If you are a good economist, a virtuous economist, you are reborn as a physicist. But if you are an evil, wicked economist, you are reborn as a sociologist. -- An Indian economist, quoted by Paul Krugman (Econ Nobel 2008)
ETH Competence Center for "Coping with Crises in Socio-Economic Systems"

- Crises in financial markets
- Crises in societal infrastructures
- Crises involving political violence

www.ccss.ethz.ch/
• Collective dynamics and organization of social agents
  (Commercial sales, YouTube, Open source softwares, Cyber risks)

• Agent-based models of bubbles and crashes, credit risks, systemic risks

• Prediction of complex systems, stock markets, social systems

• Asset pricing, hedge-funds, risk factors…

• Human cooperation for sustainability

• Natural and biological hazards (earthquakes, landslides, epidemics, critical illnesses…)

(3 guest-professors, 5 foreign associate professors, 3 post-docs, 2 senior researcher, 10 PhD students, 6-8 Master students)
Crises are not but "Dragon-kings"
Black Swan (*Cygnus atratus*)
Non-Borrowed Reserves of Depository Institutions (BOGNONBR) continue to plummet. This makes sense as under capitalized banks continue to hemorrhage money via outright losses and write downs of over valued assets. The result is that these banks now have to borrow money from the Fed to maintain their reserves so that when you go to the ATM money actually comes out...

This also explains why all interbank lending rates from LIBOR and EURIBOR to HIBOR all did moonshots. You see, there were few banks capable of lending in any size, and even fewer willing.
2008 FINANCIAL CRISIS

Total Borrowings of Depository Institutions from the Federal Reserve (BORROW)
Source: Board of Governors of the Federal Reserve System

Shaded areas indicate US recessions.
2009 research.stlouisfed.org

March 2009
The Paradox of the 2007-20XX Crisis

(Trillions of US$)

Initial Subprime Losses and Subsequent Declines in World GDP and World Stock Market Capitalization (in Trillions US Dollars)

Estimate of Subprime Losses on Loans and Securities by 10/2007
Estimate of Cumulative World GDP loss
Decline in World Stock Market Capitalization 9/07 to 10/08

Source: IMF Global Financial Stability Report; World Economic Outlook November update and estimates; World Federation of Exchanges.
“fat–tail event” ?
Self-organized criticality

(Bak, Tang, Wiesenfeld, 1987)

Turcotte (1999) Grid = 50 x 50

Best fit line
slope = -1.03
\log(N) = -1.03 \log(A) + 2.99

Earthquakes Cannot Be Predicted
Robert J. Geller, David D. Jackson, Yan Y. Kagan, Francesco Mulargia
Science 275, 1616-1617 (1997)
Heavy tails in pdf of earthquakes

Harvard catalog

Heavy tails in pdf of seismic rates

SCEC, 1985-2003, m\geq2, grid of 5x5 km, time step=1 day

Heavy tails in pdf of rock falls, Landslides, mountain collapses

(CNES, France)
Heavy tails in pdf of forest fires


Heavy tails in pdf of Solar flares

(Newman, 2005)

Heavy tails in pdf of Hurricane losses

Damage values for top 30 damaging hurricanes normalized to 1995 dollars by inflation, personal property increases and coastal county population change

\[ Y = M_0 X^{M_1} \]

\[
\begin{array}{l}
M_0 = 57911 \\
M_1 = -0.80871 \\
R = 0.97899
\end{array}
\]

Heavy tails in pdf of rain events

Peters et al. (2002)
City sizes (Zipf’s law)

Firm sizes (Zipf’s law)

Heavy-tail of movie sales

Heavy-tail of price financial returns

Fig. 2. Tail cumulative distribution function of U.S. firm sizes, by receipts in dollars. Data are for 1997 from the U.S. Census Bureau, tabulated in bins whose width increases in powers of 10. The solid line is the OLS regression line through the data and has slope of 0.994 (SE = 0.064; adjusted $R^2 = 0.976$).
Heavy-tail of pdf of book sales

Survivor Cdf

Sales per day

Heavy-tail of pdf of health care costs

Rupper et al. (2002)

