# Black Swans and Dragon Kings:

## do we experience a few more before our time is up?

Raju Chinthalapati

University of Greenwich

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# Predictability

- Some events are hard to predict based on the available information
- Some events make our Illusion of predictability comes to an end.

“I think there is a world market for may be five computers” –

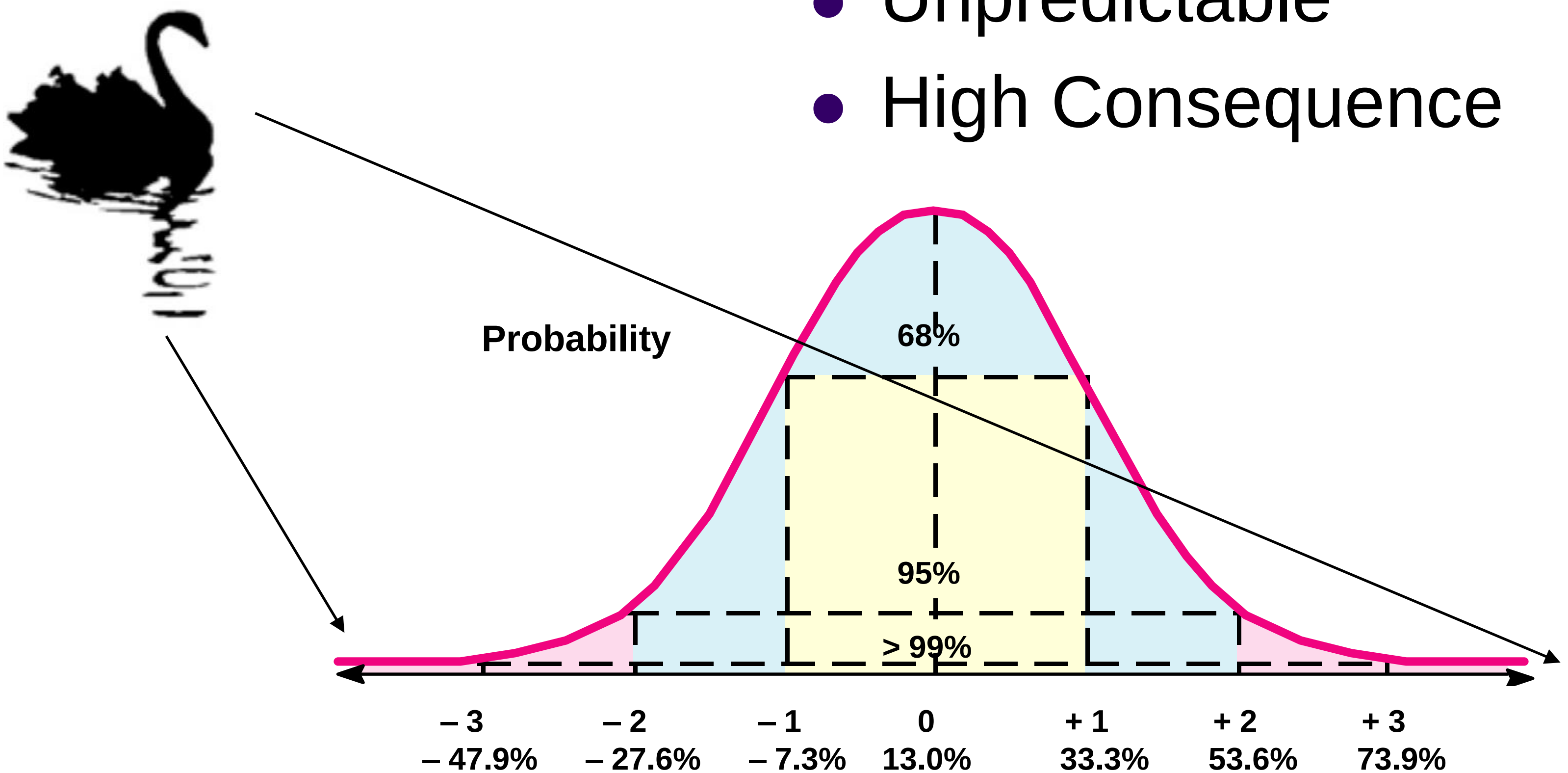
T. J. Watson

# Predictable and Unpredictable Catastrophes

- Some very big catastrophes occur not too commonly, but very difficult to predict.
- On the other hand, some gigantic catastrophes which are most predictable, but usually people ignore them!

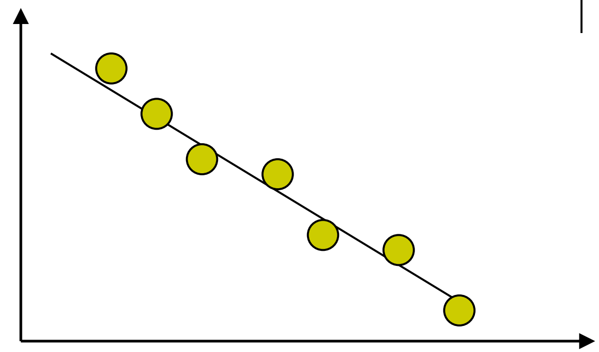
# Characteristics of Black Swan Events

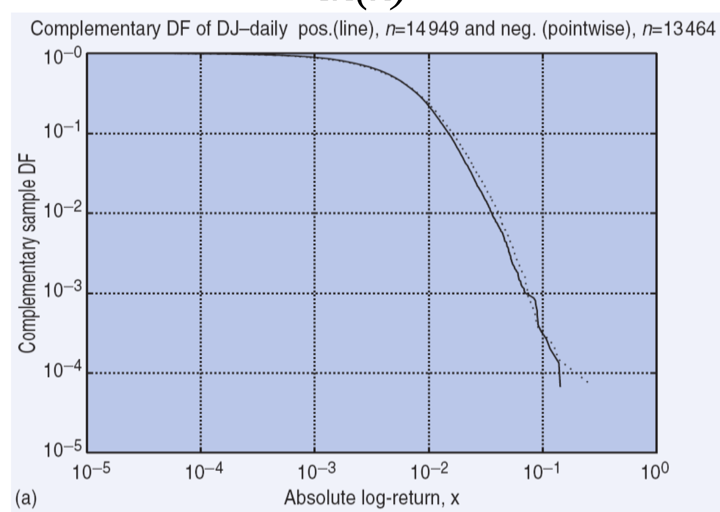
- Low probability
- Unpredictable
- High Consequence



# Power Law Distributions

- Distributions of large event sizes are according to power law
- $p(x) = C\,x^{-\alpha}$
- $ln(p(x)) = -\alpha\, ln(x) + c$
- Small size events are common, but large size events are extremely rare.

