_j + \varepsilon_i \right)$$

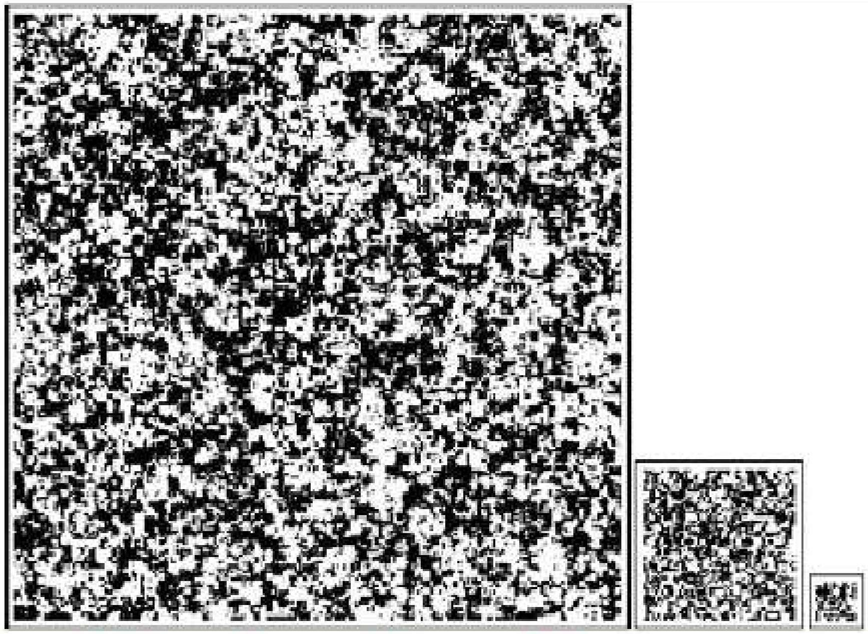
**This equation gives rise to critical transition=bubbles and crashes**

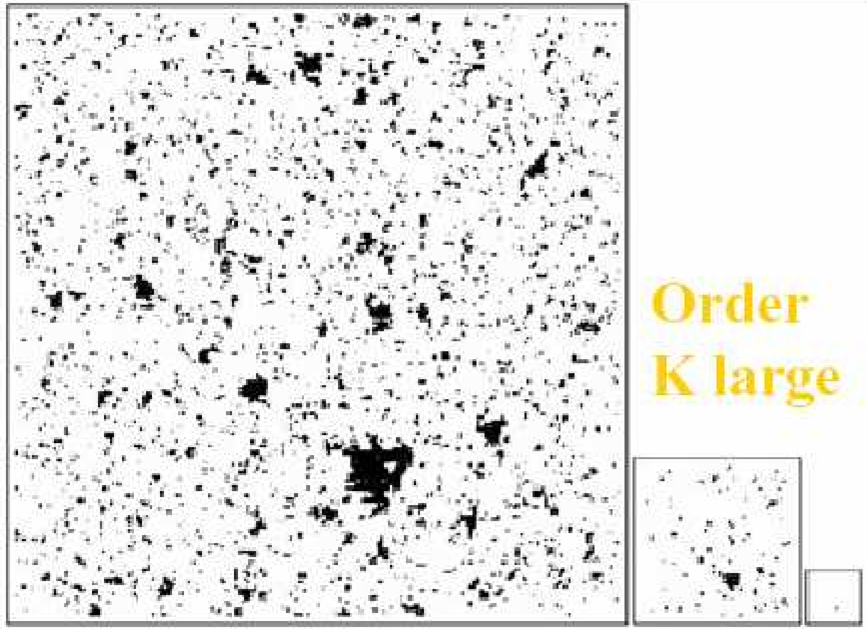
**-Crash = coordinated sell-off of a large number of investors**
**-single cluster of connected investors to set the market off-balance**
**-Crash if 1) large cluster $s>s^*$ and 2) active**

