

Generic characteristics of Complex Systems

Part 1: Systems theory

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Generic characteristics of complex co-evolving systems

Part 1 – Systems Theory

- connectivity
- inter-dependence
- feedback
- emergence

Part 2 – Complexity Theory

- self-organisation
- space of possibilities
- co-evolution
- historicity & time
- far from equilibrium

creation of new order

Complex Behaviour

- Arises from ***Interaction***
- Focuses on ***Relationships***

Complex systems can
create new order

Connectivity & interdependence



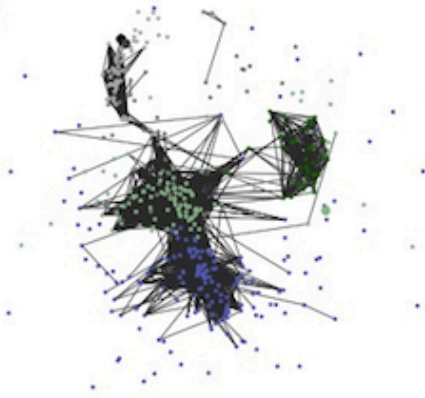
Networks of relationships with
Degrees of connectivity

- *Strength of coupling*
- *Epistatic Interactions*
 - i.e. the fitness contribution made by one individual will depend upon related individuals

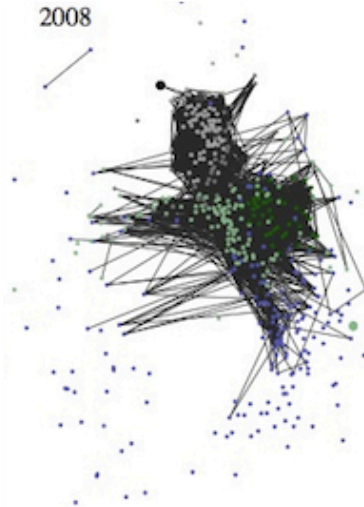
Connectivity & interdependence

- Intense interconnectivity creates **multiple** and **intricate dependencies**
 - *cannot be pulled apart*
- Outcomes are often **non-deterministic**
- Complexity does not argue for ever increasing connectivity
- May lead to ***complexity catastrophe***

2003



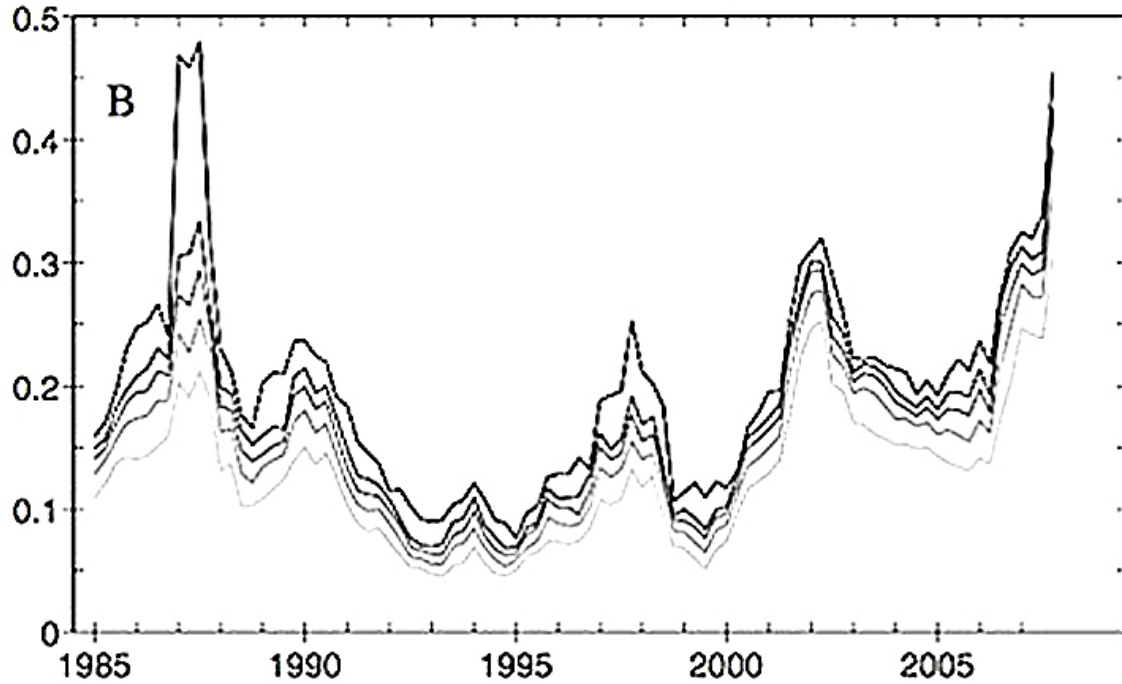
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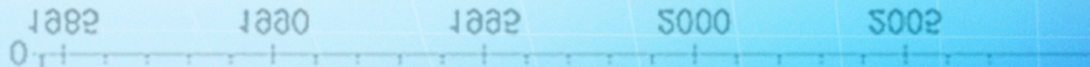
500 corporations with the highest stock-trading volume were analysed

Map of links between companies in 5 key economic sectors:

- technology (blue),
- oil (dark grey),
- other basic materials (light grey),
- finance linked to real estate (dark green)
- other finance (light green).



As the sectors came together, changes in one affected the others
– WHY?



