Managing Complexity?

Lessons from complexity theory

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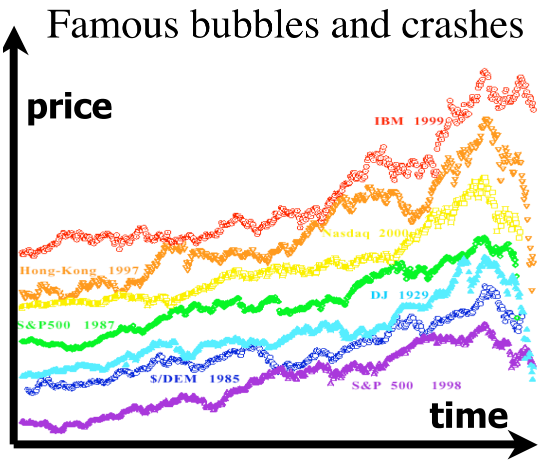
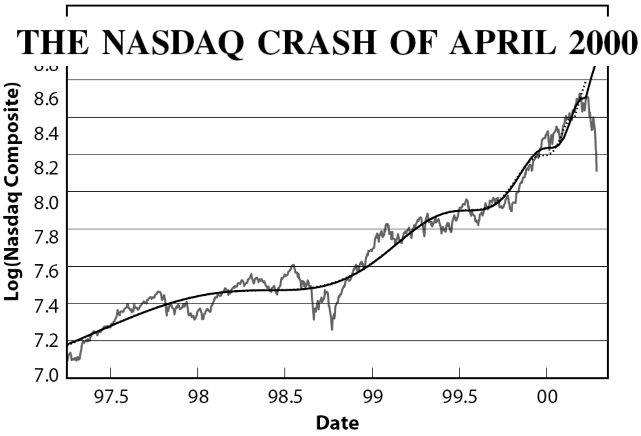
Managing the economy and the financial stock markets ?


Famous bubbles and crashes

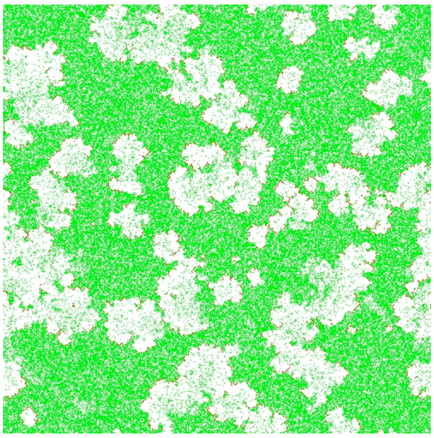

THE NASDAQ CRASH OF APRIL 2000

> **"We, at the Federal Reserve…recognized that, despite our suspicions, it was very difficult to definitively identify a bubble until after the fact, that is, when its bursting confirmed its existence…**
>
> **Moreover, it was far from obvious that bubbles, even if identified early, could be preempted short of the Central Bank inducing a substantial contraction in economic activity, the very outcome we would be seeking to avoid."**
>
> **A. Greenspan (Aug., 30, 2002)**

FIRE CONTROL

The primary response from government has been to initiation aggressive fire suppression and management in an attempt to eliminate fire from native lands. In spite of these aggressive fire suppression efforts large wildfires continue to consume vast acreages of chaparral in Southern California.

Minnich (1983, 1997) comparing the chaparral fire regimes in southern California and Baja California found that in Baja California numerous small fire events fragment stands into a fine mixture of age classes, a process which appears to help preclude large fires. While the pattern of large fires in Southern California appears to be an artifact of suppression.



