Economic & Financial Crises: Some challenges

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I. The Sacred Lore of Theoretical Economics

- <u>Efficient Market Theory</u>: Prices reflect faithfully Fondamental Values and only move because of exogeneous unpredictable news.

  ▷ Platonian markets that merely reveal fundamental values without influencing them − or is it a mere tautology??

  ▷ Bubbles/Crashes can only be of exogenous origin, not induced by markets dynamics itself

- This is no trifle debate: many real world consequences − feedback on the "real" economy (in many models, financial markets are "inert"), economic policy, market regulations, investment decisions, taxes....

- Since the mid-80's, a growing sense of disconfort culminating in the very ambiguous 2013 Nobel Prize (Fama vs. Shiller)

I. The Aftermath of 2008

- *Macro models failed to predict the crisis and seemed incapable of explaining what was happening to the economy in a convincing manner. As a policy-maker during the crisis, I found the available models of limited help. In fact, I would go further: in the face of the crisis, we felt abandoned by conventional tools.* − JC Trichet (2010)

- *Research tended to be motivated by the internal logic (...) and esthetic puzzles of established research programs rather than by a powerful desire to understand how the economy works - let alone how the economy works during times of stress and financial instability.* − Willem Buiter, The unfortunate uselessness of most 'state of the art' academic monetary economics (2009)

  Indeed: the linearized "DSGE" models used by Central Banks cannot deal with crises − the economy is assumed to be fundamentally stable! (btw, in such models, financial markets are "inert")

II. Eppur si muove

- **Excess market volatility** (Shiller)

  ▷ Markets move far too much: $2\%/day^*$

  ▷ Most market jumps occur in the **absence of any news**[†] (daily: Cutler et al.; Fair; Cornell, 1 minute: Joulin et al.)

  − *The evidence that large market moves occur on days without identifiable major news casts doubts on the view that price movements are fully explicable by news...* (Cutler, Poterba, Summers (1989))

[*]In spite of heroic efforts to find explanations, cf. Fama
[†]with 'flash crashes' − 1962, 2010, etc. − as epitome

II. Eppur si muove

- Excess volatility in economic systems – the "small shocks/large business cycles" conundrum (Bernanke et al. (1996))

  ▷ Large economic systems should "average-out" idiosyn-cratic shocks: $\sigma \sim n^{-1/2}$, but: "aggregate" volatility is high (US YOY IPI since 1950: $\sigma \approx 4\%$!) & deep crises...

  ▷ *What shocks are responsible for economic fluctuations? Despite at least two hundred years in which economists have observed fluctuations in economic activity, we still are not sure.* – John Cochrane (1994)

II. 20 years of big(ger) data

- Many <u>universal</u> quantitative "anomalies" begging for a quantitative explanation

  ▷ Pareto continuum between daily 'jumps' and decennial crashes

  ▷ Power-law distribution of "avalanches" (number of stocks that co-move)

  ▷ Excess volatility, with intermittent dynamics and long range (power-law) memory