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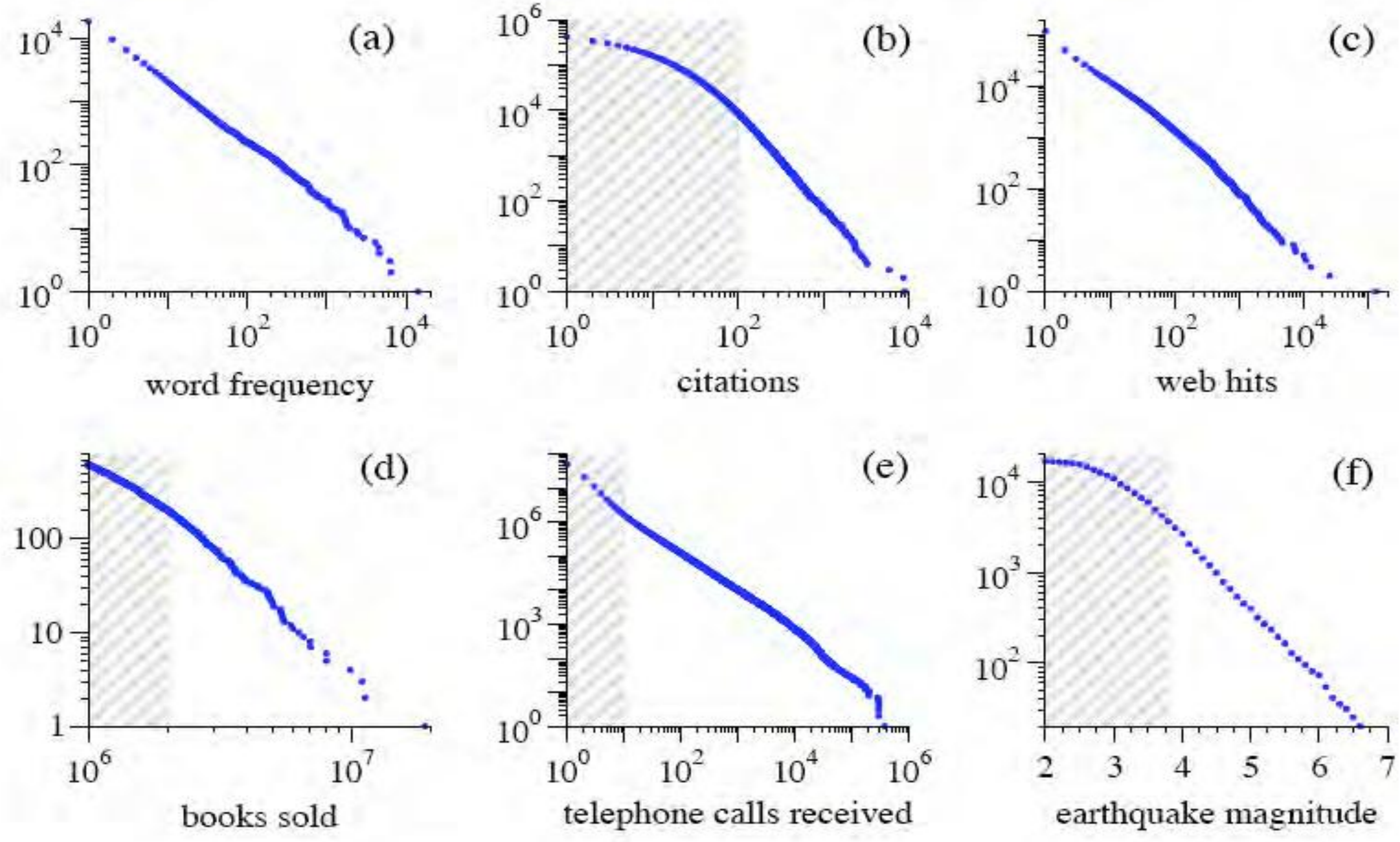
# Power Law Distributions

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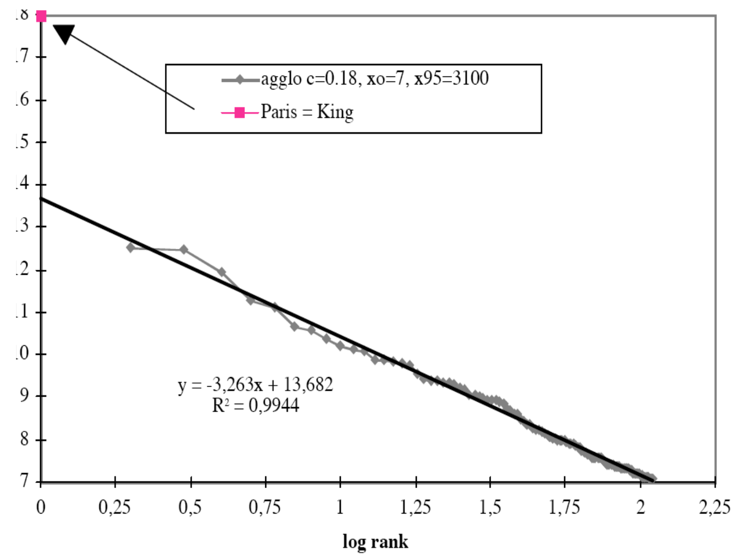
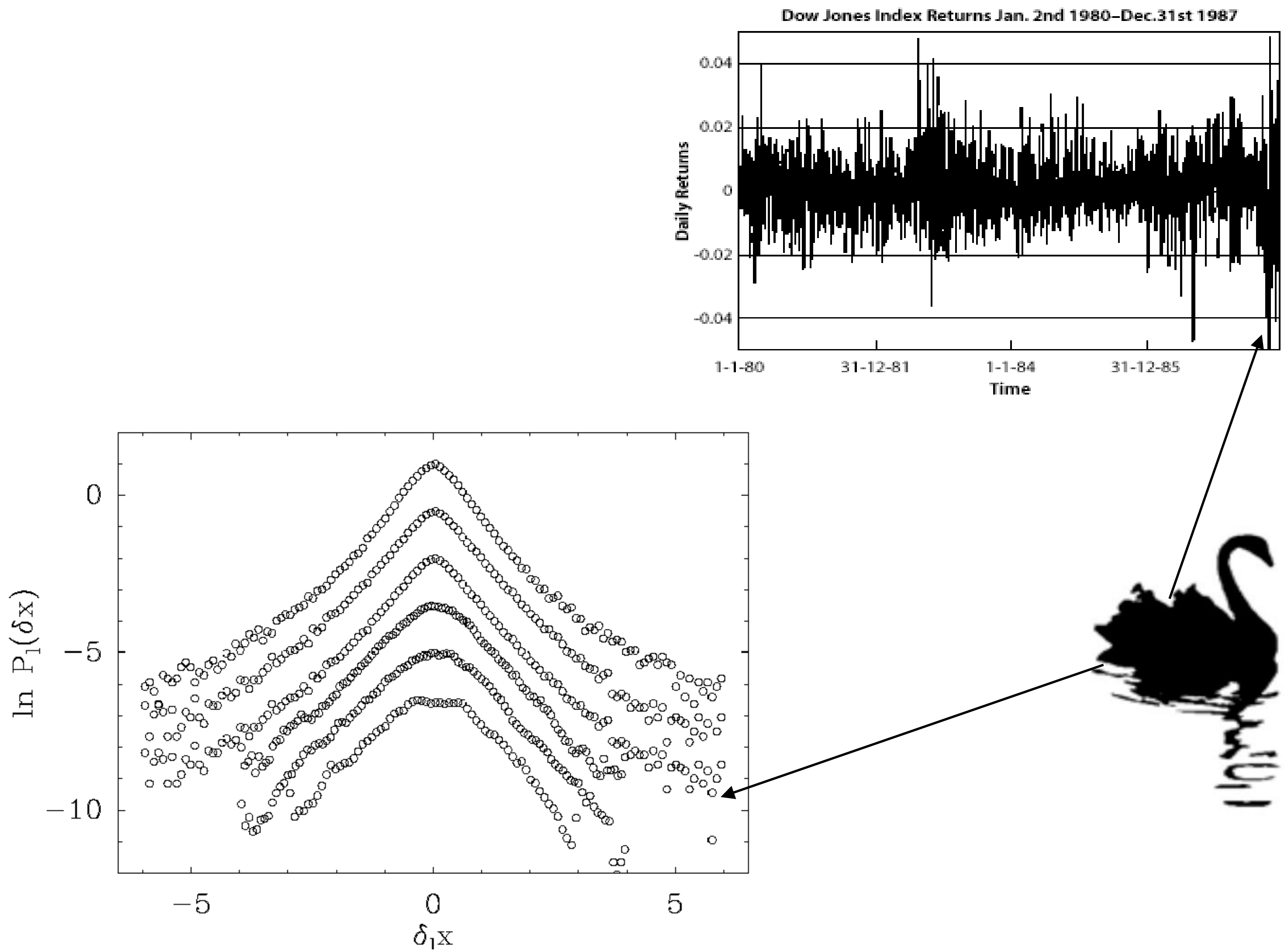
# Beyond Power Laws