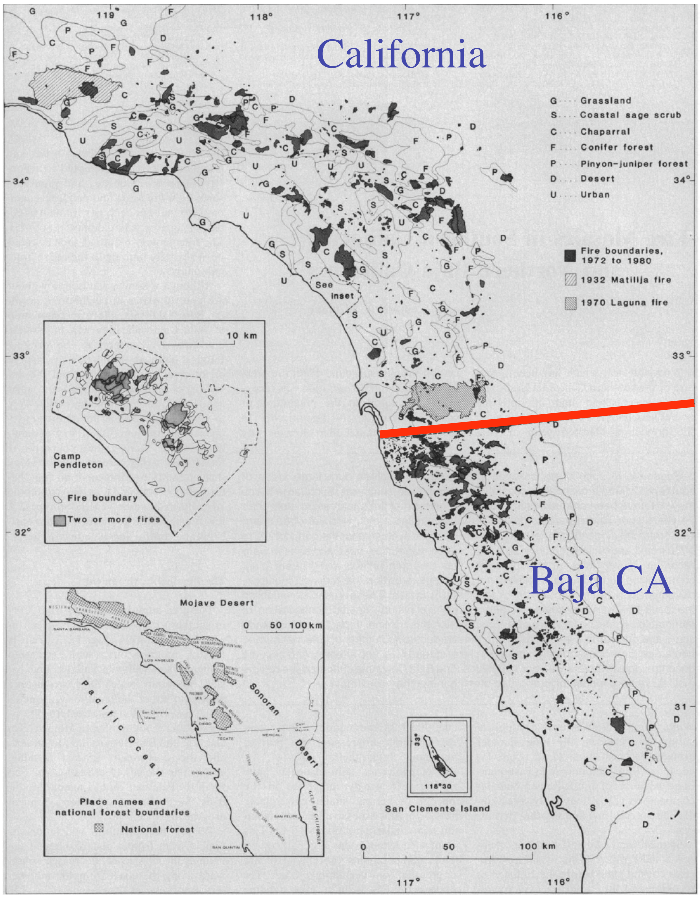


Fig. 1. Wild-land fires in southern California and northern Baja California, 1972 to 1980, with vegetation noted. A broad gradient of increasing fire area northward in Baja California shifts to a pattern of infrequent small to very large fires north of the border. Divergences in fire size between the two countries are most evident in chaparral. Fire data was mapped from Landsat imagery; vegetation was mapped from aerial photography (*33*).

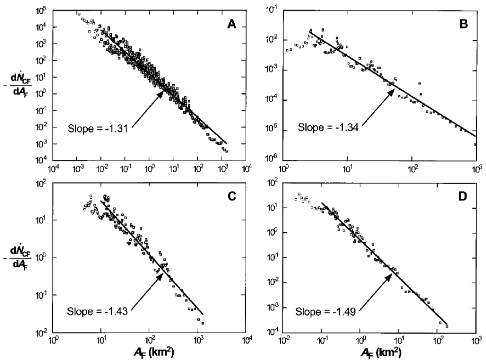
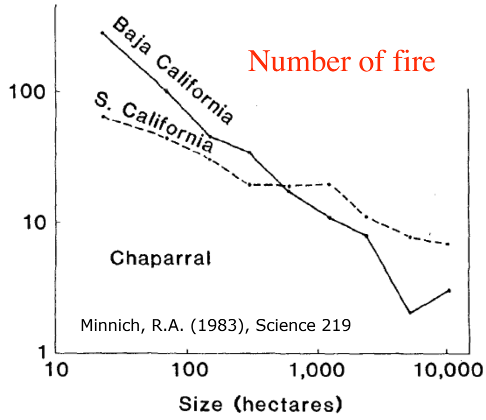


Fig. 2. Noncumulative frequency-area distributions for actual forest fires and wildfires in the United States and Australia: (**A**) 4284 fires on U.S. Fish and Wildlife Service lands (1986–1995) (*9*), (**B**) 120 fires in the western United States (1150–1960) (*10*), (**C**) 164 fires in Alaskan boreal forests (1990–1991) (*11*), and (**D**) 298 fires in the ACT (1926–1991) (*12*). For each data set, the noncumulative number of fires per year ($-d\dot{N}_{CF}/dA_F$) with area (A_F) is given as a function of A_F (*13*). In each case, a reasonably good correlation over many decades of A_F is obtained by using the power-law relation (Eq. 1) with $\alpha = 1.31$ to 1.49; $-\alpha$ is the slope of the best-fit line in log-log space and is shown for each data set.

Malamud et al., Science 281 (1998)



Number of fire

Minnich, R.A. (1983), Science 219

MANAGING COMPLEXITY?