Slope = -1.62

Estimated annual charges (dollars)

Heavy-tail of pdf of terrorist intensity

Johnson et al. (2006)

Heavy-tail of pdf of war sizes

Levy (1983); Turcotte (1999)
Heavy-tail of cdf of cyber risks

ID Thefts

Heavy-tail of YouTube view counts

Software vulnerabilities

Number

Waiting time

After-tax present value in millions of 1990 dollars

Heavy-tail of Pharmaceutical sales

1980-84 pharmaceuticals in groups of deciles
Black Swan story

• Unknown unknowable event
  ★ cannot be diagnosed in advance, cannot be quantified, no predictability

• No responsability (wrath of “God”)

• One unique strategy: long put and insurance
Causes of the 2007-XXXX crisis?

- Real-estate loans and MBS as fraction of bank assets
- Managers greed and poor corporate governance problem
- Deregulation and lack of oversight
- Bad quantitative risk models in banks (Basel II)
- Lowering of lending standards
- Securitization of finance
- Leverage
- Rating agency failures
- Under-estimating aggregate risks
- Growth of over-capacity

+ facilitating factors (Freddy Mac and Fanny Mae, social politics ...
Dragons and PREDICTION
• Most crises are “endogenous”
  ★ can be diagnosed in advance,
  can be quantified, (some) predictability

• Moral hazard, conflict of interest, role of regulations

• Responsibility, accountability

• Strategic vs tactical time-dependent strategy

• Weak versus global signals

http://www.businessweek.com/the_thread/economicsunbound/archives/2009/03/a_bad_decade_fo.html
Dragon-king story

Dragon-king-outlier drawdowns

→ Require new different mechanism

→ Follow excesses ("bubbles")

→ Bubbles are collective endogenous excesses fueled by positive feedbacks

→ Most crises are "endogenous"

→ Possible diagnostic and predictions via "coarse-grained" metrics (forest versus trees)
Beyond power laws: 7 examples of “Dragons”


Population geography: Paris as the dragon-king in the Zipf distribution of French city sizes.

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Hydrodynamics: Extreme dragon events in the pdf of turbulent velocity fluctuations.

Metastable states in random media: Self-organized critical random directed polymers

Brain medicine: Epileptic seizures

Geophysics: Gutenberg-Richter law and characteristic earthquakes.
Crashes as “Black swans”? 

Traditional emphasis on Daily returns do not reveal any anomalous events

“Black swans”
Better risk measure: drawdowns
“Dragons” of financial risks

A. Johansen and D. Sornette, Stock market crashes are outliers, European Physical Journal B 1, 141-143 (1998)


\[ N(DD) = A \exp\left(-\left(\frac{|DD|}{\chi}\right)^\zeta\right) \]
“Dragons” of financial risks

(Require special mechanism and may be more predictable)

<table>
<thead>
<tr>
<th>Cut-off $u$</th>
<th>Quantile</th>
<th>$z$</th>
<th>$\ln(L_0)$</th>
<th>$\ln(L_1)$</th>
<th>$T$</th>
<th>Proba</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>87%</td>
<td>0.916, 0.940</td>
<td>4890.36</td>
<td>4891.16</td>
<td>1.6</td>
<td>20.5%</td>
</tr>
<tr>
<td>6%</td>
<td>97%</td>
<td>0.875, 0.915</td>
<td>4944.36</td>
<td>4947.06</td>
<td>5.4</td>
<td>2.0%</td>
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<tr>
<td>9%</td>
<td>99.0%</td>
<td>0.869, 0.918</td>
<td>4900.75</td>
<td>4903.66</td>
<td>5.8</td>
<td>1.6%</td>
</tr>
<tr>
<td>12%</td>
<td>99.7%</td>
<td>0.851, 0.904</td>
<td>4872.47</td>
<td>4877.46</td>
<td>10.0</td>
<td>0.16%</td>
</tr>
<tr>
<td>15%</td>
<td>99.7%</td>
<td>0.843, 0.898</td>
<td>4854.97</td>
<td>4860.77</td>
<td>11.6</td>
<td>0.07%</td>
</tr>
<tr>
<td>18%</td>
<td>99.9%</td>
<td>0.836, 0.890</td>
<td>4845.16</td>
<td>4851.94</td>
<td>13.6</td>
<td>0.02%</td>
</tr>
</tbody>
</table>
10% daily drop on Nasdaq: 1/1000 probability