  ▷ Anomalous impact of small trades: $\langle \Delta p \rangle \sim \sqrt{Q}$

  ▷ Pareto distribution of wealth, incomes, firm sizes, trade sizes...
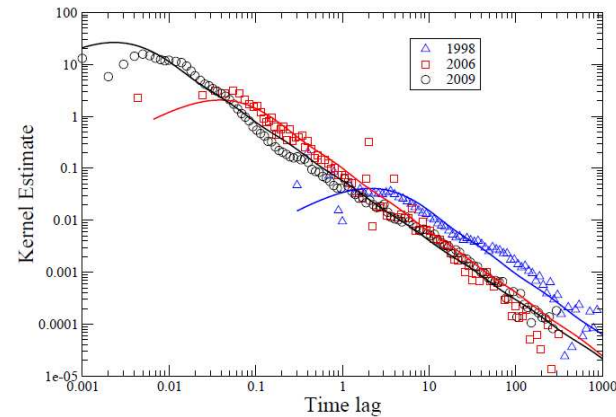
Pareto tails
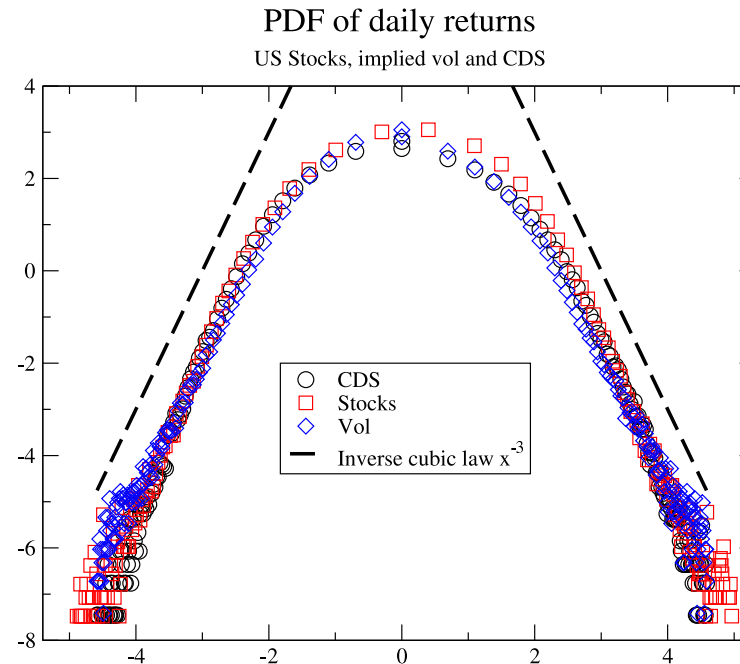
Universal distribution: daily stocks, implied volatility, CDS moves or *any other traded stuff*: ≈ inverse cubic law − but no (or too many) explanation yet. [With J. Bonart]
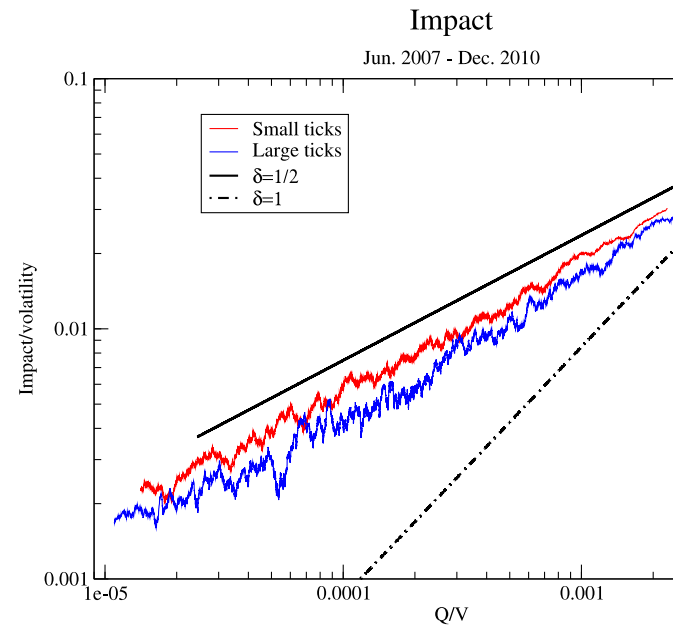
Intermittency and power-law memory
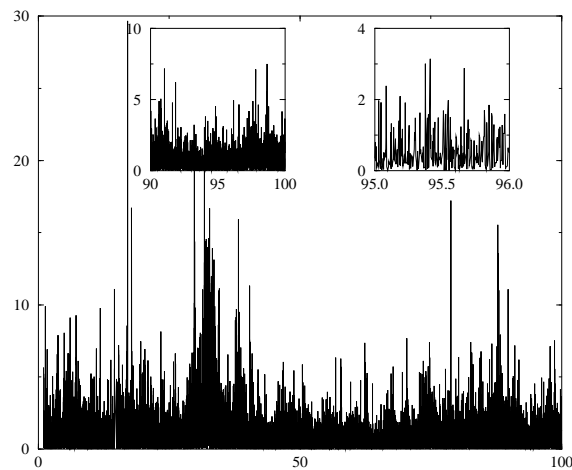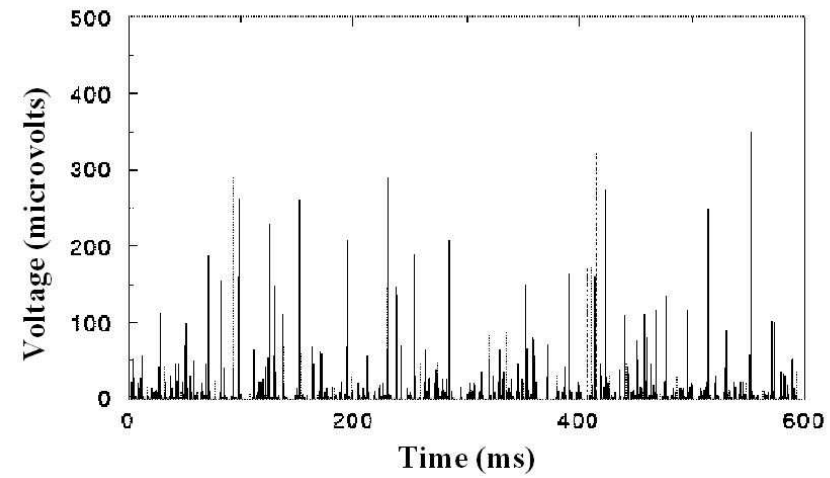
Regular exogeneous drive → endogeneous dynamics with power-law memory