•Feedbacks **(negative but also POSITIVE)**

•Emergence **(bottom-up vs top-down)**

•Heavy-tailed Power laws **(broad range of sizes and scales)**

•Outliers, Kings, “Black swans”

•The problem of predictability

•The illusion of control (Science and technology will shift from a past emphasis on motion, force, and energy to communication, organization, programming, and control.
John von Neumann, 1950)

Feedbacks: negative but also POSITIVE

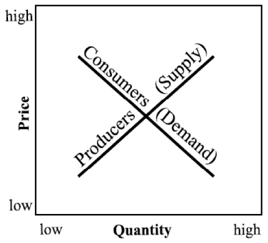
•Systemic risks: “In handling systemic issues, it will be necessary to address, on the one hand, risks to confidence in the financial system and contagion to otherwise sound institutions, and, on the other hand, the need to minimize the distortion of market signals and discipline.” (Basle Committee on Banking Supervision)
•Fires: After nearly a century of suppression, there has been increasing debate that fire control efforts have altered chaparral fire regimes in ways that magnify the treat of burning, erosion, sedimentation, and flooding at the urban/wildland interface

Mechanisms for positive feedbacks in the stock markets

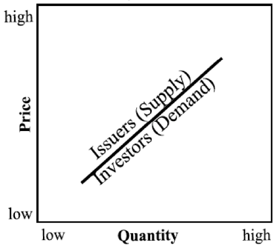
- Technical and rational mechanisms for positive feedbacks
  1. Option hedging
  2. Insurance portfolio strategies
  3. Trend following investment strategies
  4. Asymmetric information on hedging strategies

- Behavioral mechanisms for positive feedbacks
  1. It is rational to imitate
  2. It is the highest cognitive task to imitate
  3. We mostly learn by imitation
  4. The concept of “CONVENTION” (Orléan)

The Law of Supply & Demand in Utilitarian Economics

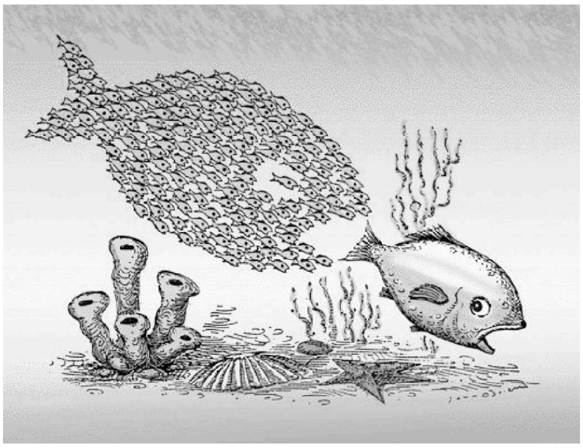


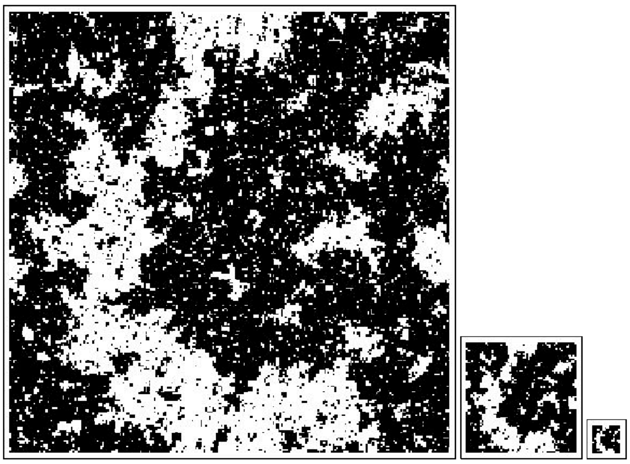
Herding in finance



Emergence: bottom-up vs top-down

- ✓A system can display properties not present in its components.
- ✓Emergent behaviors are not obvious from components alone.
- ✓No contradiction with mechanism, rather, emergent properties of mechanistic parts are far richer than previously imagined.
- ✓Top-down = “direct cascade”; bottom-up = “inverse cascade”
- ✓Understanding emergence is the central topic of complex systems.

