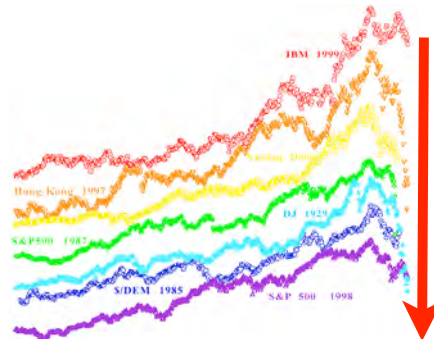


Visions on the future of econophysics

"The budget should be balanced, the Treasury should be refilled, public debt should be reduced, the arrogance of officialdom should be tempered and controlled, and the assistance to foreign lands should be curtailed lest Rome become bankrupt. People must again learn to work instead of living on public assistance."

Cicero - 55 BCE



D. Sornette

Professor of Entrepreneurial Risks at ETH Zurich

Professor of Finance at the Swiss Finance Institute

Director of the Financial Crisis Observatory

co-founder of the Competence Center for Coping with Crises in Socio-Economic Systems, ETH Zurich (<http://www.ccss.ethz.ch/>)

Professor of Geophysics associated with the Department of Earth Sciences (D-ERWD), ETH Zurich

Professor of Physics associated with the Department of Physics (D-PHYS), ETH Zurich

A partial lists of achievements of Econophysics

- scaling, power laws, “universality”
- theory of large price fluctuations [14],
- agent-based models, induction, evolutionary models [1, 9, 11, 21],
- option theory for incomplete markets [4, 6],
- interest rate curves [5, 38],
- minority games [8],
- theory of Zipf law and its economic consequences [12, 13, 27],
- theory of bubbles and crashes [17, 22, 40],
- random matrix theory applied to covariance of returns [20, 36, 37],
- methods and models of dependence between financial assets [25, 43] and in particular network theory

A partial lists of achievements of Econophysics

Need for econophysics results and insights to be known

Strategy: team up with economists to develop rigorous statistical approaches and publish in top financial or economic journals

Reach beyond physics and marry with other disciplines

Physics is no-more the Queen of sciences.

Examples: role of financial firms to influence the rest of the economy; networks of networks and fragility versus robustness; critical phenomena...

FOUR EXAMPLES

(i) the fluctuation-susceptibility theorem (response function) transforms into a remarkable classification of financial volatility shocks (endogenous versus exogenous),

(ii) the Ising model of phase transitions can be generalized to model the stylized facts of financial markets, and more towards predictions

(iii) the concepts of collective phenomena and phase transitions (with spontaneous symmetry breaking) help understand financial bubbles and their following crashes,

(iv) the mathematics of quantum physics provides a new quantum decision theory solving the known paradoxes.

Partial list of problems with standard Utility theory

- **Allais paradox** (Compatibility violation: Several choices are not compatible with utility theory)
- **Ellsberg paradox** (uncertainty aversion)
- **Kahneman-Tversky paradox** (invariance violation)
- **Rabin paradox** (payoff size effects)
- **Disjunction effect** (violation of the sure-thing principle)
- **Conjunction fallacy** (violation of probability theory)

“Bounded rationality”

- In 1957, Herbert Simon described the principle of “bounded rationality” - Nobel Prize in 1978:

“The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problem whose solution is required for objectively rational behavior in the real world, or even for a reasonable approximation to such objective rationality.”



Cognitive distortions in risk appreciation

Familiarity/ control	We overestimate the severity of unfamiliar risks and underestimate the severity of those we assume voluntarily
Loss aversion	We respond differently to identical probabilities expressed in terms of loss or profit
Availability	We tend to interpret any story through the lens of a superficially similar account
Confirmation bias	We underpin assumptions by focusing on instances that confirm it, while ignoring those that don't
Overconfidence	We see ourselves as always being right – or at least more often than other people
Anchoring	We tend to cling mentally to any number we hear in a particular context, even if it is factually far off the mark
Representativeness	We judge the substantial similarity of things based on their superficial resemblances



**=>Towards a fundamental theory of
human decision making**

(triune brain: reptilian, emotional, rational)

Quantum Decision Theory?

V.I. Yukalov and D. Sornette
Processing Information in Quantum Decision Theory,
Entropy 11, 1073-1120 (2009)

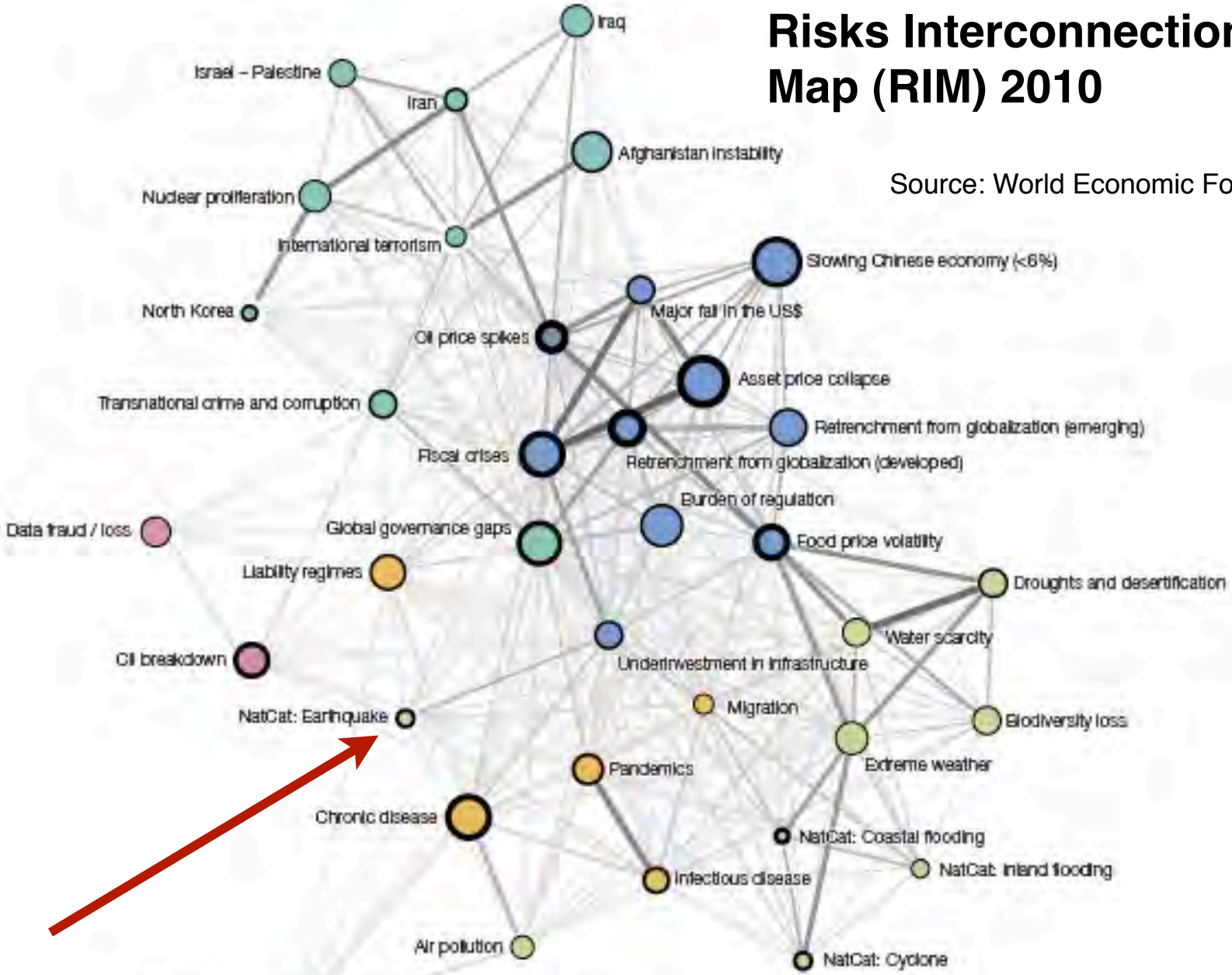
V.I. Yukalov and D. Sornette
Entanglement Production in Quantum Decision Making,
Physics of Atomic Nuclei 73 (3), 559-562 (2010).