Power-law influence kernel

> 90% of volatility is due to slowly decaying, power-law self-reflexive feedback of activity onto itself. [With S. Hardiman, N. Bercot]

Universal "Square-root" Impact

Vanishing liquidity $\rightarrow$ critical, sublinear impact

[With I. Mastromatteo, B. Tóth] $\rightarrow$ Mapping to $A + B \rightarrow \emptyset$
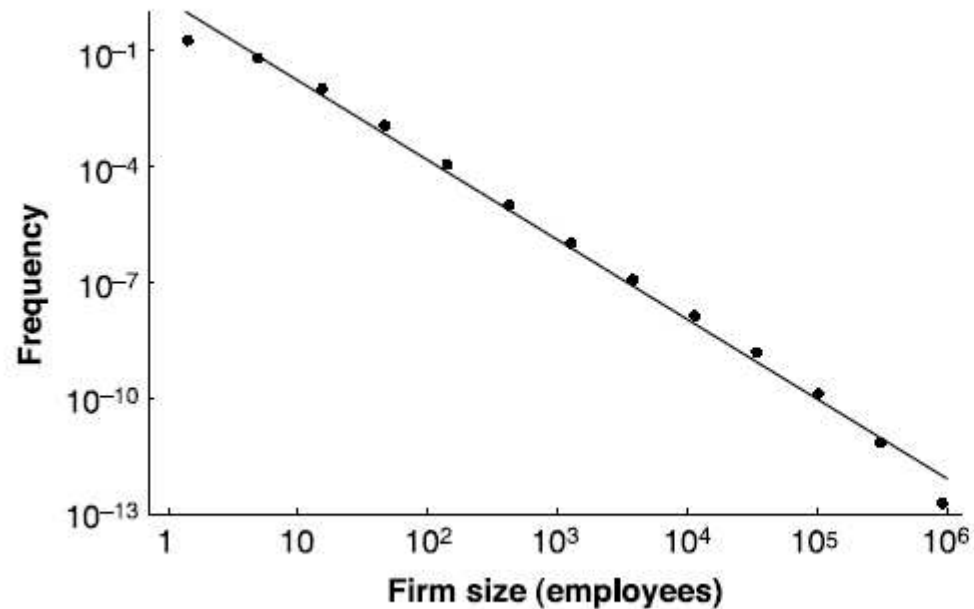
Fig. 1. Histogram of U.S. firm sizes, by employees. Data are for 1997 from the U.S. Census Bureau, tabulated in bins having width increasing in powers of three (30). The solid line is the OLS regression line through the data, and it has a slope of 2.059 (SE = 0.054; adjusted R^2 = 0.992), meaning that α = 1.059; maximum likelihood and nonparametric methods yield similar results. The data are slightly concave to the origin in log-log coordinates, reflecting finite size cutoffs at the limits of very small and very large firms.