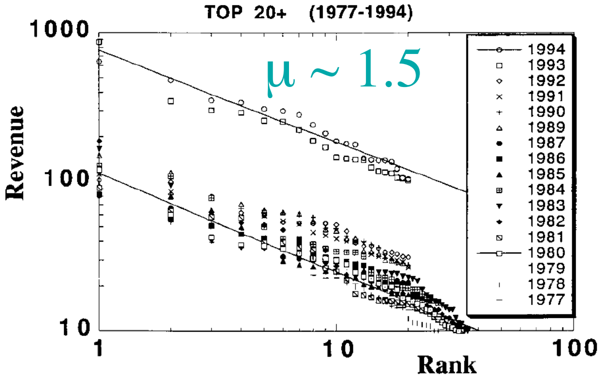


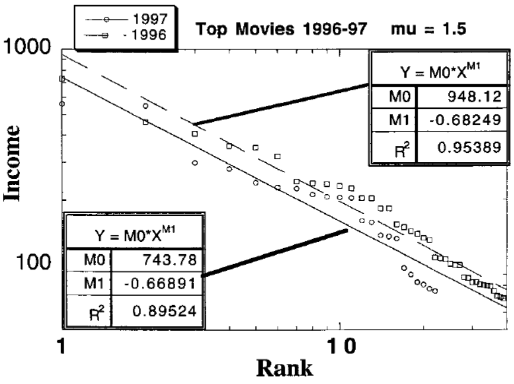


Agent-based models

Heavy-tailed distribution of innovations

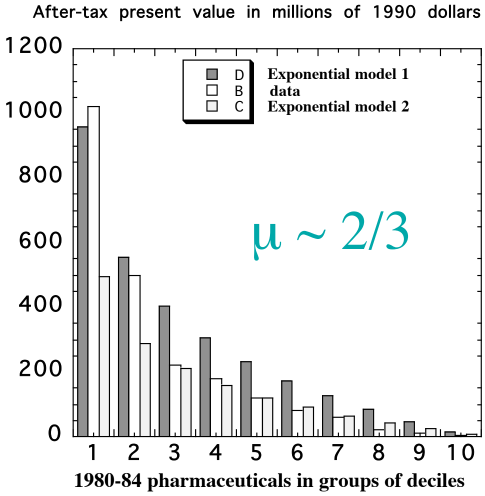
Zipf plot for the Movie industry





A. De Vany, Hollywood Economics; How extreme uncertainty shapes the film industry, Routledge (2003)

Pharmaceutical industry



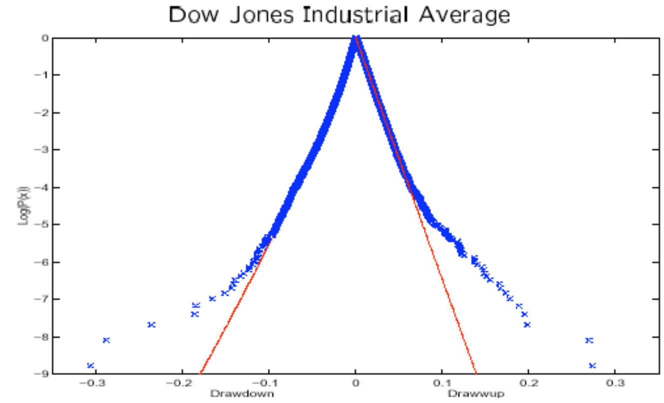
Comenor, Sornette (1998)

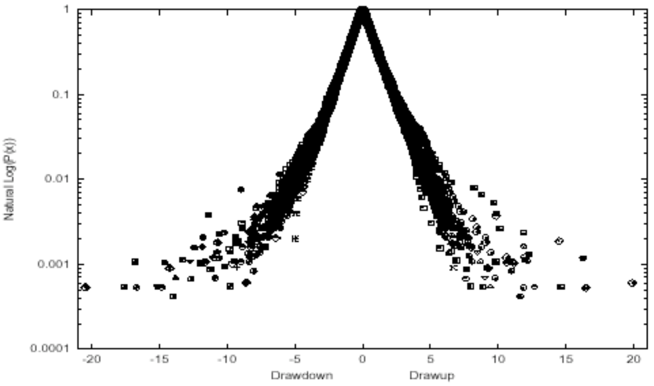
$$\boxed{P_>(W) \sim 1/W^{\mu}}$$

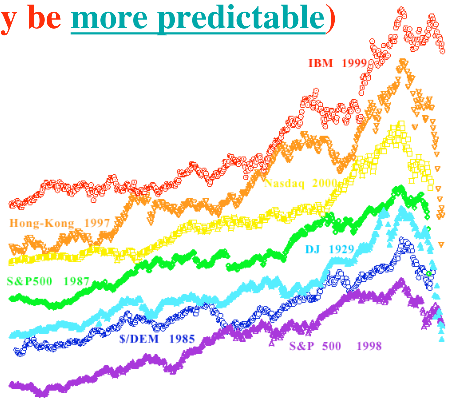
D. Sornette and D. Zajdenweber (1999) The economic return of research: the Pareto law and its implications, European Physical Journal B 8), 653-664

Outliers, Kings, “Black swans”

(require special mechanism and may be more predictable)