Questions and Strategy for the future

“Nature” is more imaginative than
mathematicians, economists or...
econophysicists

Risks Interconnection Map (RIM) 2010

Source: World Economic Forum 2010



(10-year time horizon)



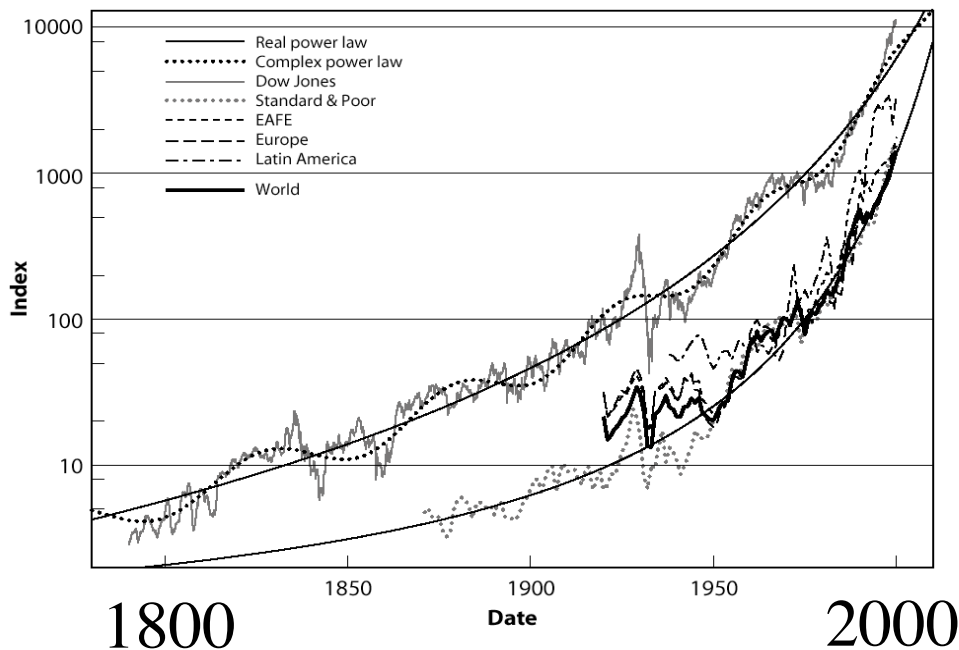
- Sub-prime default (2007)
- Bear Sterns, AIG, ... (2008)
- Lehman Brothers (15 Sept 2008)
- Global credit freeze (2008-09)
- Sovereign quasi-default (Iceland, East-Europe)
- Dubai (2009)
- Greece (2010)
- PIIGS (Portugal, Italy, Ireland, Greece, Spain)
- STUPID (Spain, Turkey, UK, Portugal, Italy, Dubai)
- East-Europe and cascade to Western Europe
- US? Dollar? Oil? Geo-political? Climate?

IMMENSE PROGRESS and INNOVATION

FINANCIAL SYSTEM

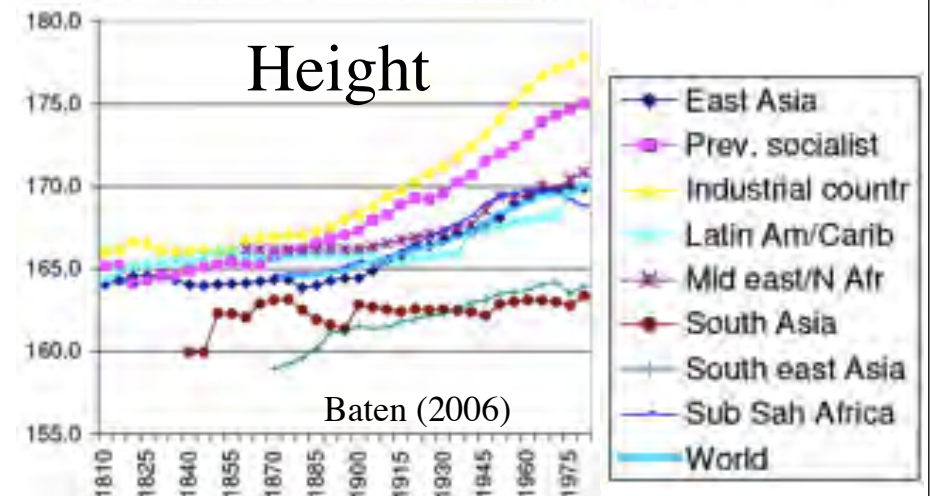
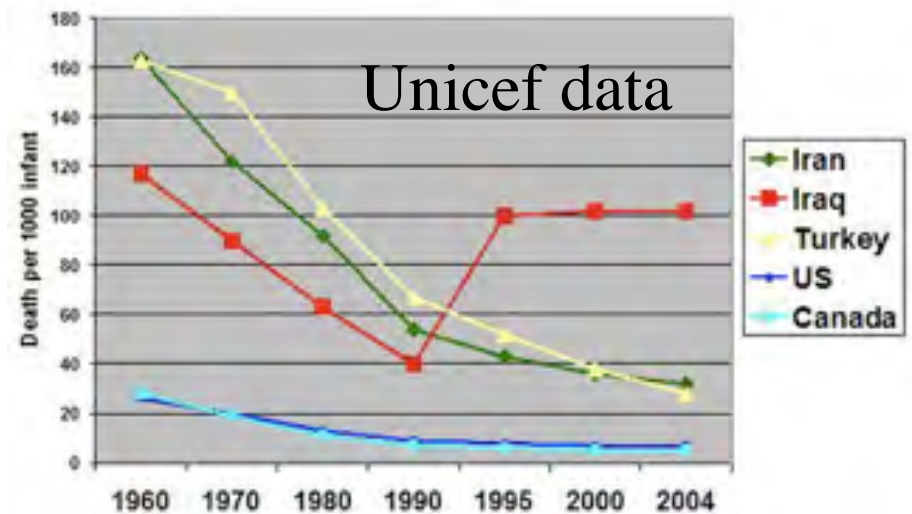
Financial innovations have fostered the use of capital for