A very heterogeneous economy! (From R. Axtell). But why a Zipf law ?

II. The Endogenous Dynamics Hypothesis

- Accumulating evidence of *universal anomalies* suggesting that the dynamics of financial markets/the economy is mostly endogeneous, and *only very weakly driven by fundamentals*

- Classical models fail to account for strong heterogeneities, interactions and feedback loops

  ▷ We are strongly influenced by the behaviour of others (who might have more information) − `panic feeds panic`

  ▷ We are strongly influenced by past patterns (that might repeat) − `trends feed trends`

  ▷ Trades impact prices (a lot) and price changes influence future trades

  → excess volatility, unstable feedback loops

  − Theories that consistently treat these effects are still at an early stage, and not widely accepted/used
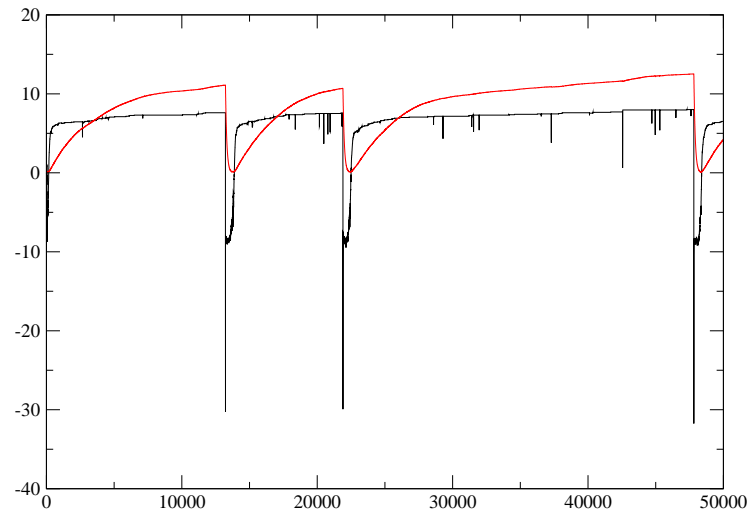
Love-locks on Pont Des Arts

The madness of crowds (Newton)

III. From micro-rules to macro-behaviour

- Crises are expected to require aggregate shocks, when in reality small local shocks can trigger large systemic effects

- Some (tentative/exciting) ideas:

  ▷ Coupled structure/function dynamics of networks → phase coexistence, hysteresis and crises: Marsili et al., Battiston et al., Axtell's job market...
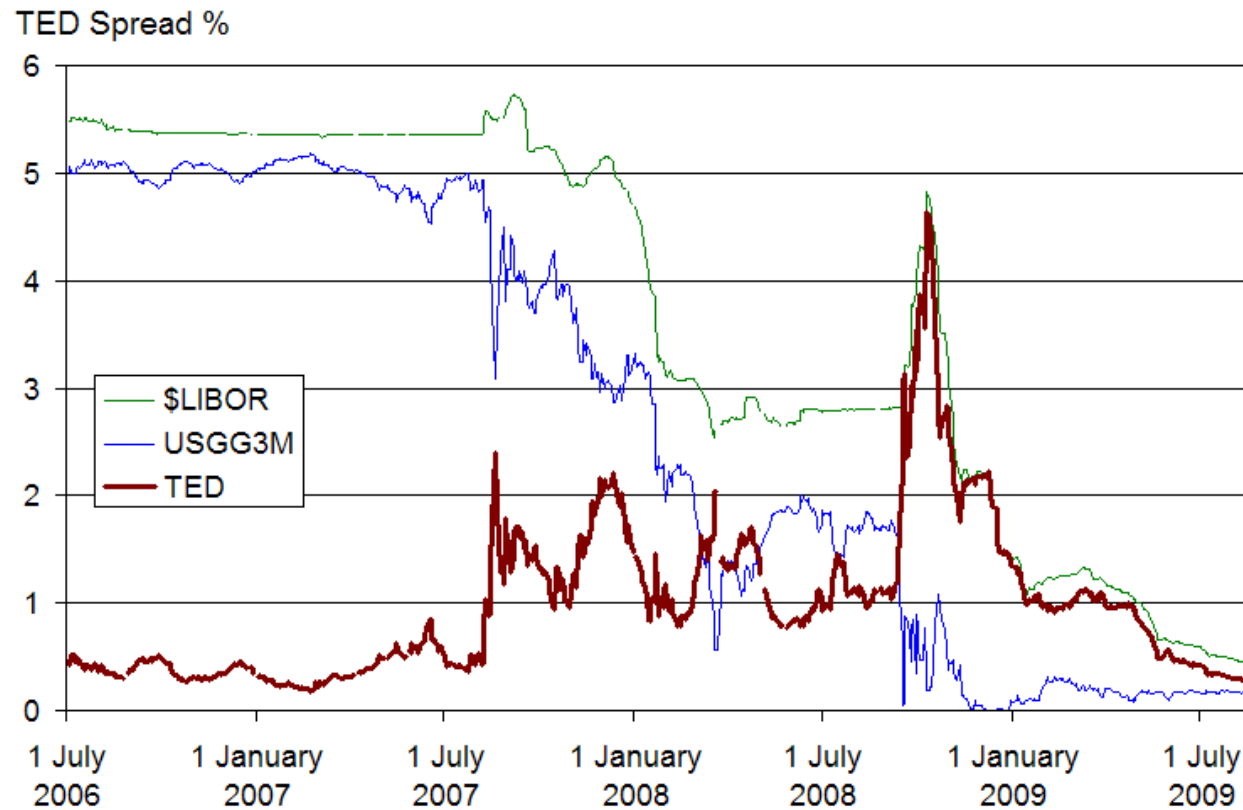
III. Spontaneous breakdown of trust networks

Network dynamics depends on trust and vice-versa

I trust you because he trusts you because I trust you → phase coexistence,

hysteresis and crises (J. Batista, JPB)

# Evaporation of trust and money market freeze

LIBOR/Overnight spread jumps after Lehman's defaults

III. From micro-rules to macro-behaviour

- Crises are expected to require aggregate shocks, when in reality small local shocks can trigger large systemic effects

- Some (tentative/exciting) ideas:

  ▷ Network models of firms + market imperfections → "equilibrium" becomes linearly unstable → purely endogenous aggregate volatility J. Bonart, JPB et al. (2014)

  − see the "complicated game" model of Galla & Farmer (agents cannot learn the right strategy → coordination breakdown)