- Kings are exceptions and they are beyond the extrapolation of the rest
- When we consider wealth of a person, (1) King Buhimol Adulyadej, (2) Sheikh Khalifa, (3) Sultan Hassanal etc are exceptions!




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)

# Crashes: Black Swans or Dragon Kings?!

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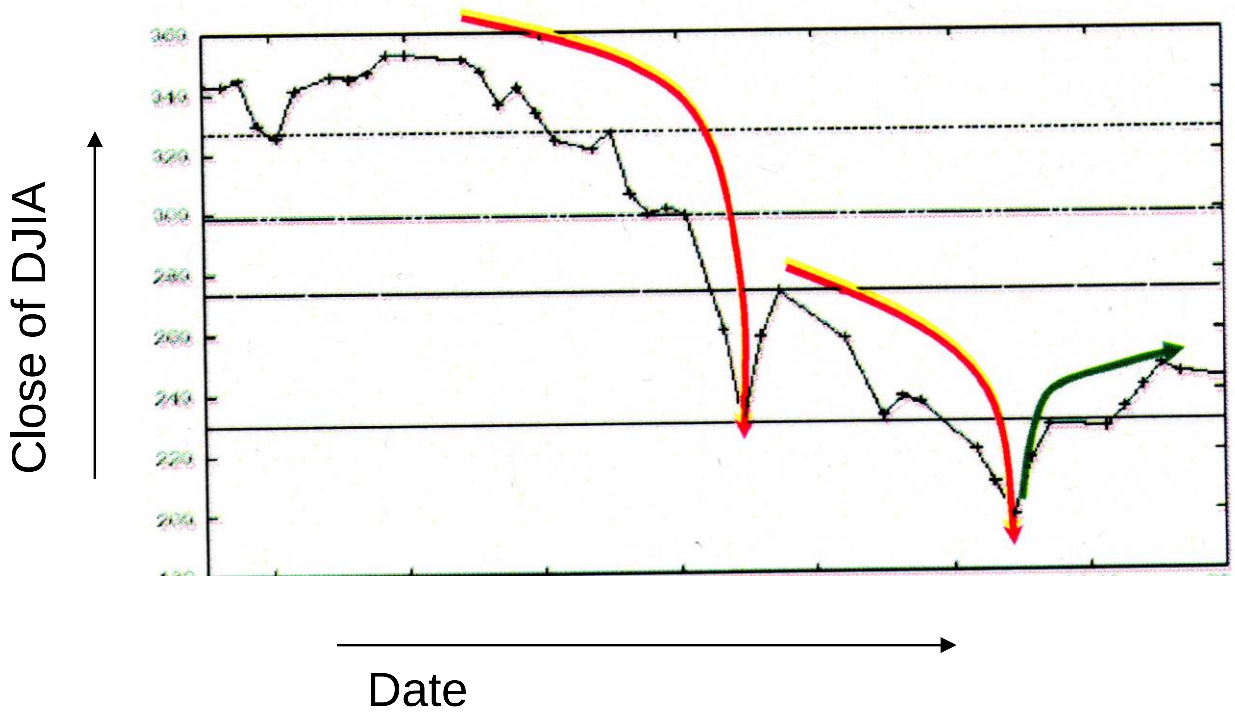
# Drawdowns