- economic development,
- welfare,
- education...



FOOD AND HEALTHCARE

- Decrease of newborn and infant mortality
- Height as a proxy for health



CONFLICTS OF INTERESTS

FINANCIAL SYSTEM

Loss of “Fiduciary Principle”

‘no man can serve two masters’

(J. Bogle, former CEO Vanguard group, JPM 2009)

“Legal relationship of confidence or trust between two parties”

The issue of “moral relativism”

Moral hazard

Incentives

FOOD AND HEALTHCARE

Loss of “Hippocratic oath”

‘nil nocere’

Fundamental conflict of interest to keep us “marginally ill”

Maximizing share-holder value

Rational focus on short-term in the presence of large risks and uncertainties

HUMAN INTRINSIC WEAKNESSES

People simply fail to do what is best even for themselves, in the face of good, freely available information.

FINANCIAL SYSTEM

The illusionary quest of society-at-large, pensions funds, mutual funds... to gain more than 2% return in real terms (above inflation)

The “gambling society” (stardom culture, emphasis on “luck”) vs work and risk management

The root cause of the crisis is our illusion on financial solution to growth (high returns, above GDP growth)

FOOD AND HEALTHCARE

The illusionary syndrome for “blue pills and red pills”...

Principle of least effort (Zipf, 1949)

Principle of immediate or short-term gratification (large “discount rate”)

The root cause of the coming healthcare crisis is our illusion in technical / medical solutions.

HUMAN INTRINSIC WEAKNESSES

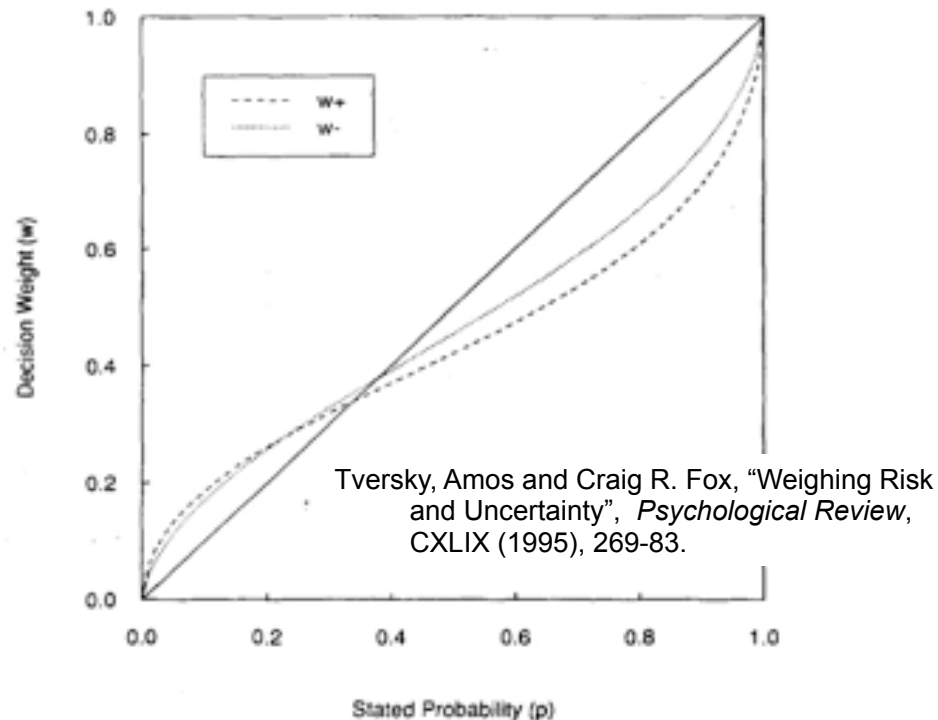
Fundamental failure to grasp the SYSTEM nature of the problems:
Instead, one problem => one proximate solution: THIS IS **WRONG!**

FINANCIAL SYSTEM

- Bankers are sellers of dreams.
- Bankers exploit our illusions and cognitive limitations... like casinos and lotteries...

FOOD AND HEALTHCARE

- The food industry exploits our weakness (addictive and/or compensatory nature of some foods).
- The pharmaceutical industry exploits our illusions for simple solutions to health problems.