**-Proba(1) = n(s)**
**-Proba(2) ~ $s^a$ with $1 < a < 2$ (coupling between decisions)**

**Proba(crash) ~ $\sum_{s>s^*} n(s)\, s^a$**

**If a=2, $\sum_{s>s^*} n(s)\, s^2 \sim |K-Kc|^{-\gamma}$**



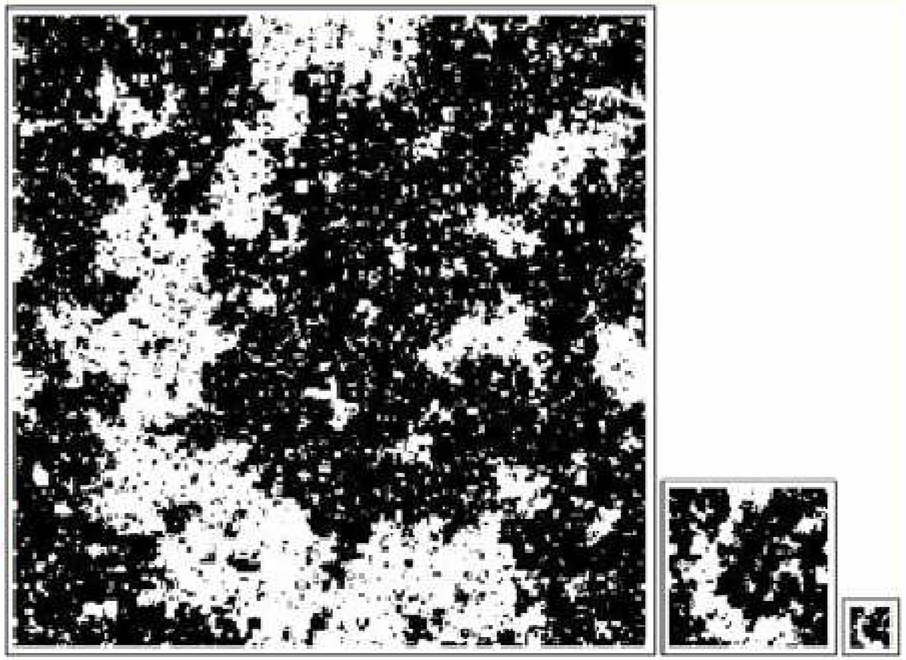


Order
K large

Disorder : K small

**Renormalization group:**
**Organization of the description scale by scale**

**Critical:**
**K=critical value**



# DISCRETE HIERARCHY OF THE AGENT NETWORK

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

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

- • Interplay between nonlinear positive and negative feedbacks and inertia

- • Discrete scale invariance
  Complex fractal dimension
  Log-periodicity

# FRACTALS

1) $d \in N$ Euclid (ca. 325-270 BC)

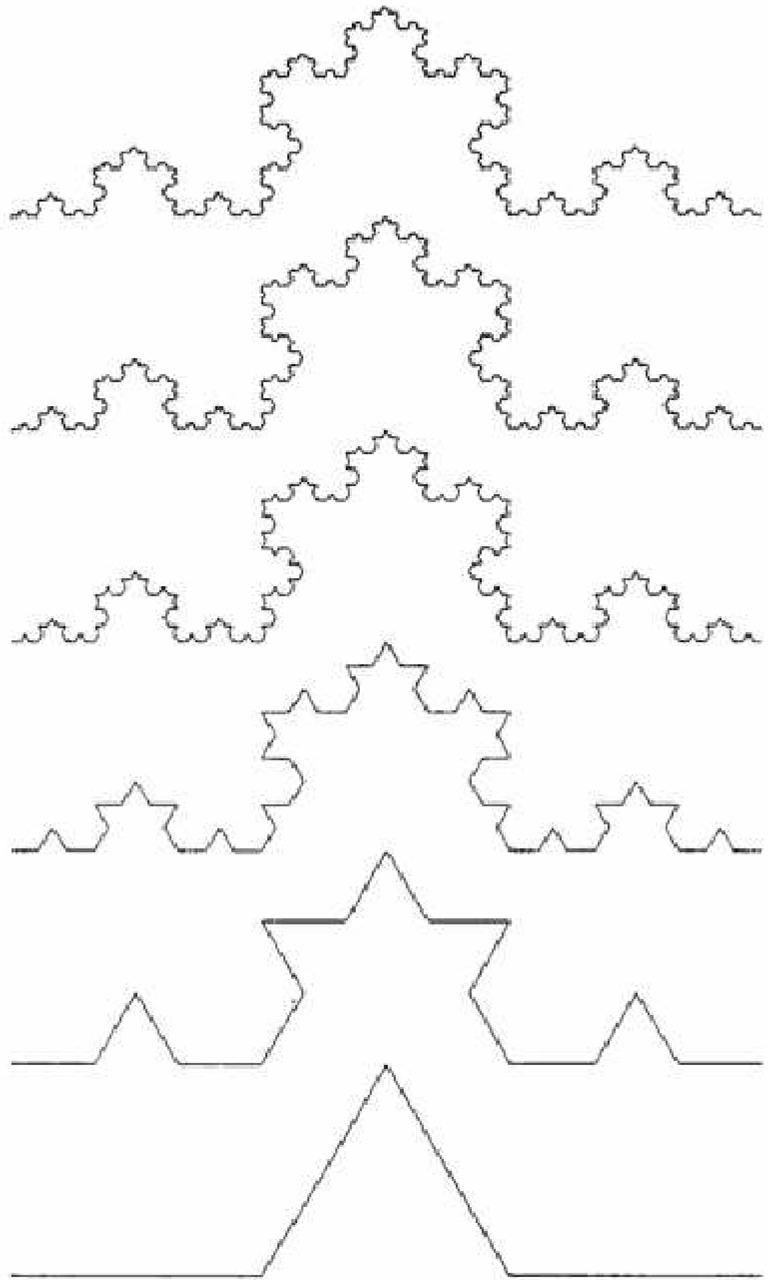
2) $d \in R$ Mandelbrot (1960-1980)
(Weierstrass, Hausdorff, Holder, ...)