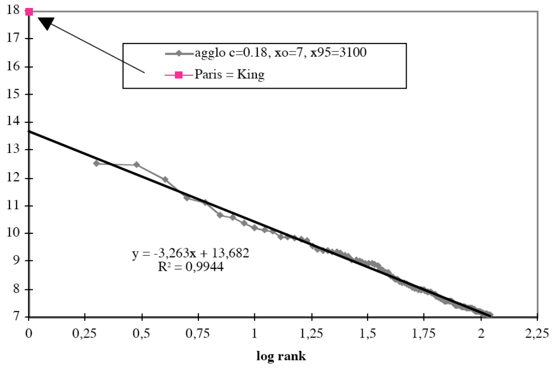


Fig. 7. French agglomerations: stretched exponential and “King effect”.

The problem of predictability

- •Prediction is the computational component of purposeful behavior.
- •Purposeful behavior consists of three parts (Sensation, Prediction, Action)
- •Purposeful behavior (and therefore prediction) exists because it is useful for reproduction/propagation.

1) **Algorithmic complexity**. Length of shortest program that can compute or describe something.
2) **Functional complexity**. Algorithmic complexity of constraint function (black box description).
3) **Structural complexity**. Algorithmic complexity of form (construction of machine).

Algorithmic complexity theory: most complex systems have been proved to be computationally irreducible, i.e. the only way to decide about their evolution is to actually let them evolve in time.

The future time evolution of most complex systems appears inherently unpredictable… BUT… lesson from PHYSICS (RG)

Lesson from bottom-up hierarchical grouping

Computational Irreducibility and the Predictability of Complex Physical Systems

256 nearest neighbor 1D cellular automata (Wolfram)

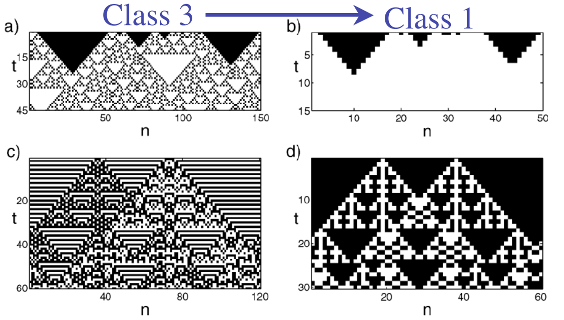


FIG. 1. Examples of coarse-graining transitions. (a) and (b) show coarse-graining rule 146 by rule 128. (a) shows results of running rule 146. The top line is the initial condition and time progress from top to bottom. (b) shows the results of running rule 128 with the coarse-grained initial condition from (a). (c) and (d) show coarse-graining rule 105 by rule 150. (c) shows rule 105 and (d) shows rule 150.

$$C(f_A^{T\cdot t}a(0)) = f_B^t C(a(0)).$$

Namely, running the original CA for Tt time steps and then coarse graining is equivalent to coarse graining the initial condition and then running the modified CA t time steps. The constant T is a time scale associated with the coarse graining.

240 coarse-grainable

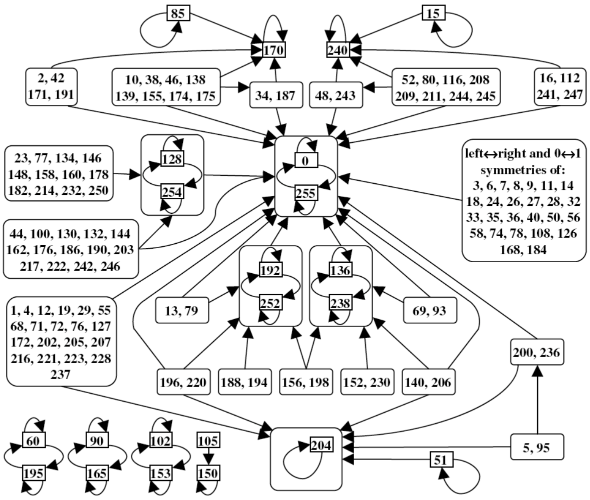


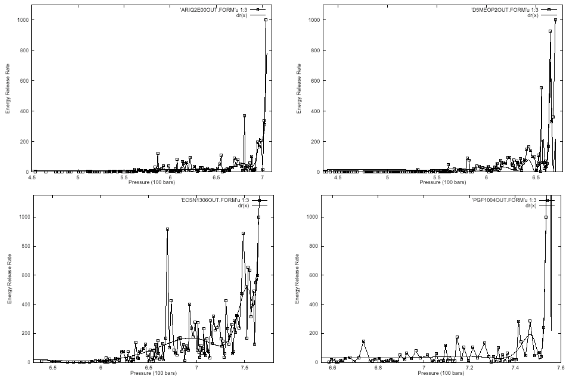
FIG. 2. Coarse-graining transitions within the family of 256 elementary CA. Only transitions with a cell block size $N = 2$, 3, and 4 are shown. An arrow indicates that the origin rules can be coarse grained by the target rules and may correspond to several choices of N and P.