Feedback

- *Positive* feedback tends to cause system **instability**
- *Negative* feedback tends to cause system **stability**

Positive Feedback

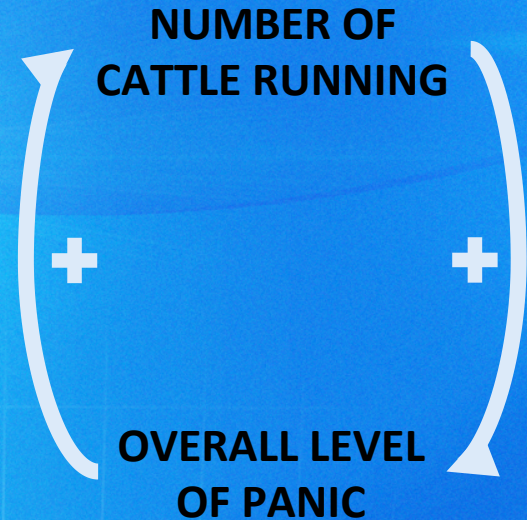
Herdwick Stampede (or human investors?)



Feedback

Positive feedback tends to cause system instability

- Positive feedback can quickly lead to
 - A bank run or even the global financial crisis
 - Loss in confidence
- e.g. alarm or panic can spread by positive feedback among investors as it does among a herd of animals

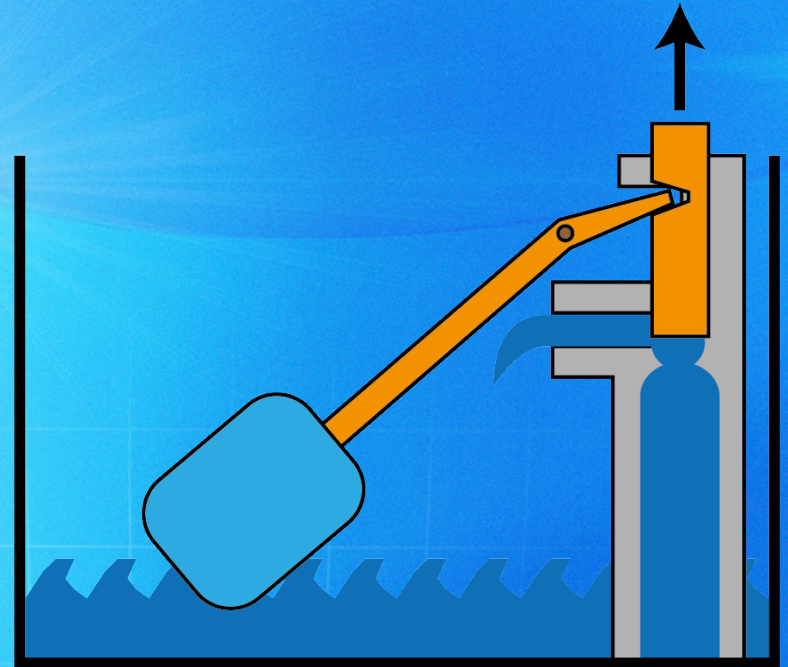
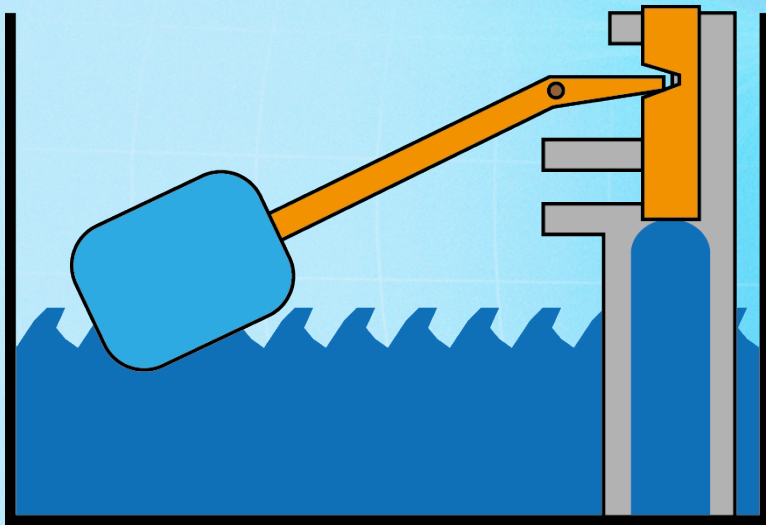


Feedback

Negative feedback tends to make a system self-regulating

- It can produce **stability** and reduce the effect of fluctuations
- e.g. the ballcock of float valve uses negative feedback to control the water level in a cistern

Feedback



Feedback

Negative feedback has a stabilising effect, and **implies a single equilibrium point.**

Based on the assumption that the *right amount of correction* can be applied in the *most timely manner.*

Both positive and negative feedback could exist at the same time or they may follow each other leading to **multiple equilibria.**

Emergence

- *Bottom-up (micro to macro):* through interaction of individual interacting agents



Two-way process!

- *Top down (macro to micro):* the emergent affects the interacting agents in two ways:
 - a) It constrains some actions;
 - b) At the same time it opens up new possibilities.

Emergence

- Emergent processes, qualities, patterns
- Arise from ***interaction***
- Cannot always be predicted
- Not additive or cumulative
- More than the sum of the parts
- ***Process of transition*** from micro-agent interaction to macro-structures
 - *e.g. learning, culture, innovation*
- new ways of organising/new organisational forms

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Thank you for your attention!

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