3) $d \in C$

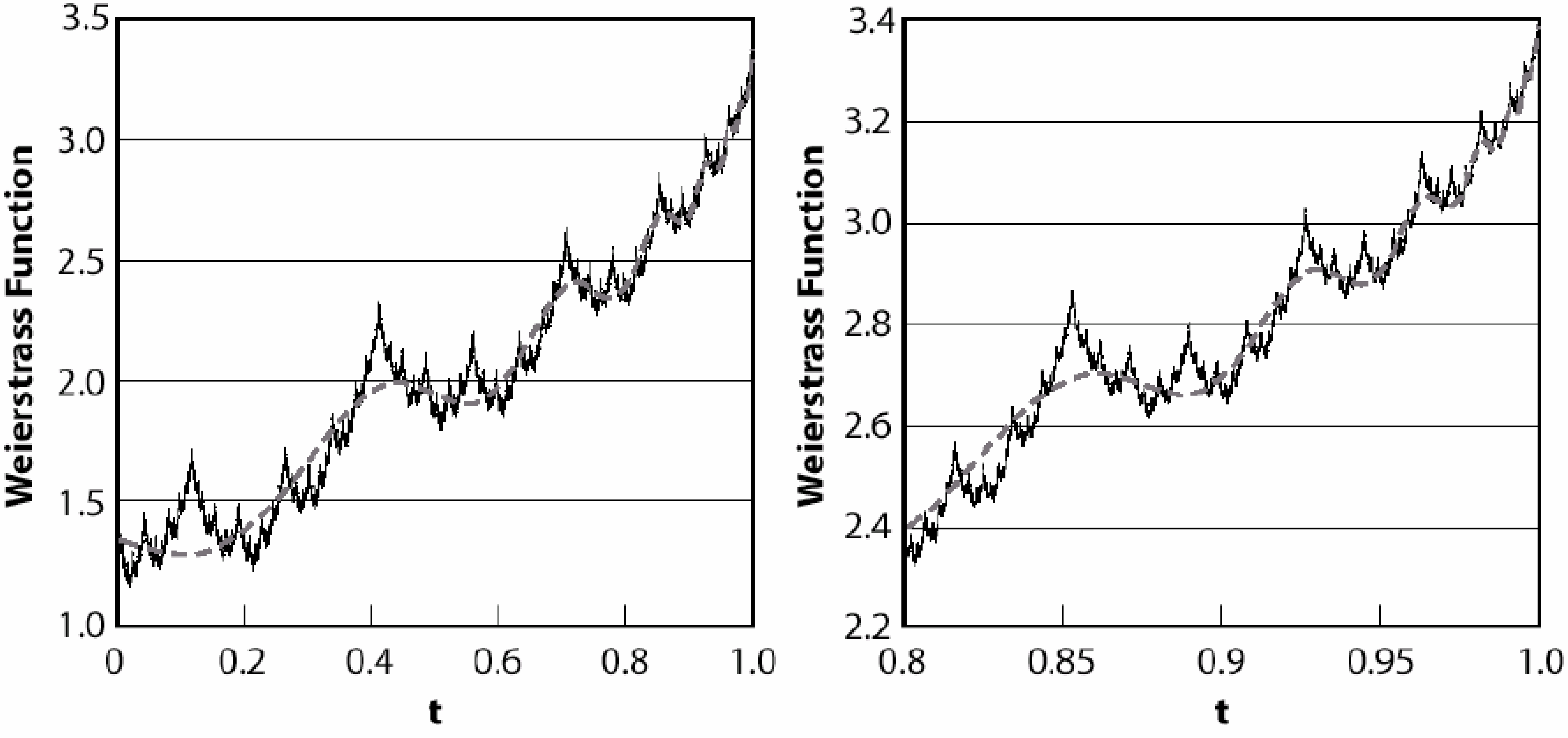
Discrete scale invariance
Complex fractal dimension
Log-periodicity