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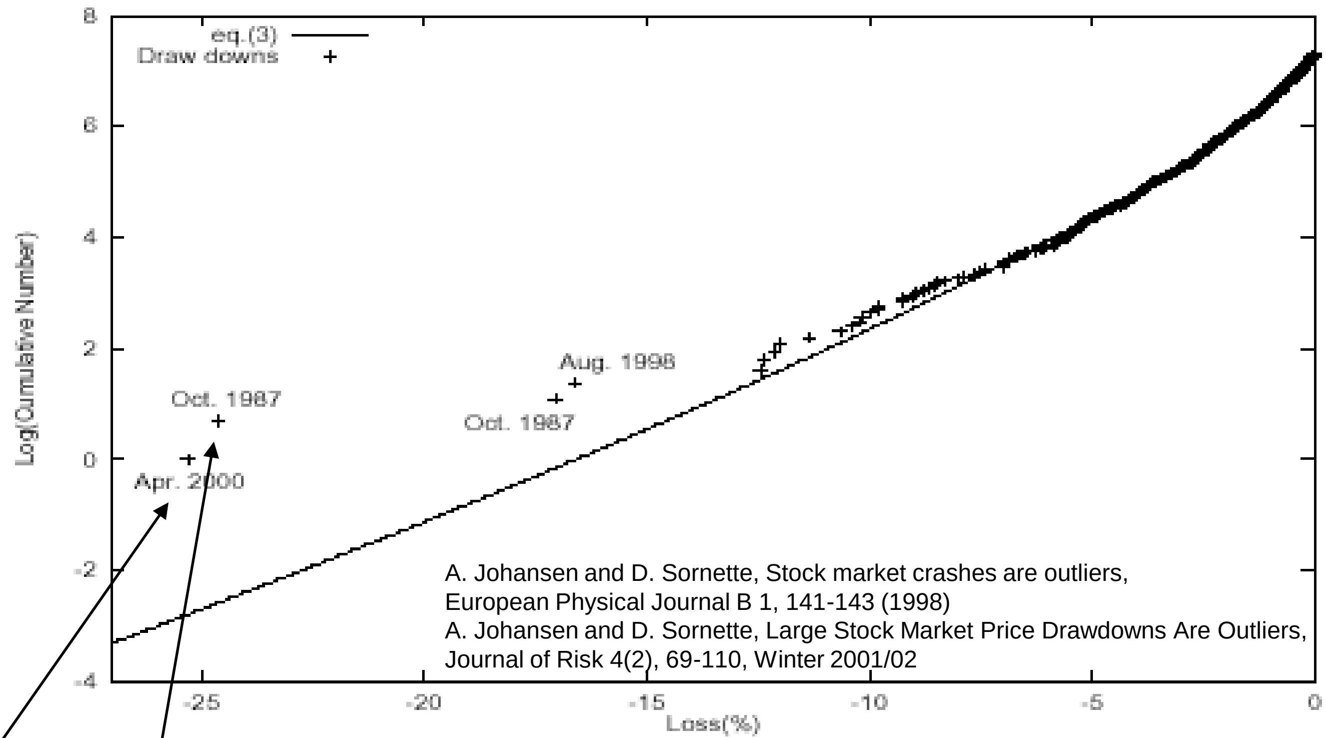
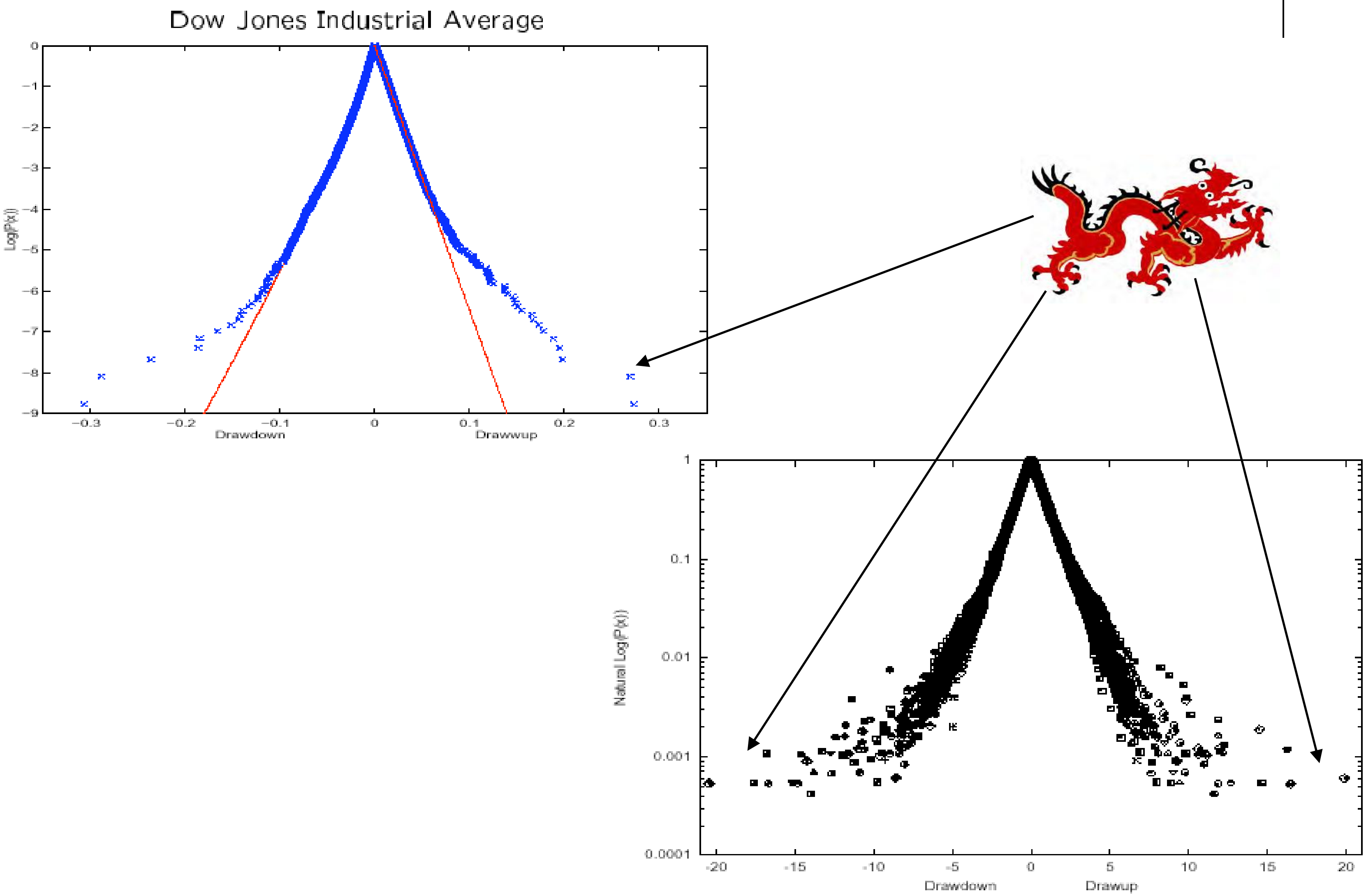
# Crisis as Dragon Kings