Endogeneous volatility in large economies
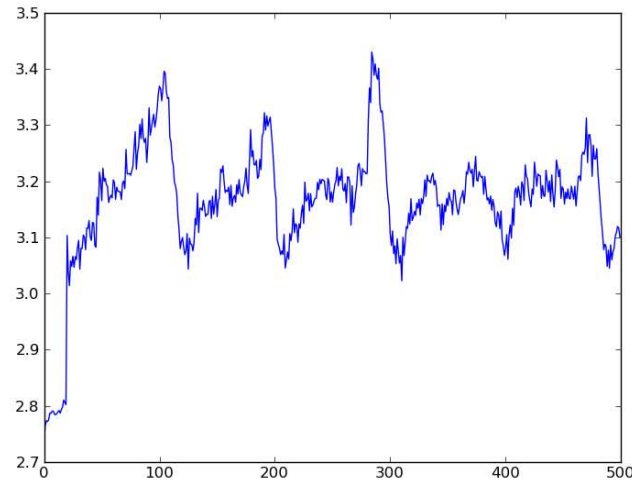
Volatility without shocks? (J. Bonart, JPB, A. Landier, D. Thesmar)

III. From micro-rules to macro-behaviour

- Some (tentative/exciting) ideas:

  ▷ Stylized "Agent Based Models" − gaining traction but still not well accepted in mainstream economics departments

  ⇒ Numerical simulations: (too?) versatile (realism/simplicity) − a true methodological challenge and the importance of *exactly solvable models* (Minority Games and variations)

  Done properly, computer simulation represents a kind of "telescope for the mind," multiplying human powers of analysis and insight just as a telescope does our powers of vision. With simulations, we can discover relationships that the unaided human mind, or even the human mind aided with the best mathematical analysis, would never grasp. M. Buchanan (NYT, October 2008)

Endogeneous crises in Stylized Macro ABM
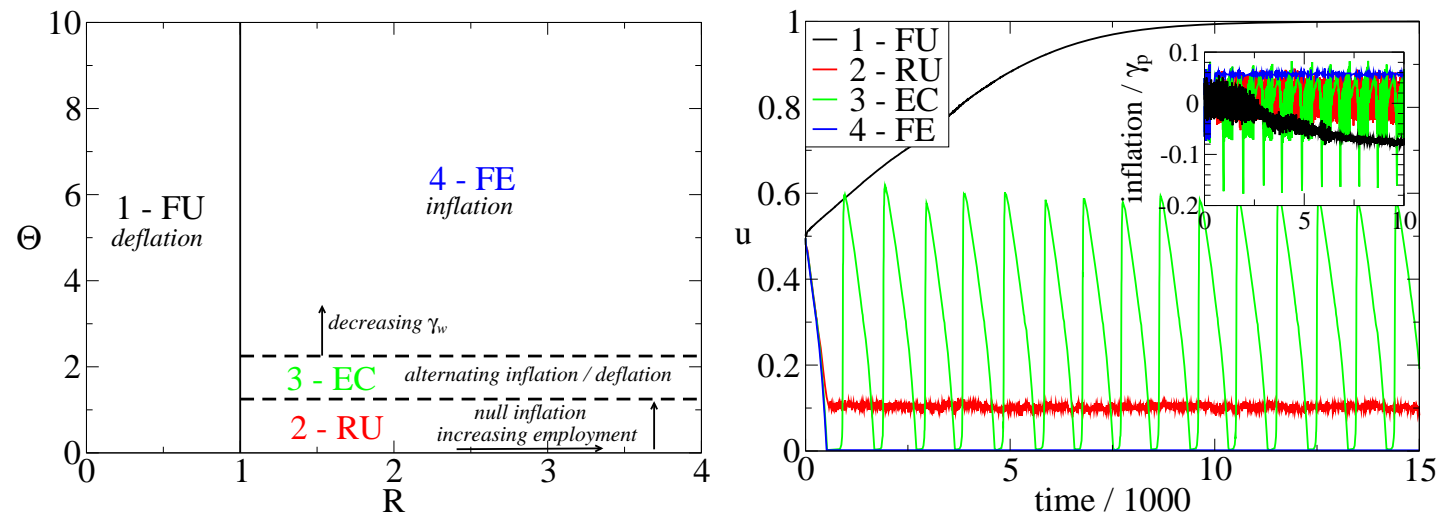
A phase diagram for the economy? (CRISIS project, S. Gualdi, M. Tarzia, F. Zamponi, JPB) – but still 9 parameters...