Cooperation and coordination problems

- Public goods (individual cost for benefit to the group) (recycling, hybrid car, valor in combat, voting, donating blood,...)
- Tragedy of the commons (shared resource gives benefit to personal use and distributed losses) (cows in shared pastures, Air, Water, Scenery, global warming, pollution...)
 - Earth renewable services are exogenous to the economic costs and decision processes
- Externalities: pollution
- Market failures: asymmetric information

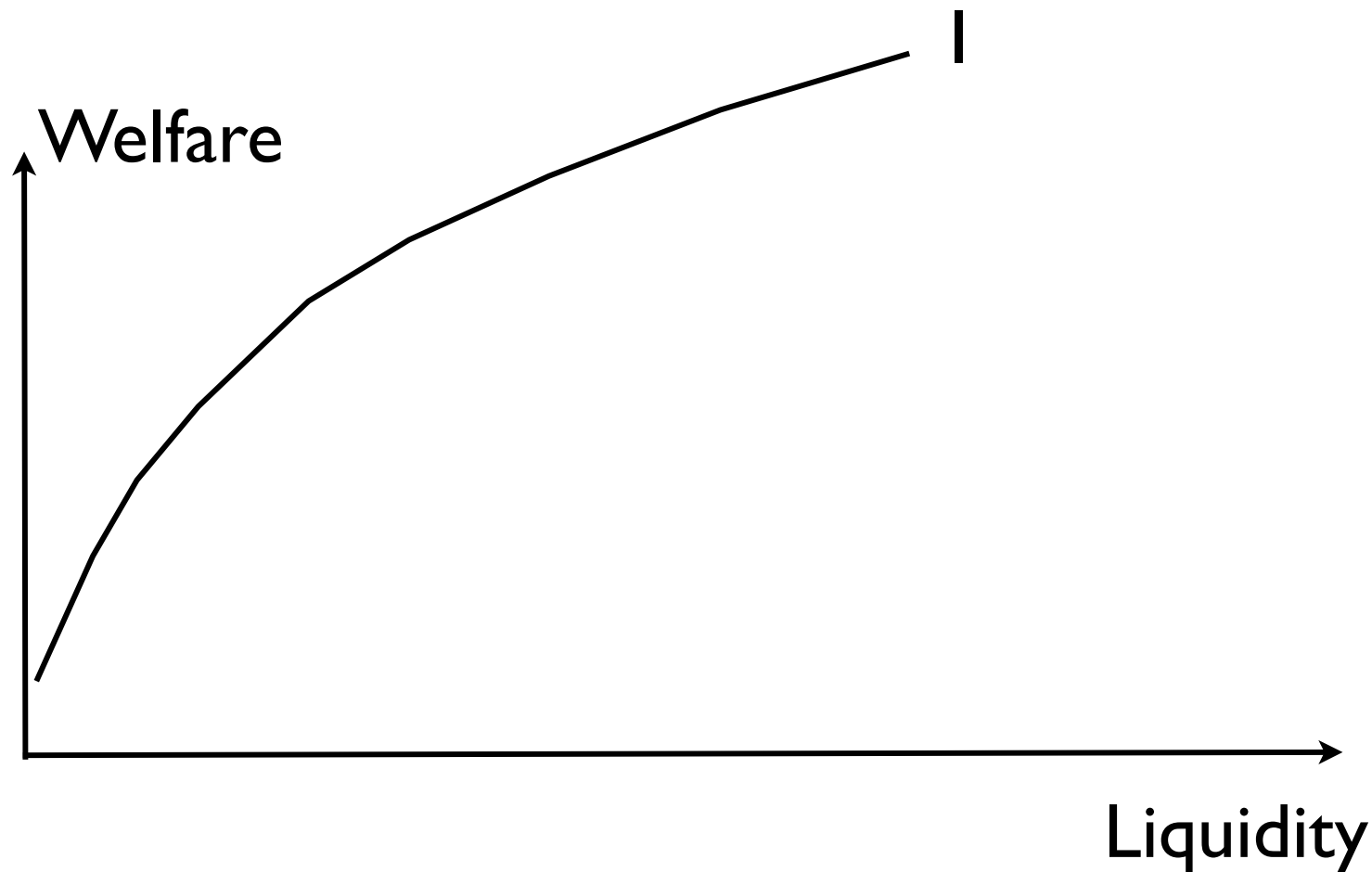
Theory and practice of human cooperation?

-Financial innovations, High Frequency Trading...
are justified by improved LIQUIDITY