1 in 1000 days => 1 day in 4 years

30% drop in three consecutive days?

\[(1/1000) \times (1/1000) \times (1/1000) = (1/1000000000)\]

=> one event in 4 millions years!
**Positive feedbacks**

**The Law of Supply & Demand in Utilitarian Economics**

- Consumers (Supply) - Producers (Demand)

**Herding Impulse in Finance**

- Issuers (Supply) - Investors (Demand)

\[
\frac{dp}{dt} = cp^d
\]

\[
p(t) = \left( \frac{c}{m} \right)^{-m} (t_c - t)^{-m}
\]

\[
m = 1/(d - 1) > 0 \text{ and } t_c = t_0 + m p_0^{1-d}/c.
\]

**Bubble preparing a crisis:**
**Faster than exponential transient unsustainable growth of price**
Mechanisms for positive feedbacks in the stock market

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

• Behavioral mechanisms:
  1. Breakdown of “psychological Galilean invariance”
  2. Imitation (many persons)
     a) It is rational to imitate
     b) It is the highest cognitive task to imitate
     c) We mostly learn by imitation
     d) The concept of “CONVENTION” (Orléan)
Imitation

- Imitation is considered an efficient mechanism of social learning.

- Experiments in developmental psychology suggest that infants use imitation to get to know persons, possibly applying a ‘like-me’ test (‘persons which I can imitate and which imitate me’).

- Imitation is among the most complex forms of learning. It is found in highly socially living species which show, from a human observer point of view, ‘intelligent’ behavior and signs for the evolution of traditions and culture (humans and chimpanzees, whales and dolphins, parrots).

- In non-natural agents as robots, tool for easing the programming of complex tasks or endowing groups of robots with the ability to share skills without the intervention of a programmer. Imitation plays an important role in the more general context of interaction and collaboration between software agents and human users.
A mutual fund manager is more likely to buy (or sell) a particular stock in any quarter if other managers in the same city are buying (or selling) that same stock. This pattern shows up even when the fund manager and the stock in question are located far apart, so it is distinct from anything having to do with local preference. The evidence can be interpreted in terms of an epidemic model in which investors spread information about stocks to one another by word of mouth.

A fundamental observation about human society is that people who communicate regularly with one another think similarly. There is at any place and in any time a Zeitgeist, a spirit of the times.... Word-of-mouth transmission of ideas appears to be an important contributor to day-to-day or hour-to-hour stock market fluctuations. (pp. 148, 155) Shiller (2000)
Finite-time Singularity

as a result of positive feedbacks

- Planet formation in solar system by run-away accretion of planetesimals
- PDE’s: Euler equations of inviscid fluids and relationship with turbulence
- PDE’s of General Relativity coupled to a mass field leading to the formation of black holes
- Zakharov equation of beam-driven Langmuir turbulence in plasma
- Rupture and material failure
- Earthquakes (ex: slip-velocity Ruina-Dieterich friction law and accelerated creep)
- Models of micro-organisms chemotaxis, aggregating to form fruiting bodies
- Surface instability spikes (Mullins-Sekerka), jets from a singular surface, fluid drop snap-off
- Euler’s disk (rotating coin)
- Stock market crashes...
Beyond power laws: 7 examples of “Dragons”


**Population geography**: Paris as the dragon-king in the Zipf distribution of French city sizes.

Material science: failure and rupture processes.

Hydrodynamics: Extreme dragon events in the pdf of turbulent velocity fluctuations.