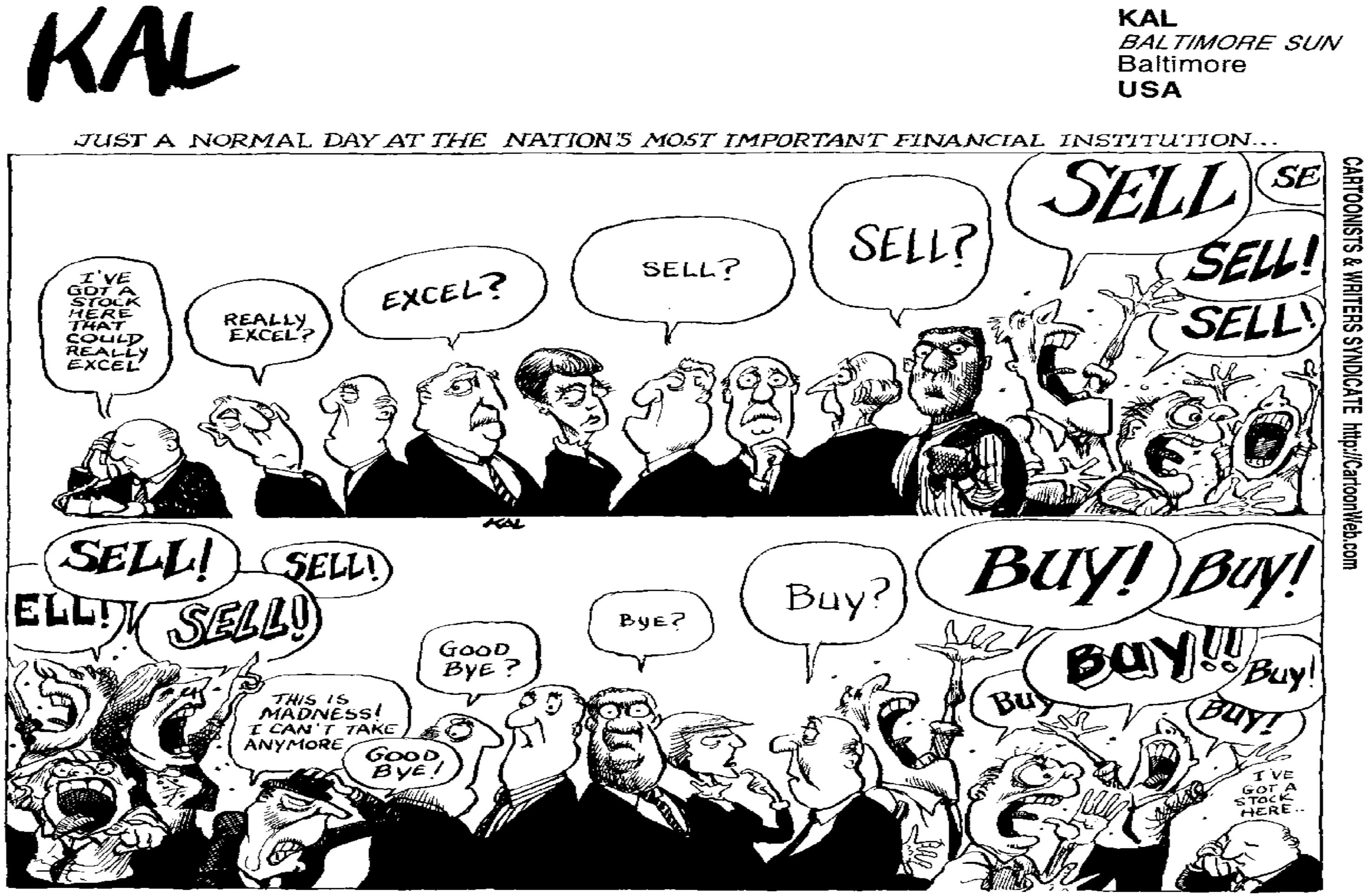

# More examples …

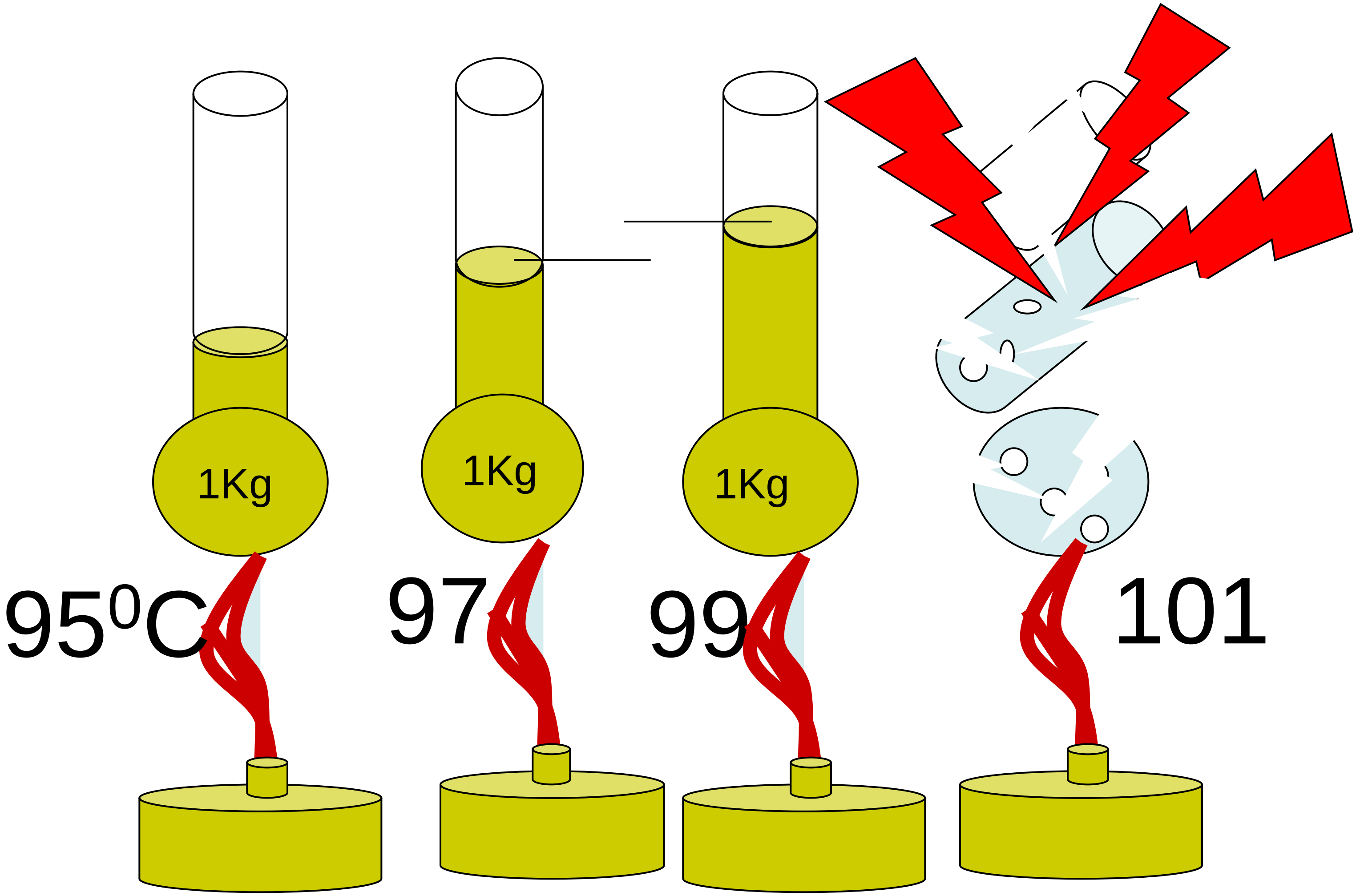


# Understanding Dragon Kings

- Most (66%) of the Dragon Kings identified in the distribution of drawdowns are stock market crashes.
- They are different from the main population and may require different mechanism to explain.
- Each crash is preceded by large financial bubble.
- Bubbles are created by positive feedbacks.
- Bubbles are endogenous.
- How to sense bubbles in the stock price?!