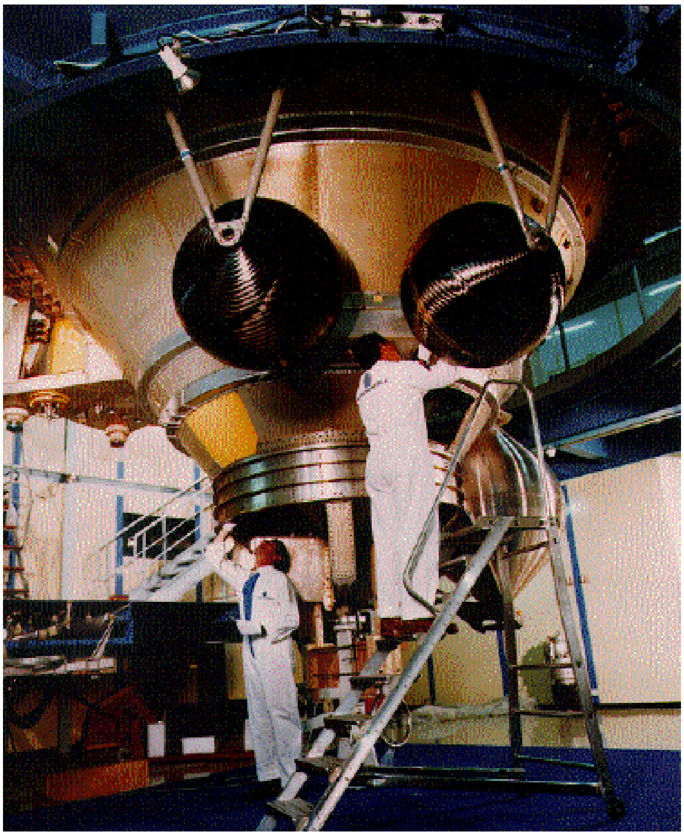
N-block approach with N=2, 3 or 4

Coarse-graining rule 110: CIR => C1

Navot Israeli and Nigel Goldenfeld PhysRevLett.92.074105 (2004)

Strategy: look at the forest rather than at the tree





Our prediction system is now used in the industrial phase as the standard testing procedure.

EADS LAUNCH VEHICLES

J.-C. Anifrani, C. Le Floc'h, D. Sornette and B. Souillard "Universal Log-periodic correction to renormalization group scaling for rupture stress prediction from acoustic emissions", J.Phys.I France 5, n°6, 631-638 (1995)

The illusion of control

•Information processing: normal people's high level of general intelligence makes them too smart for their own good.

✓After a full cycle of rise and fall after which stocks were valued just where they were at the start, all his clients lost money (Don Guyon, 1909)

✓Rats beat humans in simple games: People makes STORIES! Normal people have an "interpreter" in their left brain that takes all the random, contradictory details of whatever they are doing or remembering at the moment, and smoothes everything in one coherent story. If there are details that do not fit, they are edited out or revised! (T. Grandin and C. Johnson, Animals in translation (Scribner, New York, 2005)

•Are two heads better than one? (The wisdom of crowds: why the many are smarter than the few and how collective wisdom shapes business, societies and nations, J. Surowiecki, 2004)

Yes IF:

1. No multi-equilibria (only one solution; otherwise "average of Nice and LA is in the Atlantic")
2. Independence between decisions (otherwise: inadequate sampling, word of mouth, herding)
3. No feedbacks between people's decisions (otherwise: self-reinforcing bias)

•Groupthink is often characterized by

✓A tendency to examine too few alternatives
✓A lack of critical assessment of each other's ideas
✓A high degree of selectivity in information gathering
✓A lack of contingency plans
✓Poor decisions are often rationalized; over-confidence is reinforced but not accuracy
✓The group has the illusion of invulnerability and shared morality