=> **do we need so much liquidity?**

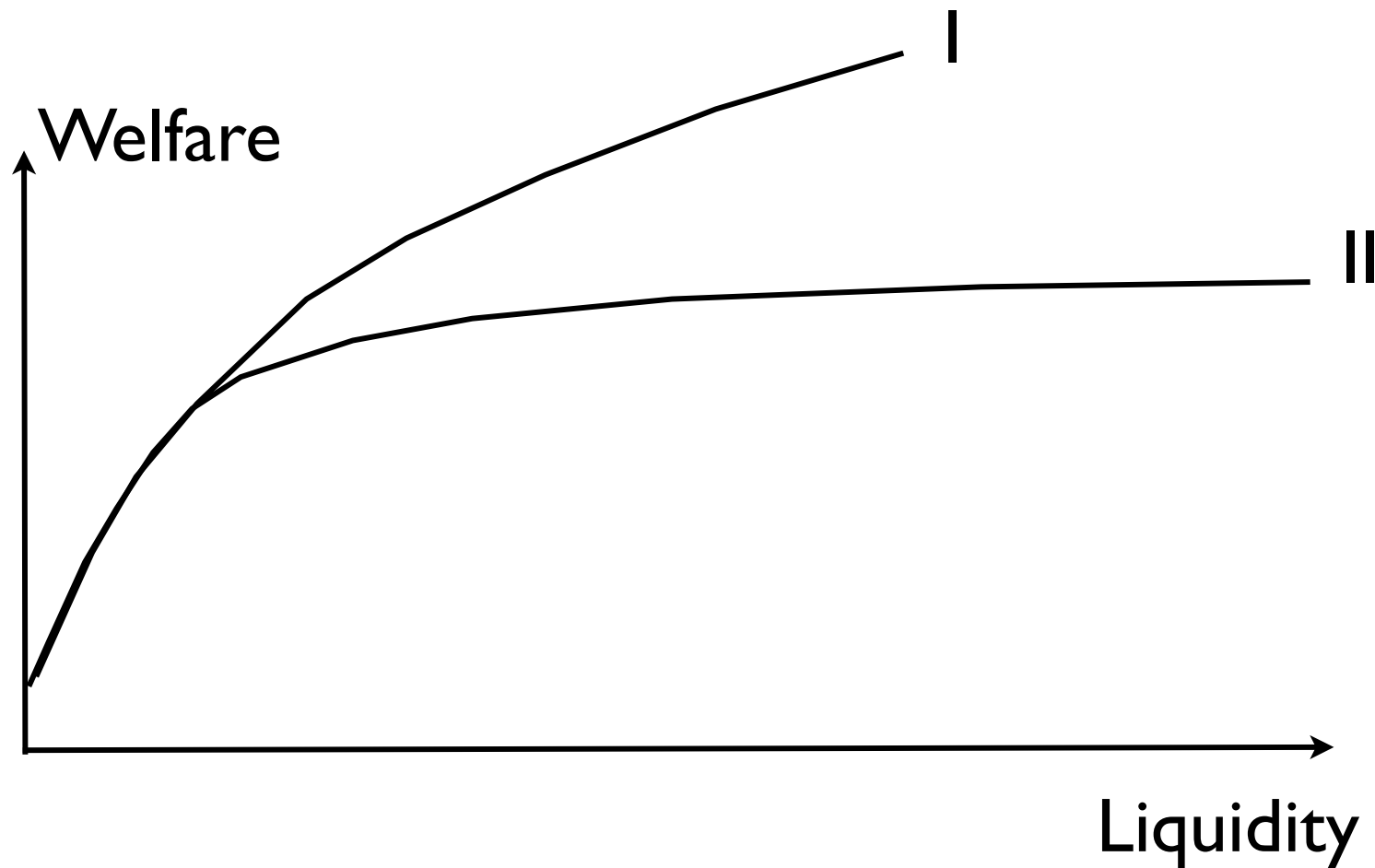
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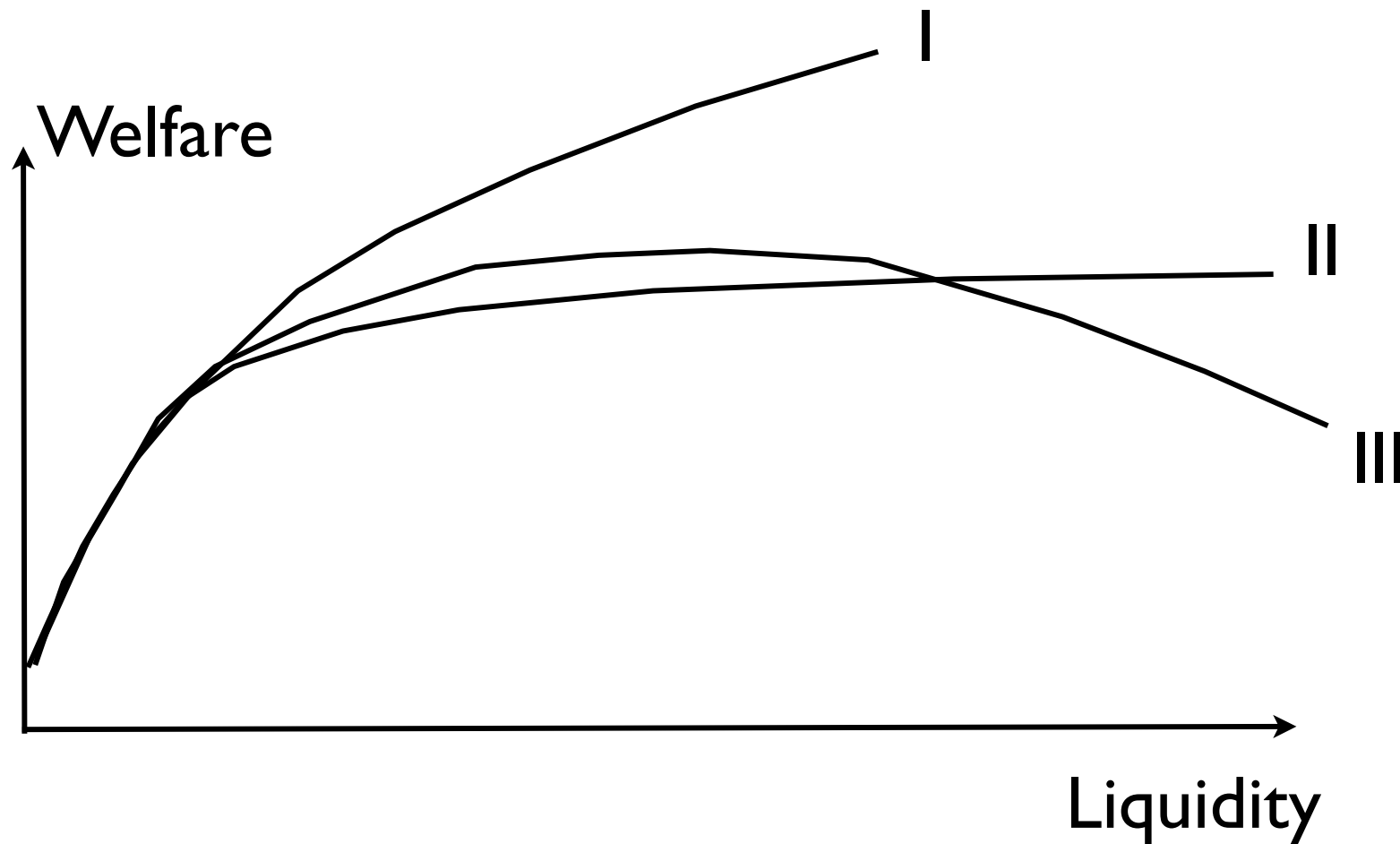
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-Financial innovations, High Frequency Trading...
are justified by improved LIQUIDITY

=> **do we need so much liquidity?**



Questions and Strategy for the future

from post-mortem data analysis

to

real-time hand-on experiments,
trading and design

At present: most exciting progresses at the boundary between economics and the biological, cognitive, and behavioral sciences.

Physics has still a role to play as a unifying framework full of concepts and tools to deal with the complex.

The modeling skills of physicists explain their impressive number in investment and financial institutions (**data-driven approach coupled with a pragmatic sense of theorizing**)

KEY CHALLENGE:

true inter-disciplinarity by “marriage”

"How many things are looked on as quite impossible until they have been actually effected?" (Pliny the Elder, 1st c. AD: Natural History, Book VII, section 6)

"It is impossible to produce a superior performance unless you do something different from the majority".
Sir John Templeton.

Everybody knew it is impossible.
He/She did not know it.
He/She did it.



- Entrepreneurship includes innovation, **risk-taking**, predicting the environment, the competitors, local and global economics and geopolitical evolution, the future...
- Prediction of complex systems, with emphasis on network effects, cascades, avalanches, **large and extreme events** and the consequences for risk mitigation, risk management and risk steering
- Mechanisms of creation of value and innovation by translating, adapting and evolving concepts and tools from the **sciences of systems** to the corporate and business world.

Solutions for Financial and biological Health?