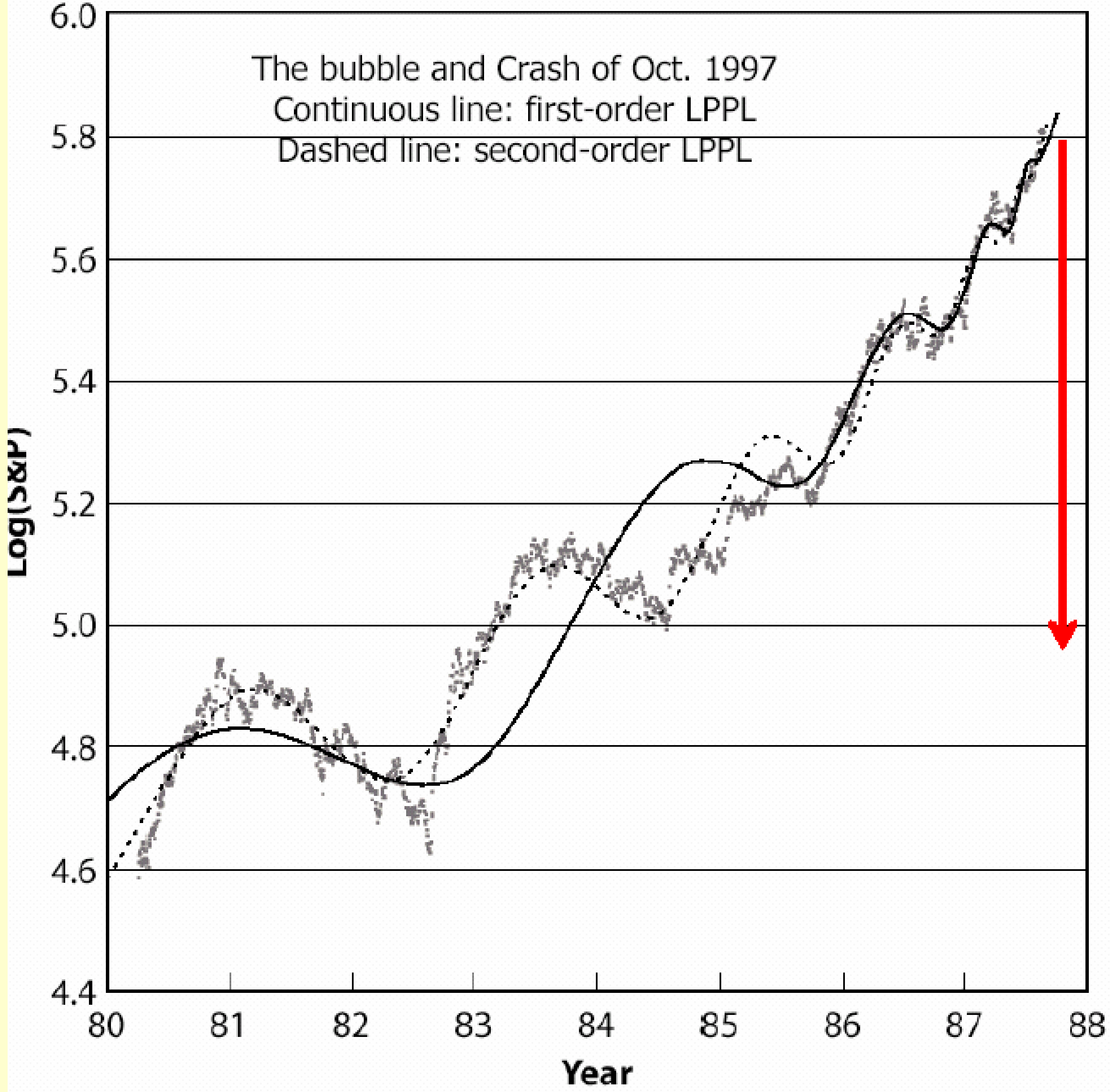
Prefered scaling ratio is 3

$$D(n) = \ln 4/\ln 3 + i\, 2\pi n/\ln 3$$



# Fractal function




The bubble and Crash of Oct. 1997
Continuous line: first-order LPPL
Dashed line: second-order LPPL
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
Log(S&P)
80
81
82
83
84
85
86
87
88
Year

# Conclusion

- Interesting and stimulating workshop
- Financial markets are complex systems of interacting agents
- Collective behaviour in complex systems leads to new phenomena (phase transitions, extreme events)
- Emergence of universal patterns in complex systems
- Computer cluster allows computational study of complex systems