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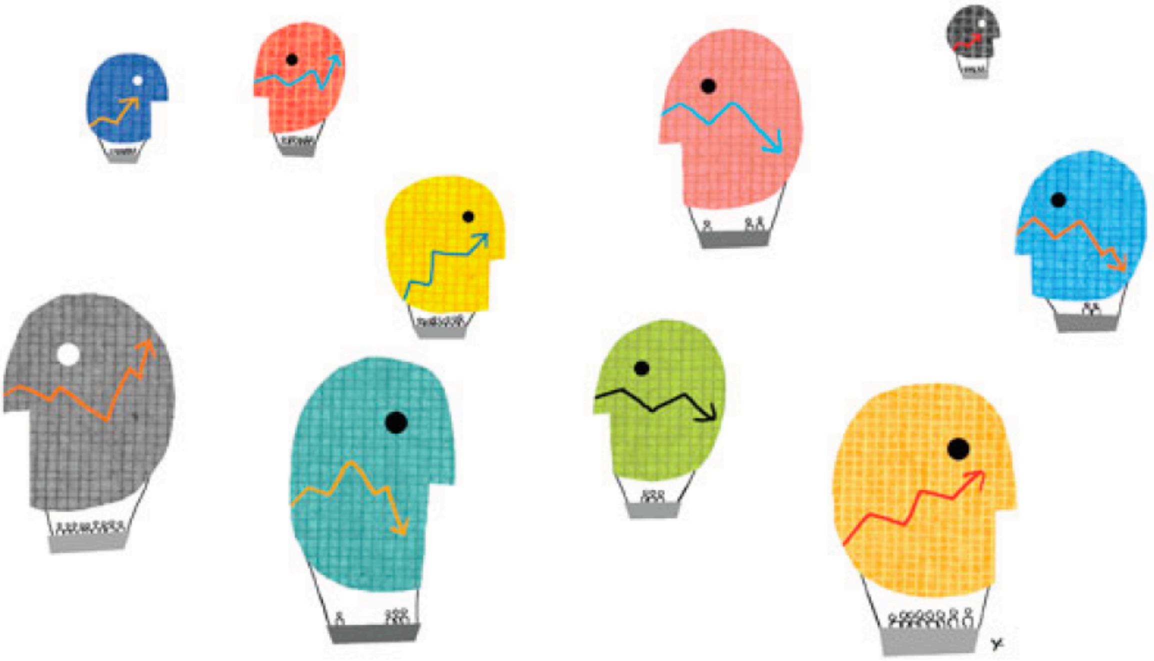
Market model to aggregate ideas

UNDER NEW MANAGEMENT

Here's an Idea: Let Everyone Have Ideas



Rite-Solutions, a software company

WILLIAM C. TAYLOR March 26, 2006 The NewYork Times

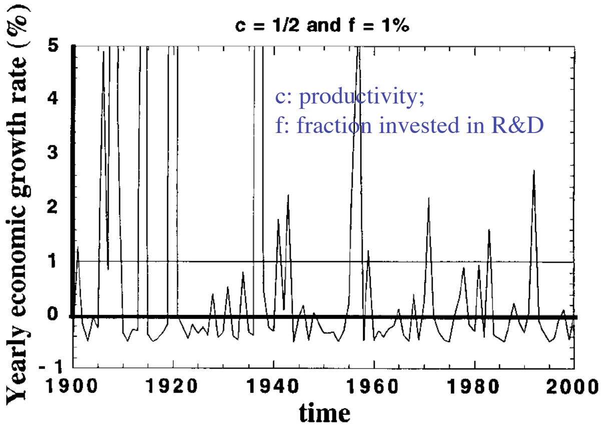
Psychology of Entrepreneurship

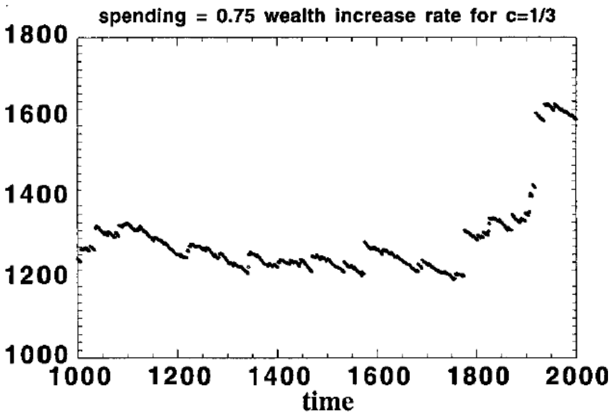
What do you prefer?