# Herding Behaviour

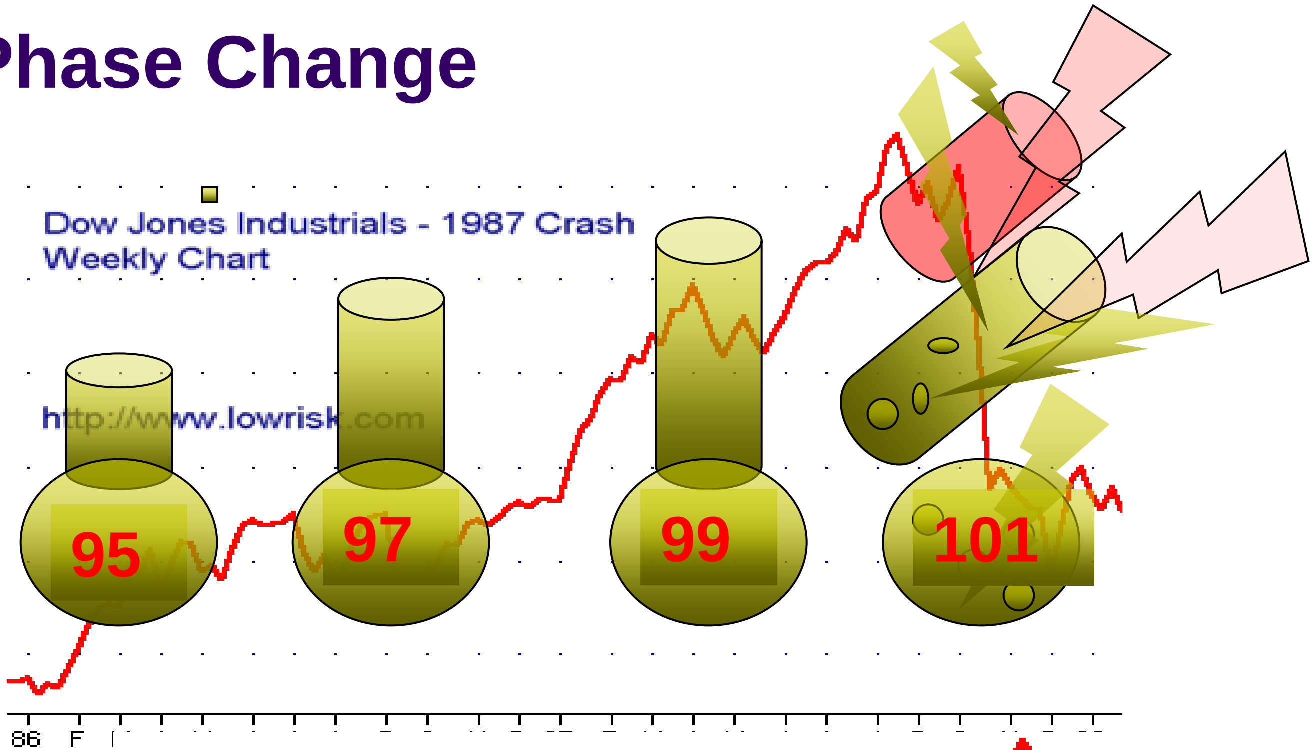





(S. Solomon)

# Phase Change

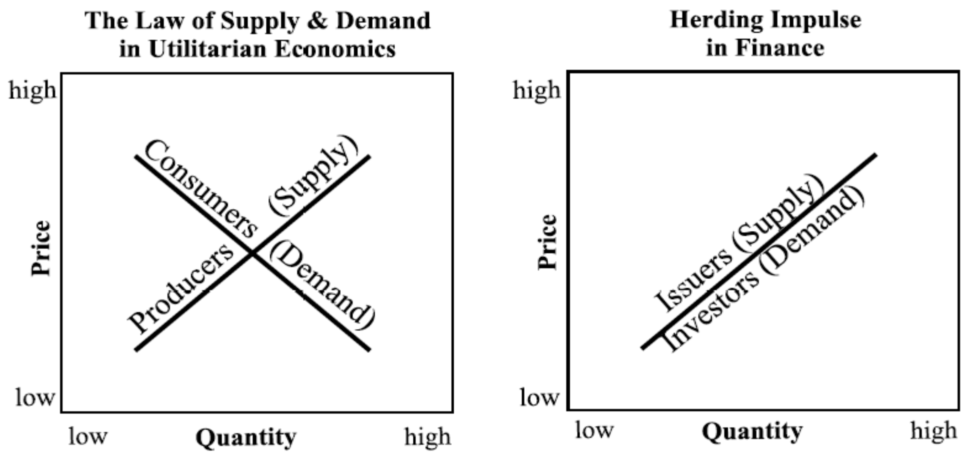
# Phase Change





(S. Solomon)

# Positive Feedbacks

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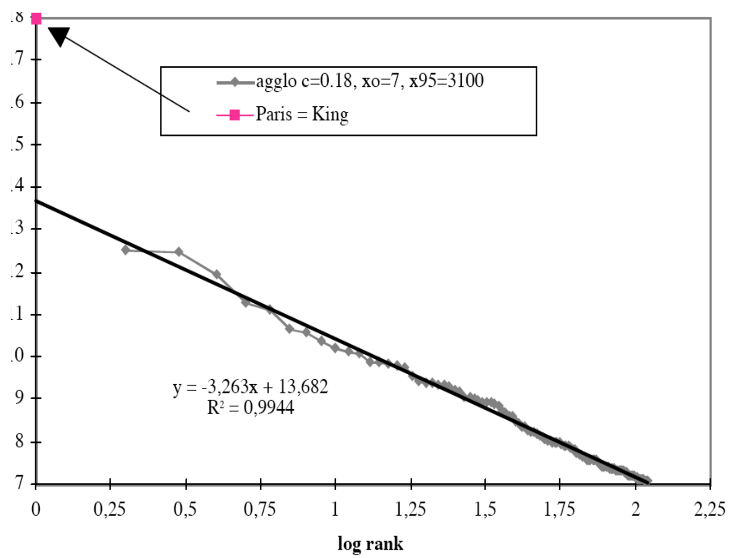
- Location, Location, Location!!



# Signatures and Fingerprints

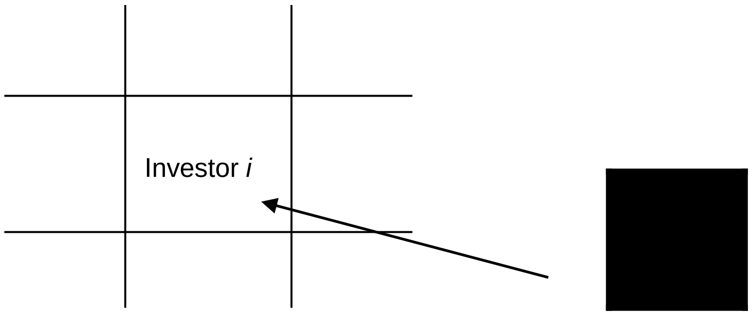
- Crashes are signatures of positive feedbacks
- Bubbles are fingerprints prior to large crashes
- We may detect the fingerprints by studying the price dynamics before large crashes
- We need a reasonably consistent mathematical model that represents the fingerprints in the pricing pattern
- We consider Sornette et al.'s work

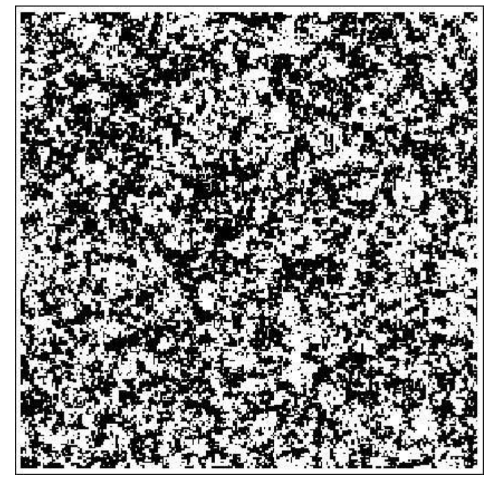
# Price Dynamics for bubbles

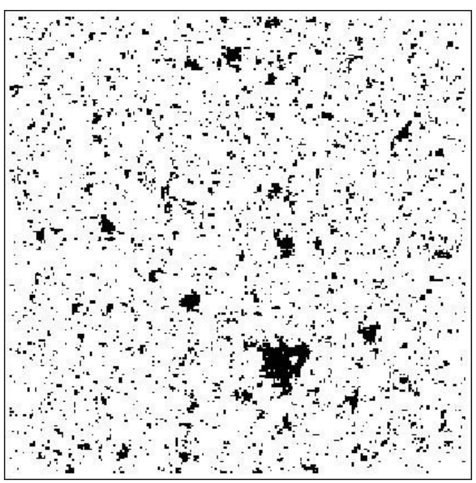
- Let h(t) be crash probability
- Rational bubbles