Metastable states in random media: Self-organized critical random directed polymers

**Brain medicine**: Epileptic seizures

Geophysics: Gutenberg-Richter law and characteristic earthquakes.
Paris as a king-dragon

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

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Pine Resin (Homogeneous)

Trachyte (Nearly Homogeneous)

Granite (Heterogeneous)

Pumice (Extremely Heterogeneous)

Applied stress in kg/cm³

Fig. 4. Frequency of elastic shocks under increasing stresses in materials with different heterogeneity. From Mogi [1962]
Energy distribution for the [+62] specimen #4 at different times, for 5 time windows with 3400 events each. The average time (in seconds) of events in each window is given in the caption.

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Geophysics: Gutenberg-Richter law and characteristic earthquakes.
Mathematical Geophysics Conference  Extreme Earth Events
Villefranche-sur-Mer, 18-23 June 2000
Fig. 3.2. Apparent probability distribution function of the square of the fluid velocity, normalized to its time average, in the eleventh shell of the toy model of hydrodynamic turbulence discussed in the text. The vertical axis is in logarithmic scale such that the straight line, which helps the eye, qualifies as an apparent exponential distribution. Note the appearance of extremely sparse and large bursts of velocities at the extreme right above the extrapolation of the straight line. Reproduced from [252].
Pdf of the square of the Velocity as in the previous figure but for a much longer time series, so that the tail of the distributions for large fluctuations is much better constrained. The hypothesis that there are no outliers is tested here by collapsing the distributions for the three shown layers. While this is a success for small fluctuations, the tails of the distributions for large events are very different, indicating that extreme fluctuations belong to a different class of their own and hence are outliers.

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Metastable states in random media

Self-organized critical random directed polymers

Fig. 1. Typical set of optimal configurations for a RDP of length $W=4096$ and for $0 \leq y \leq 1200$: (a) global system [gray framed boxes outline regions of succeeding plots such that the horizontal and vertical extensions of these boxes follow Eqs. (10) and (8) with $\alpha \approx 0.9$], (b) magnification of the largest box in (a), (c) magnification of the largest box in (b) and (d) magnification of the box in (c). Note, that at each grid point of the lattice we assign an independent random number drawn from an exponential distribution with unit mean and variance.

Definition of “avalanches”

FIG. 2. Schematic representation of optimal RDPs fixed at their two end points. An avalanche is defined by the area $S$ spanned by the transition from the optimal configuration at $y$ to $y+1$, i.e., $S$ is the area interior to the perimeter formed by the union of the two optimal RDP configurations at $y$ and $y+1$ and the two vertical segments $((0,y);(0,y+1))$ and $((W,y);(W,y+1))$. The successive avalanches are represented in different gray scales.
$P(S)dS \propto \frac{W^{2/3}}{\sigma^{1+\mu}}dS$,
$\mu = 2/5$.

+ characteristic avalanche scale

**FIG. 3.** Distribution $P(S)$ of RDP avalanche sizes obtained numerically for system widths from $W=8$ to 512 on a log-log plot. Here the system lengths $L$ are $2 \times 10^7$ (for $W=8$), $3 \times 10^6$ ($W=16$), $2 \times 10^7$ ($W=32$), $10^8$ ($W=64$), $2 \times 10^8$ ($W=128$), $5 \times 10^7$ ($W=256$), and $9 \times 10^6$ ($W=512$).

**FIG. 4.** $P(S)$ as a function of the rescaled variable $S/W^{5/3}$ for $W=8–512$ on a log-log plot.
Two characteristic scales and their scaling laws

Fig. 7. Estimated $W$ dependence of the three characteristic avalanche sizes, $S_{up}$, the upper limit for which $P(S)$ seems well approximated by a power law, is judged from Fig. 4 to have high and low values marked by $\nabla$ and $\triangle$, respectively (values taken at the midpoint of the triangle’s horizontal side). $S_{bump}$ ($\square$) tracks the location of the bump of $P(S)$ and is here chosen as the position of the inflection point of the different distributions displayed in Fig. 3. $S_{tail}$, (●) represents the lower limit of the linear domain of the curves in Fig. 6. The solid line (proportional to $W^{5/3}$) and the dashed line (proportional to $W^{4/3}$) are included as guides.