R: hiring/firing ratio; Θ: maximum debt ratio

Conclusion − Endogenous crises and SOC?

- Financial markets, the economy, many other social phenomena seem to avoid "CLT" and exhibit crises, ruptures, sudden discontinuities that resemble far-from-equilibrium phenomena in complex systems*

  → Most price jumps appear unrelated to any news at all

  → Market statistics share features with slowly driven, heterogeneous interacting systems with many equilibria

  → Many "power-laws" (relations, distributions, correlations) suggesting emergent multi-scale, critical phenomena but begging for a quantitative explanation

*i.e. made of many heterogeneous, strongly interacting elements

Conclusion – Endogenous crises and SOC?

- HYPOTHESIS: Financial markets/the economy operate close to criticality, making them particularly fragile to small shocks

  ▷ Self Organized Criticality ? (P. Bak's intuition)

  → Optimized systems are often critical/fragile – cf. Bird flocks, human imitation ($J \approx J_c$), brain, markets?

  → A beautiful (generic) scenario: controlling an unstable system (e.g. stick balancing) – see F. Patzelt & K. Pawelzik

  – The dynamics of a well controlled system becomes unobservable and is fragile to surprises

  – Similar to the Minority Game and other stylized agent based: maximum extraction of information drives the system to criticality

  ▷ How to make this quantitative and induce a paradigm shift in the next 20 years

Starlings in Rome and Fish Schools
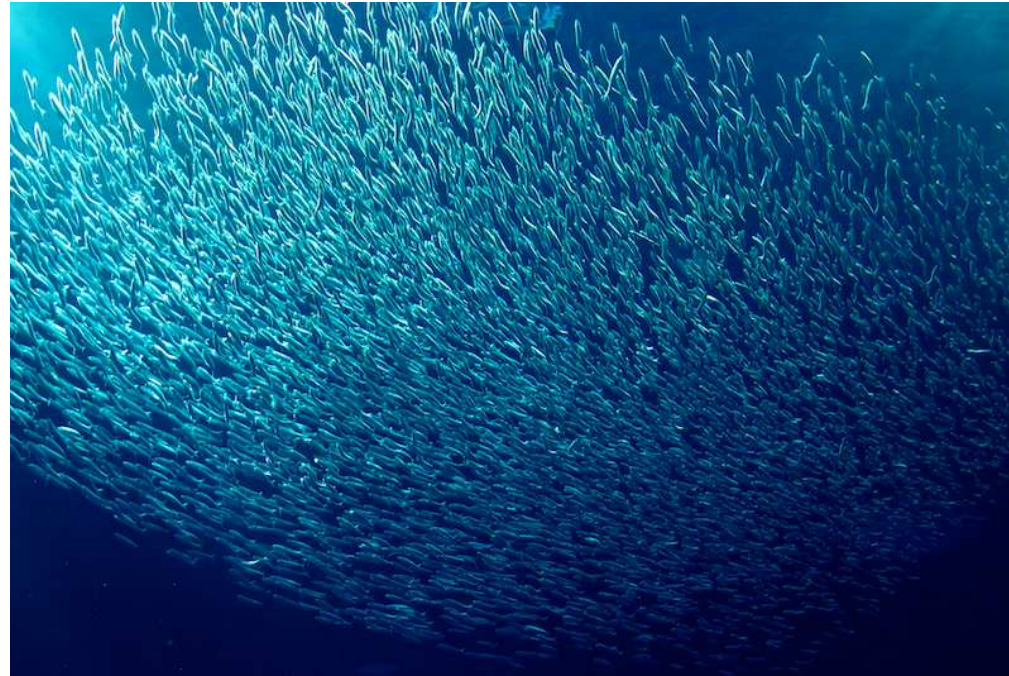
A. Cavagna, B. Bialek et al.