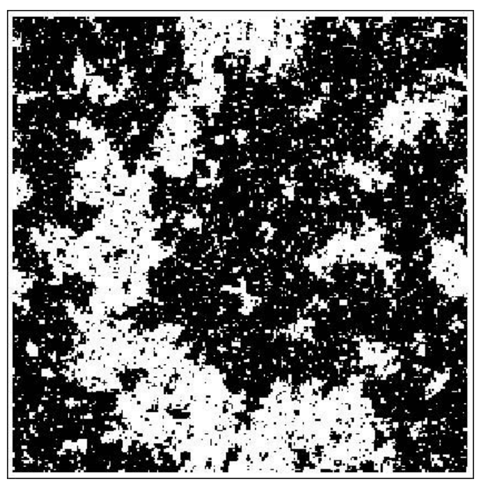
$$p(t) = p(t_0) + \kappa[p(t_0) - p_1]\int_{t_0}^{t} \ldots)\, dt'$$

# Microscopic Model of Interactions







$$s_i = Sign(K \sum_{j \in N(i)} s_j + \sigma \varepsilon_i)$$

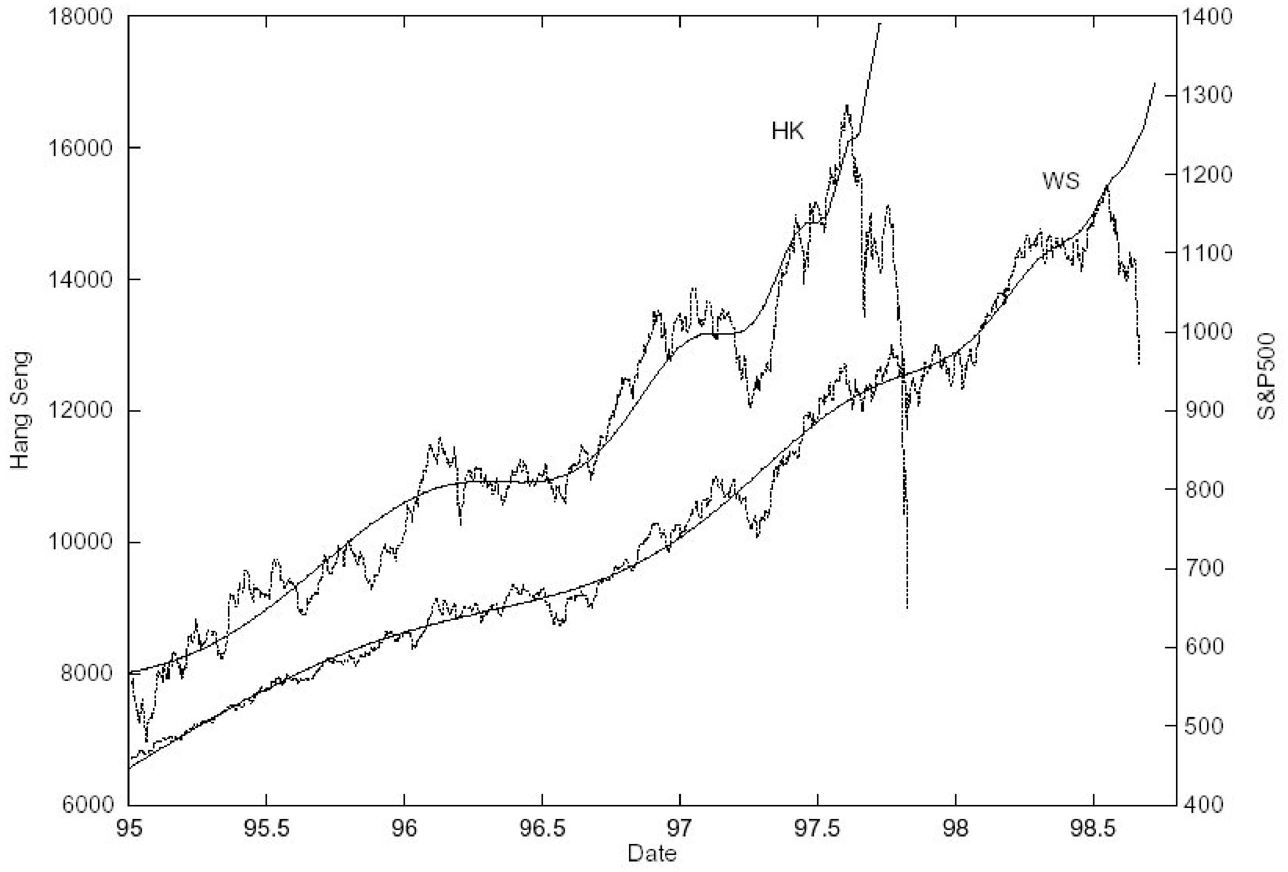
Crash hazard rate *h(t)*

# Price dynamics before crash: fingerprint

- Log periodic oscillations

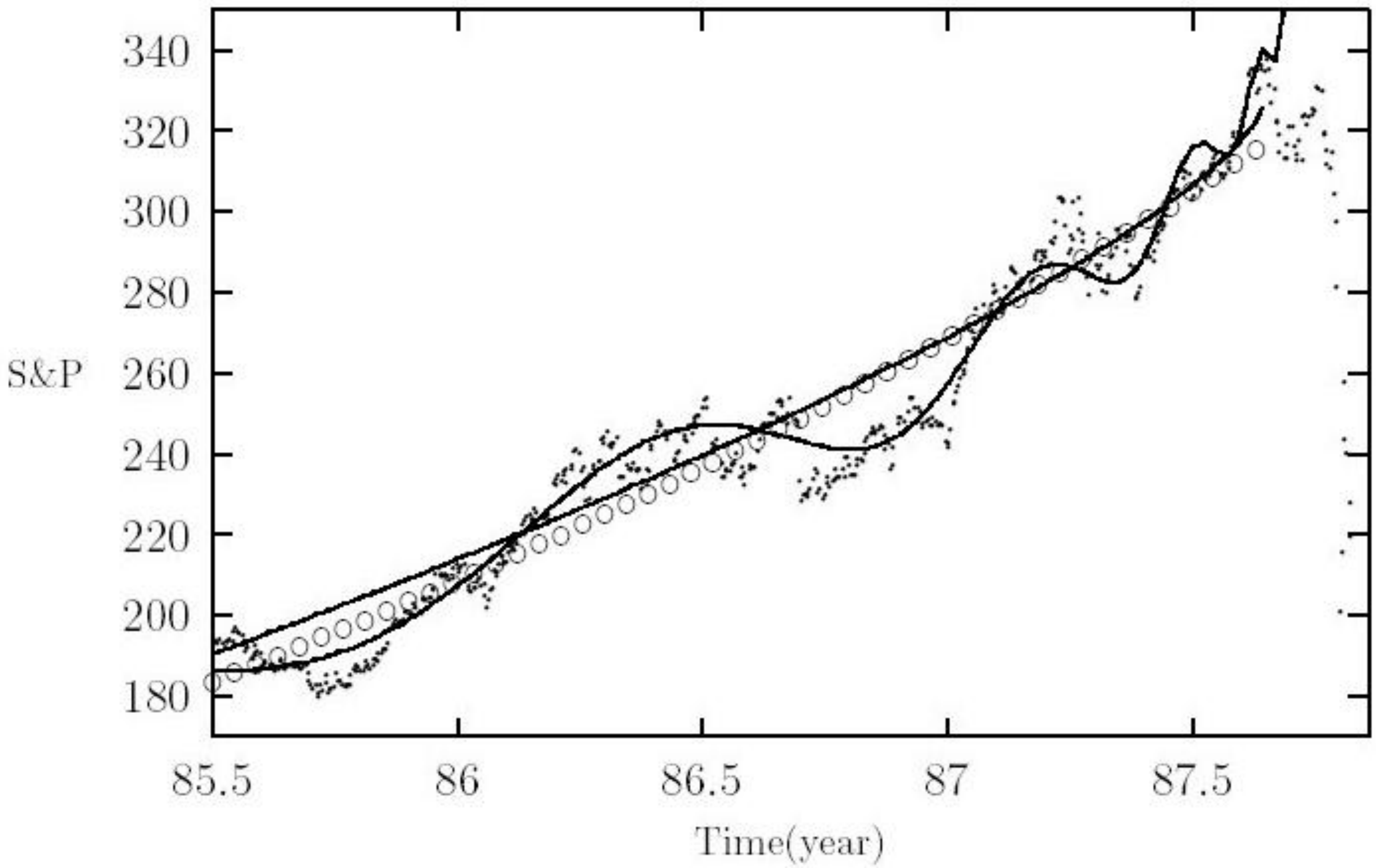
$$p(t) \approx A - B(t_c - t)^{\beta} + C(t_c - t)^{\beta} Cos(\omega \log(t_c - t) + \phi)$$