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**Brain medicine**: Epileptic seizures

Geophysics: Gutenberg-Richter law and characteristic earthquakes.
Epileptic Seizures – Quakes of the Brain?

with Ivan Osorio – KUMC & FHS
Mark G. Frei - FHS
John Milton -The Claremont Colleges

(arxiv.org/abs/0712.3929)
Bursts and Seizures

- awake, relaxed, eyes open
- awake, relaxed, eyes closed
- sleep (stage 2)
- seizure
Gutenberg-Richter distribution of energies

![Gutenberg-Richter distribution of energies](image)

- SCSN '84–'00: Seismic Moment PDF
- Human Seizures: Total Energy PDF
- Slope: $\beta + 1 = 1.67$
Pdf of inter-event waiting times

Inter-Quake Interval (s) for $M \geq 3, L=0.25^\circ$
Gutenberg-Richter distribution of sizes

Omori law: Direct and Inverse

The longer it has been since the last event, the longer it will be since the next one!
19 rats treated intravenously (2) with the convulsant 3-mercapto-propionic acid (3-MPA)
SYNCHRONISATION AND COLLECTIVE EFFECTS IN EXTENDED STOCHASTIC SYSTEMS

Earthquake-fault model

FIG. 1. Evolution of the cumulative earthquake slip, represented along the vertical axis in the white to black color code shown above the picture, at two different times: (a) early time and (b) long time, in a system of size $L = 90$ by $L = 90$, where $\Delta \sigma = 1.9$ and $\beta = 0.1$.

(Prof. R.E. Amritkar)
Interaction (coupling) strength

Heterogeneity; level of compartmentalization

Coexistence of SOC and Synchronized behavior

SYNCHRONIZATION
EXTREME RISKS

SELF-ORGANIZED CRITICALITY

INCOHERENT
Landau-Ginzburg Theory of Self-Organized Criticality and of Dragon-kings!

Dynamics of an order parameter (OP) and of the corresponding *control* parameter (CP): within the sandpile picture, $\frac{\partial h}{\partial x}$ is the slope of the sandpile, $h$ being the local height, and $S$ is the state variable distinguishing between static grains ($S = 0$) and rolling grains ($S \neq 0$).

**Normal form of sub-critical bifurcation**

$$\frac{\partial S}{\partial t} = \chi \{ \mu S + 2\beta S^3 - S^5 \} \quad (1)$$

where

$$\mu = \left[ \left( \frac{\partial h}{\partial x} \right)^2 - \left( \frac{\partial h}{\partial x} \big|_c \right)^2 \right] \quad (2)$$

and $\beta > 0$ (subcritical condition).

**Diffusion equation**

$$\frac{\partial h}{\partial t} = -\frac{\partial F(S, \frac{\partial h}{\partial x})}{\partial x} + \Phi \quad (3)$$

L. Gil and D. Sornette
Mechanism:
Negative effective Diffusion coefficient

\[ n = 0.01 \]

\[ \frac{\chi}{\alpha} = 100 \]

\[ \frac{\chi}{\alpha} = 0.1 \]

\[ \mu = 1.0 \pm 0.1 \]

System sizes range from \( L/a = 64 \) to 2048.

\[ P(M)\,dM \approx M^{-(1+\mu)}\,dM. \]
FIG. 3. Distribution $P(J)$ of flux amplitudes at the right border, in the same conditions as for Fig. 1.
Interaction (coupling) strength

Heterogeneity; level of compartmentalization

SYNCHRONIZATION
EXTREME RISKS

SELF-ORGANIZED CRITICALITY

INCOHERENT

Coexistence of SOC and Synchronized behavior

Generic diagram for coupled threshold oscillators of relaxation
Low dose of convulsant in rats (like most humans)

Distribution of inter-seizure time intervals for rat 5, demonstrating a pure power law, which is characteristic of the SOC state. This scale-free distribution should be contrasted with the pdf’s obtained for the other rats, which are marked by a strong shoulder associated with a characteristic time scale, which reveals the periodic regime.
Interaction (coupling) strength

Heterogeneity; level of compartmentalization

Generic diagram for coupled threshold oscillators of relaxation

Coexistence of SOC and Synchronized behavior

Incoherent

Self-Organized Criticality

Synchronization

Extreme Risks

Heterogeneity; level of compartmentalization

Generic diagram for coupled threshold oscillators of relaxation
Interaction (coupling) strength

Synchronization

Extreme Risks

Self-Organized Criticality

Incoherent

Coexistence of SOC and Synchronized behavior

Heterogeneity; level of compartmentalization

Generic diagram for coupled threshold oscillators of relaxation
The pdf’s of the seizure energies and of the inter-seizure waiting times for subject 21.