1. Gain regularly with rare large losses (LTCM; negative “skewness)
2. Lose a little regularly with rare large gains

In general, people and companies choose option 1!

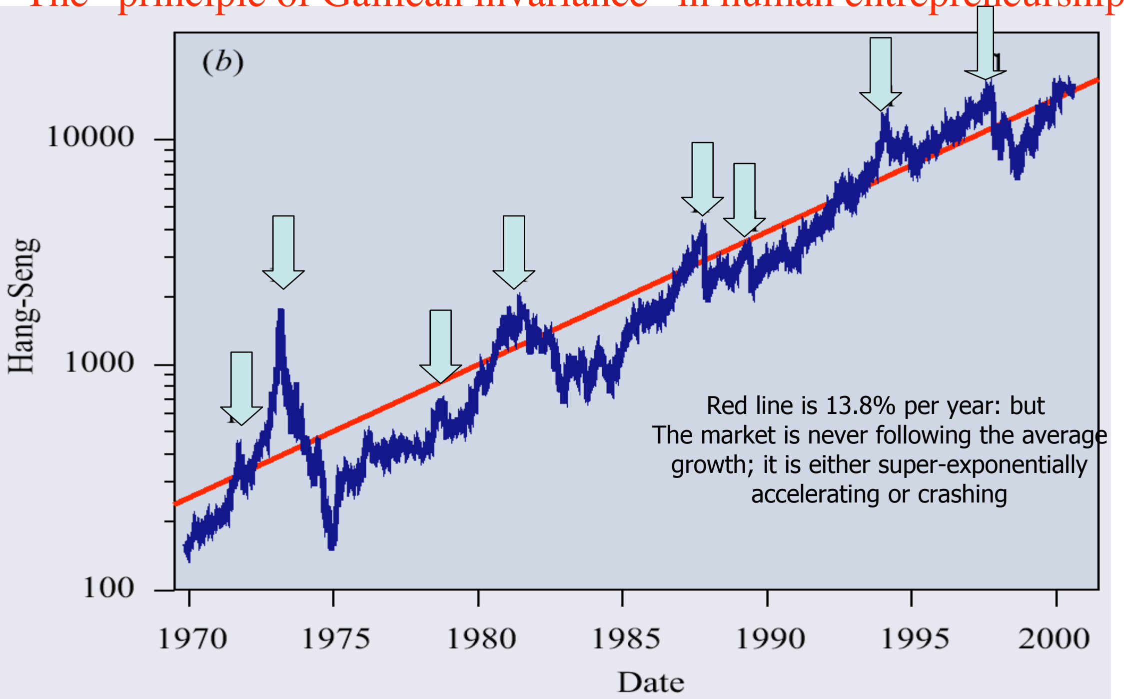
But this is probably suboptimal for Innovation and Entrepreneurship!





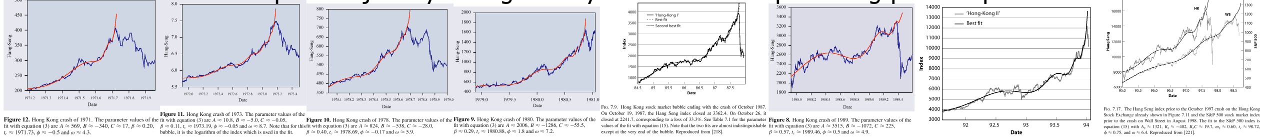
Psychology of Entrepreneurship

The “principle of Galilean invariance” in human entrepreneurship



Red line is 13.8% per year: but The market is never following the average growth; it is either super-exponentially accelerating or crashing

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



WHAT HAVE WE LEARNED?

- **Feedbacks** **(negative but also POSITIVE)**
- **Emergence** **(bottom-up vs top-down)**
- **Heavy-tailed Power laws** **(broad range of sizes and scales)**
- **Outliers, Kings, "Black swans"**
- **The problem of predictability**
- **The illusion of control** (Science and technology will shift from a past emphasis on motion, force, and energy to communication, organization, programming, and control.
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Recommendations

- Promote outliers, kings, black swans… both at the individual and collective levels
- Scientists' role to explore new scenarios, new horizons for helping policy making
- "Fooled by randomness": how to take into account our psychological biases?