End of clappings: 2 types
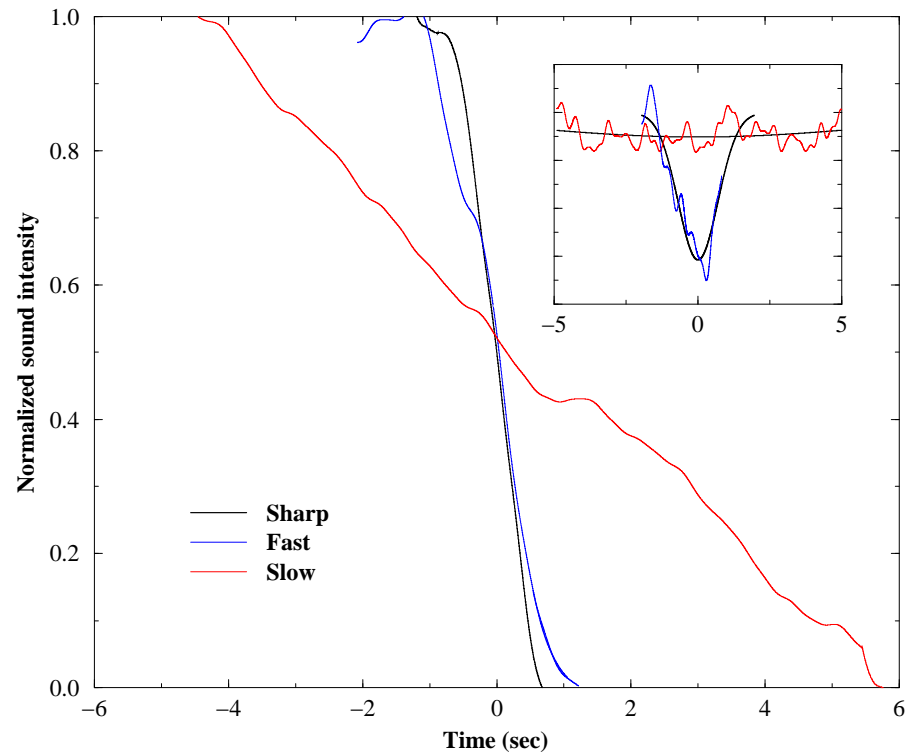
(Q. Michard, JPB)

References

- This talk is based on the following papers:

▷ A. Joulin, A. Lefevre, D. Grunberg, J.-P. Bouchaud, *Stock price jumps: news and volume play a minor role*, Wilmott Mag., Sept/Oct 2008; arXiv:0803.1769

▷ J.-P. Bouchaud, *Economics needs a scientific revolution*, Nature, Oct. 2008.

▷ J.-P. Bouchaud, *The Endogenous Dynamics of Markets: Price Impact, Feedback Loops and Instabilities*, in `Lessons from the 2008 Crisis`, edited by A. Berd (Risk Books, Incisive Media, London, 2011).

▷ I. Giardina, J.-P. Bouchaud, *Bubbles, crashes and intermittency in agent based market models*, Eur. Phys. J. B 31, 421 (2003)

References

▷ M. Wyart, J.-P. Bouchaud: *Self-referential behaviour, over-reaction and conventions in financial markets* J. Econ. Behav. Organ. 63, 1 (2007)

▷ J.-P. Bouchaud, *Crises and collective socio-economic phenomena: simple models and challenges*, J. Stat. Phys. 151, 567 (2013)

▷ R. Chicheportiche, J.-P. Bouchaud, *The fine structure of volatility feedback*, arXiv:1206.2153

▷ S. Gualdi, M. Tarzia, F. Zamponi, J.-P. Bouchaud, *Tipping points in macroeconomic Agent Based models*, arXiv:1307.5319

▷ J. Bonart, J.-P. Bouchaud, A. Landier, D. Thesmar, *Instabilities in large interconnected economies: aggregate volatility without idiosyncratic shocks*, arxiv:1406