Note the shoulder in each distribution, demonstrating the presence of a characteristic size and time scale, qualifying the periodic regime.
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Complex magnitude distributions

Characteristic earthquakes?

Singh, et. al., 1983, BSSA 73, 1779-1796

Knopoff, 2000, PNAS 97, 11880-11884

Main, 1995, BSSA 85, 1299-1308

Wesnousky, 1996, BSSA 86, 286-291
Predictability of catastrophic events: Material rupture, earthquakes, turbulence, financial crashes, and human birth

D. Sornette
Simplest Example of a “More is Different” Transition

Water level vs. temperature

BOILING PHASE TRANSITION

More is different: a single molecule does not boil at 100°C

Extrapolation?
The breaking of macroscopic linear extrapolation
Interaction (coupling) strength

Coexistence of SOC and Synchronized behavior

SYNCHRONIZATION

EXTREME RISKS

SELF-ORGANIZED CRITICALITY

INCOHERENT

Heterogeneity
Who initiates parturition?

You said how many weeks?

It’s about time

Figure 47-6. Changes in plasma levels of pregnancy hormones.
Generic Critical Precursors to a Bifurcation

Braxton hicks contractions

(Simple example of Catastrophe theory)

-Amplitude of fluctuations
-Response to external forcing

D. Sornette, F. Ferre and E. Papiernik
Mathematical model of human gestation and parturition: implications for early diagnostic of prematurity and post-maturity
Critical Precursory Fluctuations

\[
\frac{dA}{dt} = (\mu - \mu_c)A - \frac{A^3}{A_s^2} + f(t)
\]

Without NL term:

\[
A(t) = \int_0^t e^{-\delta(t-\tau)} f(\tau) \, d\tau
\]

\[
\delta = \mu_c - \mu
\]

\[
\langle [A(t)]^2 \rangle = \int_0^t d\tau \int_0^t d\tau' \, e^{-\delta(t-\tau)} e^{-\delta(t-\tau')} \langle f(\tau) f(\tau') \rangle
\]

\[
= D \int_0^t e^{-2\delta(t-\tau)} \, d\tau \quad \rightarrow \quad \frac{D}{2(\mu_c - \mu)}
\]
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.

J.-C. Anifrani, C. Le Floc'h, D. Sornette and B. Souillard
Various Bubbles and Crashes

Each bubble has been rescaled vertically and translated to end at the time of the crash.
A Consistent Model of ‘Explosive’ Financial Bubbles With Mean-Reversing Residuals

\[
\frac{dI}{I} = \left[ r + \rho \Sigma + \kappa h(t) \right] dt - \alpha \rho_Y Y dt + (\sigma_Y + \sigma_W) dW
\]
1. Systematic qualification of “dragon-kings” in pdfs of drawdowns

2. Existence or absence of a “critical” behavior by LPPL patterns found systematically in the price trajectories preceding this outliers

Results: In worldwide stock markets + currencies + bonds

• 21 endogenous crashes
• 10 exogenous crashes

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.
Predictability of the 2007-XXXX crisis:
15y History of bubbles and Dragon-kings

- Real-estate bubbles (2003-2006)
- Commodities and Oil bubbles (2006-2008)

Didier Sornette and Ryan Woodard
(http://arxiv.org/abs/0905.0220)
The Internet stock index and non-Internet stock index the Nasdaq composite which are equally weighted.