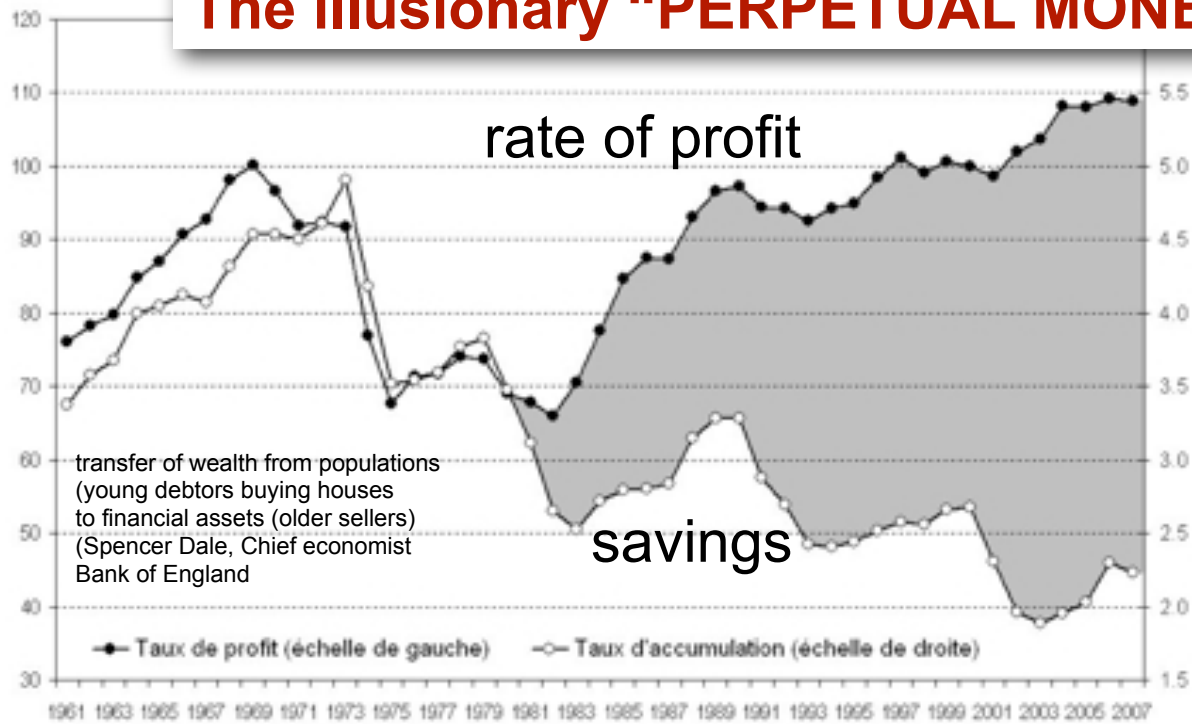
The problem of institutional and academic memory loss

- Regulation and system design (Glass-Steagall act (1933); Sarbanes-Oxley act (2002); Dodd-Frank act (2010)...)
- Credit creation by banks (R. Werner)

The key question: is there evidence that the new financial innovations and a much expanded bank system has brought any real gain for innovations, economic development, employment?

As Krugman suggested, is “boring banking” sufficient?

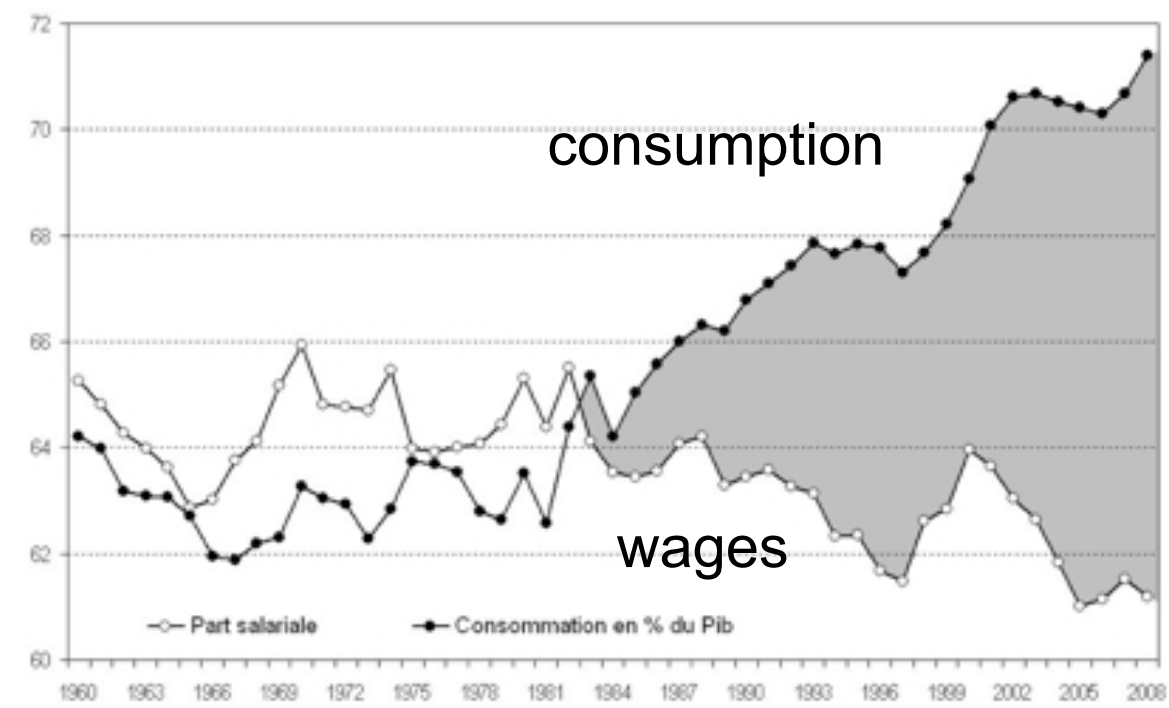
The illusory "PERPETUAL MONEY MACHINE"



Rate of profit and rate of accumulation: The United States + European Union + Japan

* Rate of accumulation = rate of growth rate of the net volume of capital * Rate of profit = profit/capital (base: 100 in 2000)