# Empirical Evidence



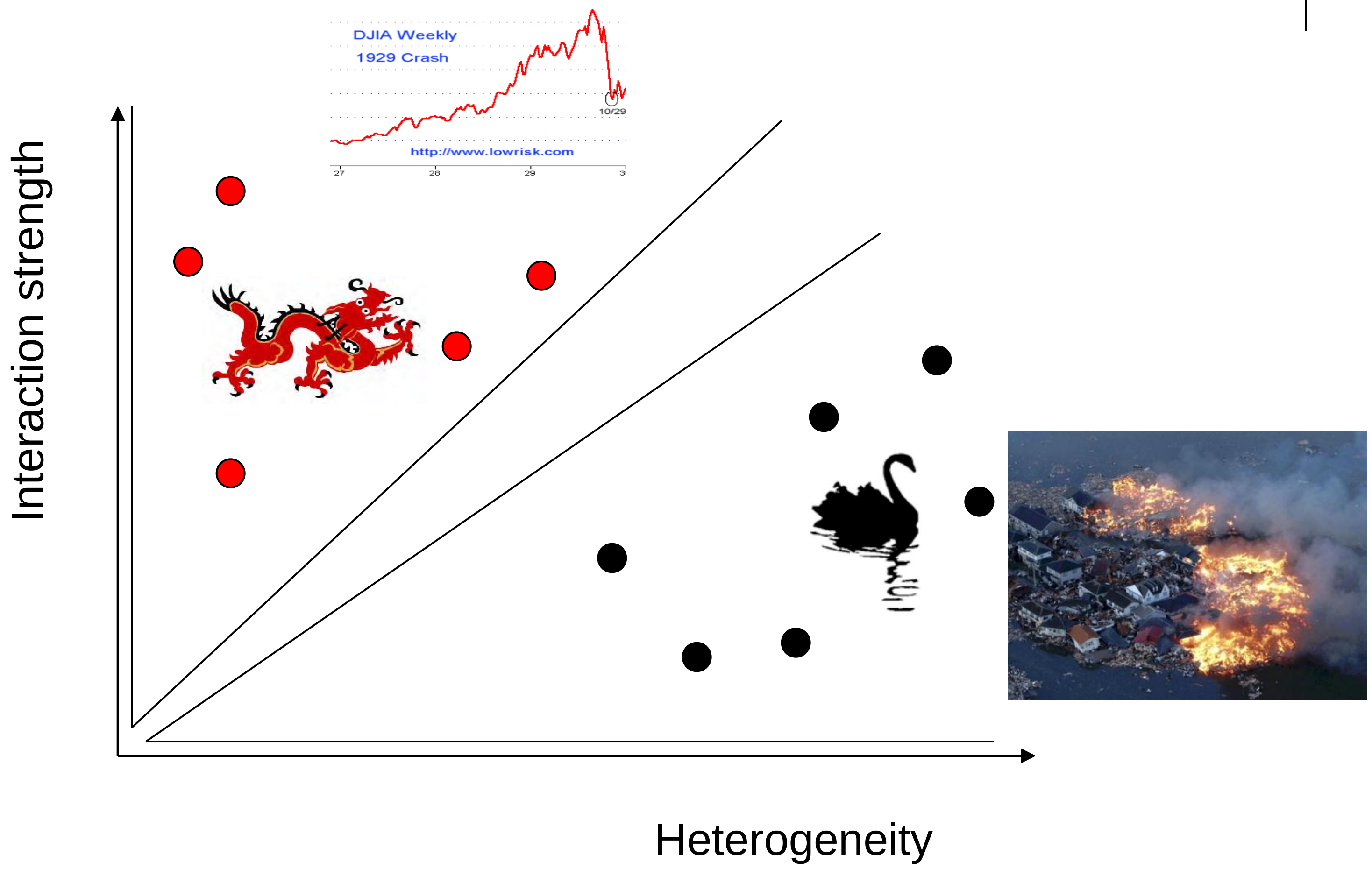

The Hang Seng index prior to the October 1997 crash on the Hong-Kong Stock Exchange and the S&P 500 stock market index prior to the crash on Wall Street in August 1998. The fit to the Hang Seng index is equation with beta = 0.34, tc = 97.74, omega = 7.5. The fit to the S&P 500 has parameters beta = 0.60, tc = 98.72, omega = 6.4. Reproduced from Sornette

# Empirical Evidence




The New York stock exchange index S&P500 from July 1985 to the end of 1987. The circles represent a constant return increase - exponential function with a characteristic increase of = 4 years−1 and var(Fexp) = 113. The best fit to a pure power-law gives 327 − 79(87.65 − t)0.7 and varpow = 107. The best fit to Eq gives A = 412, B = −165, tc = 87.74, C = 12, omega = 7.4, phi = 2.0, beta = 0.33 and varlp = 36. Reproduced from Sornette.

# Qualitative Phase Diagram



# Conclusions

- Worst catastrophes, especially human made ones are predictable
- Financial catastrophes leave footprints of predictability well in advance
- If everybody realises the future catastrophe and collectively work together to prevent it then *nobody would escape*!
- But some people can save themselves from the predictable catastrophes!!

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# Thank You

Raju Chinthalapati
cv20@gre.ac.uk