The two indexes are scaled to be 100 on 1/2/1998.
Fig. 1. (Color online) Plot of the UK Halifax house price indices from 1993 to April 2005 (the latest available quote at the time of writing). The two groups of vertical lines correspond to the two predicted turning points reported in Tables 2 and 3 of [1]: end of 2003 and mid-2004. The former (resp. later) was based on the use of formula (2) (resp. (3)). These predictions were performed in February 2003.

Fig. 5. (Color online) Quarterly average HPI in the 21 states and in the District of Columbia (DC) exhibiting a clear upward faster-than-exponential growth. For better representation, we have normalized the house price indices for the second quarter of 1992 to 100 in all 22 cases. The corresponding states are given in the legend.
bubble peaking in Oct. 2007

Source: DS + R. Woodard (FCO, ETH Zurich)
CORN

GOLD

SOYBEAN

WHEAT

R.Woodard and D.Sornette (2008)
Typical result of the calibration of the simple LPPL model to the oil price in US$ in shrinking windows with starting dates $t_{\text{start}}$ moving up towards the common last date $t_{\text{last}} = \text{May 27, 2008}$.

PCA first component on a data set containing, emerging markets equity indices, freight indices, soft commodities, base and precious metals, energy, currencies...

(Peter Cauwels  FORTIS BANK - Global Markets)
The illusionary "PERPETUAL MONEY MACHINE"

Source: J.P. Morgan, Bloomberg, Oct 20 2008
Securitization of non-financial assets (commodities, real-estate, credit)

Subprime financial crisis

US housing boom

Expectation on rising price

Individual borrower

Commercial bank
Wall Street lender

Mortgage lender

Structured investment Vehicles (SIVs)

Hedge funds, pension funds and other financial institutions

Mortgage-backed securities, CDOs

Financing counterpart
THE GREAT MODERATION

Source: SIR JOHN GIEVE, Deputy Governor, Bank of England, Feb 2009

Notes: Shaded bars indicate recessions. The dashed red line indicates the onset of the current recession. Volatility is computed using deviations of the GDP growth rate from a constant mean and a GARCH (1,1) with a 0.729 first-order serial correlation. Sources: Bureau of Economic Analysis; authors’ calculations.

Separation of financial and credit risks

Securitization leads to larger inter-connectivity

Coupling strength increases
Securitization leads to larger inter-connectivity

Separation of financial and credit risks

Coupling strength increases
In summary

Each excess is partially “solved” by the subsequent excess... leading to a succession of
  - uns sustainable wealth growth
  - instabilities

The present crisis+recession is the consolidation after this series of unsustainable excesses.

One could conclude that the extraordinary severity of this crisis is not going to be solved by the same of implicit or explicit “bubble thinking”.

"The problems that we have created cannot be solved at the level of thinking that created them." Albert Einstein
Absence of fundamental change

-March-August 09 equities rally esp. based on financials that have reported excellent Q1 figures based on trading (root of the actual problem), there is a lot to be told about that...

- financial institutions accounting is more opaque and creative as ever, just look at the recent changes, launched, actually in order to solve the problem (which roots again in creativity of frying air).

- TARP and PPIP are launched in order to artificially pump up asset prices based on leverage and asymmetric upside downside risk taking (investors vs tax payers) - again the roots of the current crisis.

-Debts of private institutions has been transformed into government debts (sustainable?)

TARP: trouble asset release program
PPIP: public-private investment program

August 2009
Financial Crisis Observatory

The Financial Crisis Observatory (FCO) is a scientific platform aimed at testing and quantifying rigorously, in a systematic way and on a large scale the hypothesis that financial markets exhibit a degree of inefficiency and a potential for predictability, especially during regimes when bubbles develop.

Current analysis and forecasts

**CDS** (19 February 2009)
Our analysis has been performed on data kindly provided by Amjed Younis of Fortis on 19 February 2009. It consists of 3 data sets: credit default swaps (CDS); German bond futures prices; and spread evolution of several key euro zone sovereigns. The date range of the data is between 4 January 2006 and 18 February 2009. Our log-periodic power law (LPPL) analysis shows that credit default swaps appear bubbly, with a projected crash window of March-May, depending on the index used. German bond futures and European sovereign spreads do not appear bubbly. (See report for more information.)