Sources and data of the graphs: <http://hussonet.free.fr/toxicap.xls>



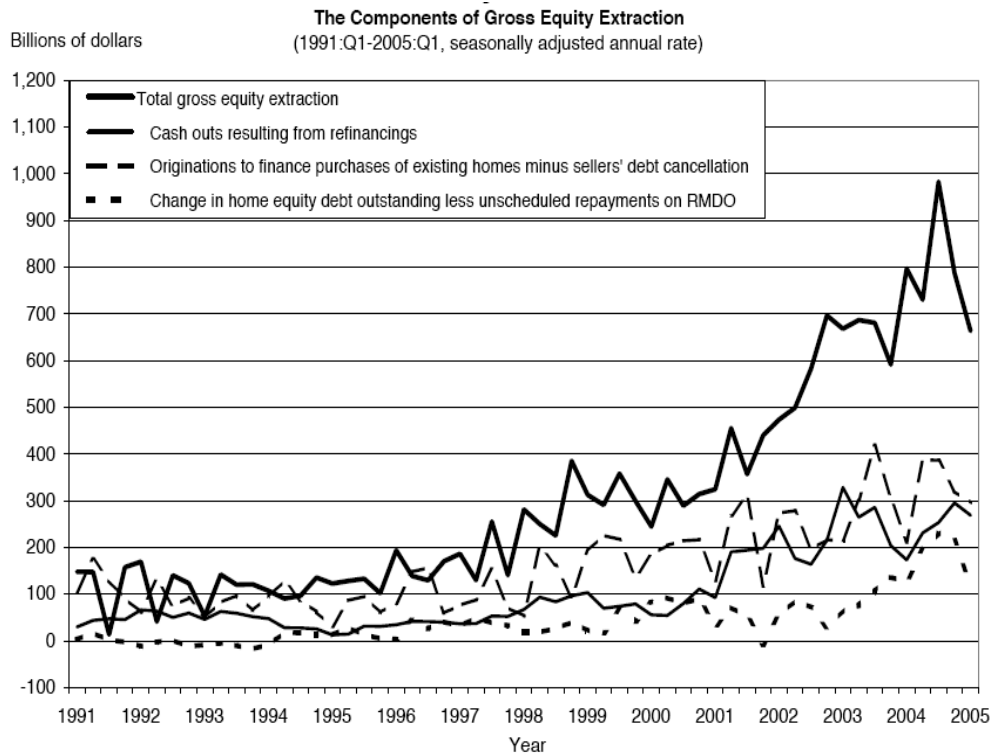
The gap widens between the share of wages and the share of consumption (gray zones), so as to compensate for the difference between profit and accumulation. FINANCE allows increasing debt and virtual wealth growth... which can only be transitory (even if very long).

United States Share of wages and of private consumption in Gross Domestic Product (GDP)

Source of data and graphics: <http://hussonet.free.fr/toxicap.xls>

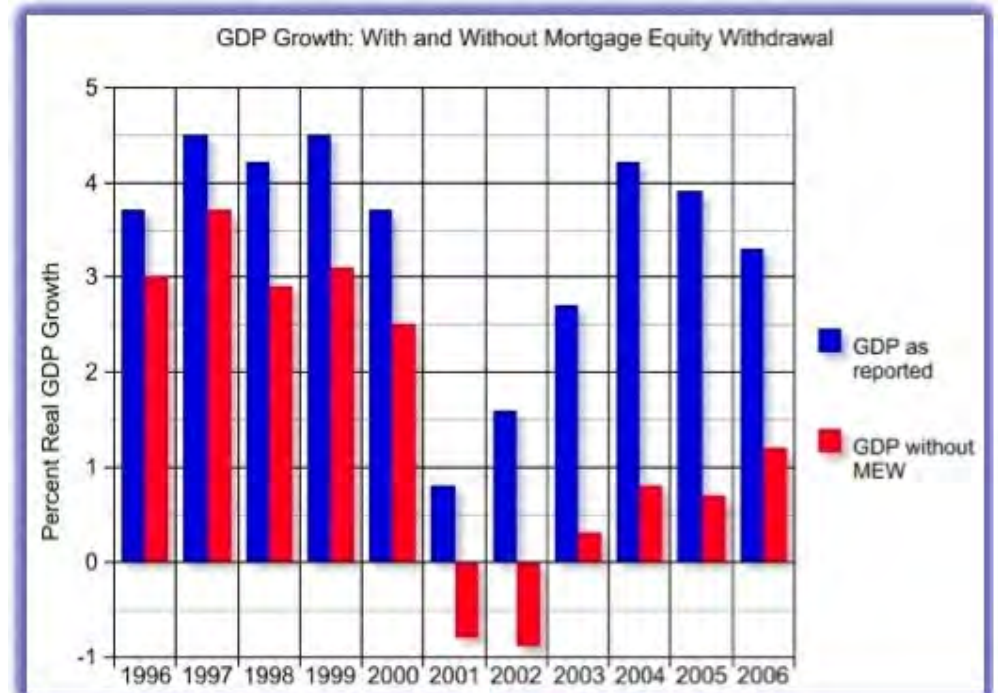
Wealth Extraction

Over the past decade and a half, (B - F) has been closely correlated with realized capital gains on the sale of homes. $B-F = \text{change in home equity debt outstanding less unscheduled repayment on RMDO}$



Alan Greenspan and James Kennedy (Nov. 2005)