**OIL** (27 May 2008)
Oil prices exhibited a record rise followed by a spectacular crash in 2008. The peak of $145.29 per barrel was set on 3 July 2008 and a recent low of $40.81 was reached on 5 December, a level
**The Financial Bubble Experiment**
advanced diagnostics and forecasts of bubble terminations

- **Hypothesis H1**: financial (and other) bubbles can be diagnosed in real-time before they end.

- **Hypothesis H2**: The termination of financial (and other) bubbles can be bracketed using probabilistic forecasts, with a reliability better than chance (which remains to be quantified).
The Financial Bubble Experiment:
advanced diagnostics and forecasts of bubble terminations

The Financial Crisis Observatory*
Department of Management, Technology and Economics,
ETH Zurich, Kreuzplatz 5, CH-8032 Zurich, Switzerland
(Dated: November 2, 2009)

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**TABLE I:** Checksums of Financial Bubble Experiment forecast documents.

Forecasting financial crashes: the ultimate experiment begins

If a new technique for predicting crashes really works, a bold new experiment will measure how well.

Is it really possible to predict the end of financial bubbles? Didier Sornette at the Swiss Federal Institute of Technology in Zurich thinks so and has set up the Financial Crisis Observatory at ETH to study the idea.

We've looked at his extraordinary predictions before. Earlier this year, he identified a bubble in the Shanghai Composite Index and much to this blog's surprise, forecast its end with remarkable accuracy.
Credit default swap
18 Feb 2009 to 18 June 09

- t1_min: 2006-01-04
- t2_min: 2009-01-28
- t2_max: 2009-02-18
- Peak date: 2008-12-05
- 20/80 q: 2009-04-05/2009-05-21
- Num. fits: 40
- New peak date: 2009-03-09

Observations
New observations
The Chinese Equity Bubble: Ready to Burst
K. Bastiaensen, P. Cauwels, D. Sornette, R. Woodard and W.-X. Zhou

Figure 1: Shanghai Composite Index with LPPL result.
Successful forecast of end of Chinese Shanghai index bubble

SSE Composite Index, Shanghai (SSEC, 000001.SS)


The Chinese Equity Bubble: Ready to Burst,
Merrill Lynch index on Corporates non financials (10 sept 09)

90% confidence: tc < 24 October 2009
60% confidence: tc < 30 September 2009
• a defense of trans-disciplinarity

• out-of-equilibrium view of the world (economics, geosciences, biology...)

• extreme events are the rule rather than the exception. Their study reveal important new mechanisms.

• the question of prediction
Final remarks

1-All proposals will fail if we do not have better science and better metrics to monitor and diagnose (ex: biology, medicine, astronomy, chemistry, physics, evolution, and so on)

2-Leverage as a system variable versus the illusion of control by monetary policy, risk management, and all that

3-Need to make endogenous policy makers and regulators (“creationist” view of government role, illusion of control and law of unintended consequences of regulations)

4-Fundamental interplay between system instability and growth; the positive side of (some) bubbles

5-Time to reassess goals (growth vs sustainability vs happiness). In the end, endogenous co-evolution of culture, society and economy

KEY CHALLENGE: genuine trans-disciplinarity by TRAINING in 2-3 disciplines + CHANGE OF CULTURE
A Complex System View on the Financial and Economic Crisis

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

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M. Fedorovsky (ETH Zurich)
S. Reimann (ETH Zurich)
Critical Phenomena in Natural Sciences

Chaos, Fractals, Selforganization and Disorder: Concepts and Tools

First edition
2000

Second enlarged edition
2004 and 2006

Extreme Financial Risks
From Dependence to Risk Management

Nov 2005
Theory of Zipf’s Law and Beyond

Yannick Malevergne
Alex Saichev
Didier Sornette

2009
Why Stock Markets Crash: Critical Events in Complex Financial Systems
by Didier Sornette - Business & Economics - 2003 - 421 pages
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by B. Dubrulle, F. Graner, D. Sornette - Scaling laws (Statistical physics) - 1997
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