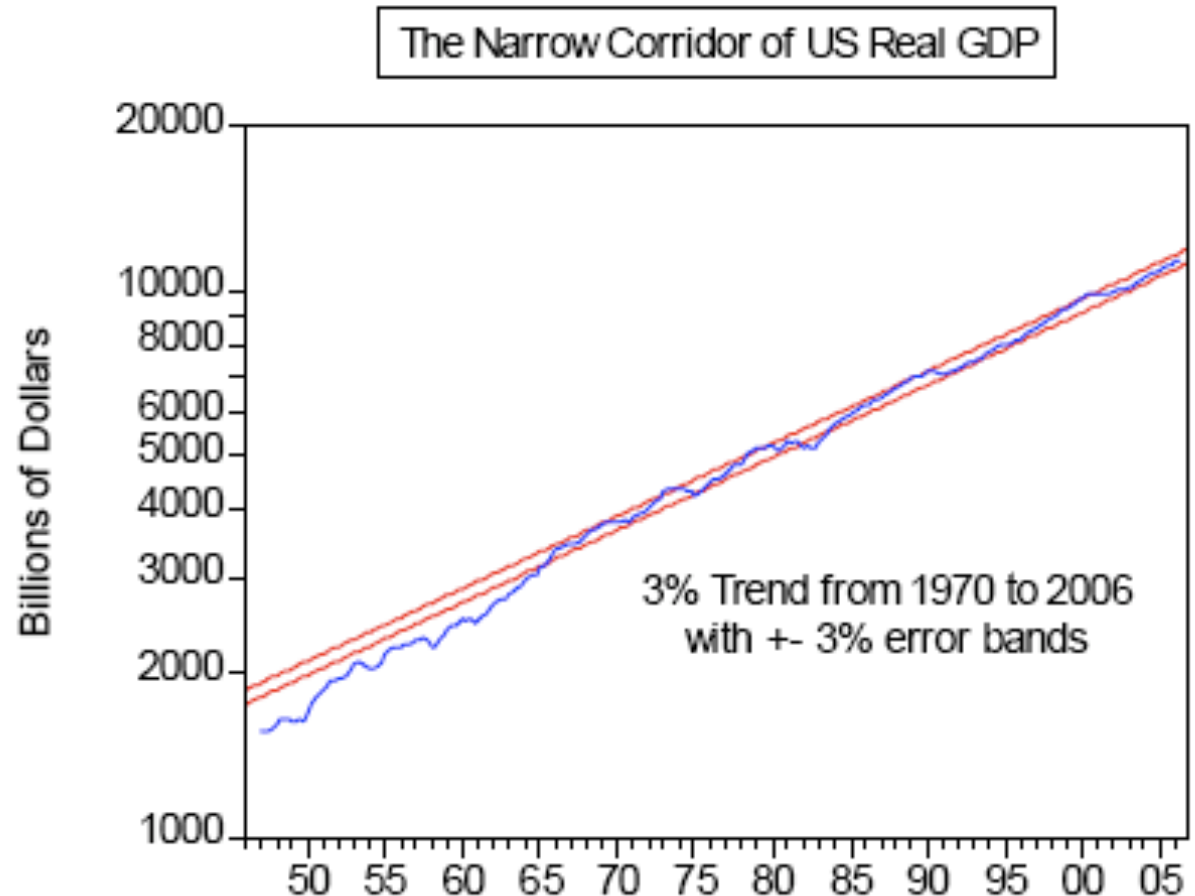
Mortgage Equity Withdrawal impact on GDP



source: John Mauldin (April 09)

The illusory “PERPETUAL MONEY MACHINE”

- An economy which grows at 2 or 3 per cent cannot provide a universal profit of 15 per cent, as some managers of equities claim and many investors dream of.
- Financial assets represent the right to a share of the surplus value that is produced. As long as this right is not exercised, it remains **virtual**. But as soon as anyone exercises it, they discover that it is subject to **the law of value**, which means, quite simply, that you cannot distribute more real wealth than is produced.



From 1982 until 2007, the U.S. only experienced two shallow recessions that each lasted just 8 months. This stretch of 25 years may be the best 25 years in the US economic history. But much of this prosperity was bought with debt, as the ratio of debt to GDP rose from \$1.60 to \$3.50 for each \$1.00 of GDP.

Solutions for healthy lifes?

Hyp: +90%(?) of modern health problems come from forgetting simple low-tech grandmother-like recipes.

- importance of deep breathing (also for brain which consumes 30%)
- drink a lot of water (dilute and eliminate toxins) and outside meals (not to interfere with digestion)
- digestion starts in the mouth (chew a lot)
- exercise every morning 10 minutes (stretching, breathing) with non-routine “fractal” like runs, push-ups, HIIT... (A. de Vany)
- law of chemistry: effective food combining => do not mix alkaline (starchy) and acid (protein) food (mixing perturbs digestion and intestine flora and therefore our immune system which starts in the intestine)
- eat a lot of raw vegetable and fruits (water-rich food)
- less meat (uric acid and putrefaction gives its taste) and diary products
- optimistic positive psychology, get a companion or a cat, socialize...



Promoting sustainable behavior by means of “social capital”

Social capital includes reciprocal effects, fairness, altruism and other-regarding behavior rule the world.

Self-sustaining incentive to foster “social capital” of a culture / society / communities / group.

Field studies and lab experiments in close combination with complex system theory (ABM) can considerably contribute to improve the understanding of cooperation in order to promote and spread a sustainable behavior.

Living examples of “social capital in action”

- **Microfinance (Yunus)**: Losses and defaults of micro credits are almost negligible. The implementation of **joint liabilities, social collateral and peer pressure mechanisms** ensures a sustainable, effective and efficient way for self-help without spending money. Lending micro credits is less risky and more profitable than standard investments.
- **eBay** uses a simple version of cross-reporting schemes. Buyers and sellers can publicly rate each other to prevent abuse. This rating opportunity implements an additional feedback mechanism that takes the advantage of sustaining cooperation by punishing norm violators/defectors.
- **Dimension Fund Advisors** (Investment firm in Santa Monica, 1981): cultivating a culture of Trust (full disclosure, “penalty box”, full disclosure preventing asymmetric information)
- **Switzerland...**

ECONOMICS

Adam Smith “Inquiry into the Nature and Causes of the Wealth of Nations” (1776)

•Francis Edgeworth and Alfred Marshall (1890) develop the concept of **equilibrium**

•“everything in the economy affects everything else”

•Vilfredo Pareto (1897): power law distribution of incomes

•Louis Bachelier (1900): random walk model of Paris stock market and solution of diffusion equation

•Benoit Mandelbrot (1963) proposes heavy-tailed distributions (Levy stable laws) for the pdf of cotton returns

•initially supported by Merton Miller, Eugene Fama, and Richard Roll (Chicago), Paul Samuelson (MIT), and Thomas Sargent (Carnegie Mellon), but opposition from Paul Cootner and Clive Granger;

•distributions of returns are becoming closer to the Gaussian law at timescales larger than one month.

PHYSICS

•Isaac Newton Philosophiae Naturalis Principia Mathematica (1687) [(**novel at the time**) **notion of causative forces**]

•Clerk Maxwell and Ludwig Boltzmann (1871-1875): **equilibrium** in gases

•mean-field theory or self-consistent effective medium methods

•distribution of event sizes (earthquakes, avalanches, landslides, storms, forest fires, solar flares, commercial sales, war sizes, ...)

•Einstein (1905): theory of Brownian motion

•Benoit Mandelbrot (1977): Fractals

•Much of the efforts in the econophysics (1993-2000s) refined the Levy hypothesis into

$$\text{pdf}(r) \sim 1/r^3$$

