Putting financial and economic crises in context: a brief history of instabilities in financial and global markets

Dragon-kings versus black swans

Mechanism(s) at the origin of financial crises

Precursors and predictability of financial instabilities

Applications to the 5 successive bubbles leading to the 2007-2009 global crisis; CDS swap bubbles, Shanghai SSE composite bubble, ...

Investment opportunities, (strategic + tactical) time varying risks
Cries frequently emanate from the financial centers with transmission through interest rate shocks and commodity price collapses. Thus, the recent US sub-prime financial crisis is hardly unique.

Sovereign External Debt: 1800-2006
Percent of Countries in Default or Restructuring
Sources: Bordo et al. (2001), Caprio et al. (2005), Kaminsky and Reinhart (1999), Obstfeld and Taylor (2004), and Carmen M. Reinhart and Kenneth S. Rogoff,
Increase in Public Debt in the 3 years following a banking crisis (inflation adjusted)

The IMF estimates that the cost of the current crisis to the United States will eventually reach 34% of GDP or close to $5 trillion. However, the Obama administration, through its various implicit and explicit guarantees, is already using a number close to $9 trillion. And Reinhart and Rogoff's historical average of 86% of GDP implies an ultimate cost of over $12 trillion.

The subsequent rise in government debt which, according to Reinhart and Rogoff, has been "... a defining characteristic of the aftermath of banking crises for over a century". (Reinhart and Rogoff)
IMF estimate of the cost of the Banking crisis

Total private wealth across the world today is about $37 trillion less the losses incurred in 2007-09, so the real number is probably closer to $30 trillion now.

Total global savings (loosely adjusted for the big losses in 2008) are probably somewhere in the region of $100 trillion.

In other words, financing this crisis could absorb one-third of total global savings.

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**IMF estimate of the cost of the Banking crisis**

<table>
<thead>
<tr>
<th>Country</th>
<th>2008 GDP ($ billion)</th>
<th>Δ Deficit (% of GDP)</th>
<th>Projected Bond Issuance ($ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>$1,069</td>
<td>26%</td>
<td>$278</td>
</tr>
<tr>
<td>Canada</td>
<td>$1,564</td>
<td>14%</td>
<td>$219</td>
</tr>
<tr>
<td>France</td>
<td>$2,978</td>
<td>21%</td>
<td>$625</td>
</tr>
<tr>
<td>Germany</td>
<td>$3,818</td>
<td>14%</td>
<td>$535</td>
</tr>
<tr>
<td>Italy</td>
<td>$2,399</td>
<td>28%</td>
<td>$672</td>
</tr>
<tr>
<td>Japan</td>
<td>$4,844</td>
<td>28%</td>
<td>$1,356</td>
</tr>
<tr>
<td>South Korea</td>
<td>$858</td>
<td>14%</td>
<td>$120</td>
</tr>
<tr>
<td>Mexico</td>
<td>$1,143</td>
<td>6%</td>
<td>$69</td>
</tr>
<tr>
<td>Spain</td>
<td>$1,683</td>
<td>35%</td>
<td>$589</td>
</tr>
<tr>
<td>Turkey</td>
<td>$799</td>
<td>12%</td>
<td>$96</td>
</tr>
<tr>
<td>UK</td>
<td>$2,787</td>
<td>29%</td>
<td>$808</td>
</tr>
<tr>
<td>US</td>
<td>$14,330</td>
<td>34%</td>
<td>$4,872</td>
</tr>
<tr>
<td><strong>Total, G12</strong></td>
<td><strong>$38,272</strong></td>
<td><strong>27%</strong></td>
<td><strong>$10,239</strong></td>
</tr>
</tbody>
</table>

**Δ Deficit (% of GDP)**

- IMF Estimate: 27%
- Rogoff, Best Case: 40%
- Rogoff, Average: 86%

**Projected Bond Issuance ($ billion)**

- IMF Estimate: $10,239
- Rogoff, Best Case: $15,309
- Rogoff, Average: $33,029

*Source: CIA World Fact Book, IMF, Rogoff & Reinhart*
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- Dragon-kings versus black swans
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- Precursors and predictability of financial instabilities
- Applications to the 5 successive bubbles leading to the 2007-2009 global crisis; CDS swap bubbles, Shanghai SSE composite bubble, and so on
- Investment opportunities, (strategic + tactical) time varying risks
Crises are not but “Dragon-kings”
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 2007-20XX 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
• Most crises are “endogenous”
  ★ can be diagnosed in advance, can be quantified, (some) predictability

• Accountability, moral hazard, conflict of interest, regulations

• strategic vs tactical time-dependent strategy

Source: Simon Johnson (May 2009)
Endogenous vs Exogenous Crashes

1. Systematic qualification of outliers/kings in pdfs of drawdowns

2. Theory of positive feedback loops of higher return anticipations competing with negative feedback spirals of crash expectations.

3. Existence of a “critical” behavior by LPPL signatures found systematically in the price trajectories preceding “outliers.”

Results: In worldwide stock markets + currencies + bonds

- 21 endogenous crashes
- 10 exogenous crashes

Hong-Kong

Textbook example of a series of super-exponential acceleration followed by crashes

Arrows show peaks followed by corrections of more than 15% in less than three weeks

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
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)


\[ N(DD) = A \exp (- (|DD|/\chi)^z). \]
"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>
</tr>
<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>

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

Zipf law for city sizes (France)
Beyond power laws: 6 “Dragons-kings”


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.

Brain medicine: Epileptic seizures

Geophysics: Gutenberg-Richter law and characteristic earthquakes.
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Investment opportunities, (strategic + tactical) time varying risks
Dragon-king story

- Most crises are “endogenous”
- Follow excesses (“bubbles”)
What is a bubble?

**Academic Literature:** No consensus on what is a bubble...

Can asset price bubbles be detected? This survey of econometric tests of asset price bubbles shows that, despite recent advances, econometric detection of asset price bubbles cannot be achieved with a satisfactory degree of certainty. For each paper that finds evidence of bubbles, there is another one that fits the data equally well without allowing for a bubble. We are still unable to distinguish bubbles from time-varying or regime-switching fundamentals, while many small sample econometrics problems of bubble tests remain unresolved.

**Professional Literature:** we do not know... only after the crash
“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.”
What is a bubble?

Positive feedbacks

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

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

\[m = 1/(d - 1) > 0 \text{ and } t_c = t_0 + mp_0^{1-d}/c.\]

Our proposition:
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.
Humans Appear Hardwired To Learn By 'Over-Imitation'

*ScienceDaily (Dec. 6, 2007) — Children learn by imitating adults--so much so that they will rethink how an object works if they observe an adult taking unnecessary steps when using that object, according to a new Yale study.*
Universal Bubble and Crash Scenario

Displacement

Credit creation

Euphoria

Critical stage / Financial distress

Revulsion

Charles Kindleberger, Manias, Panics and Crashes (1978)
Crash = result of collective behavior of individual traders

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

95°C 97 99 101

Prof. Dr. Didier Sornette  www.er.ethz.ch  D-MTEC  Chair of Entrepreneurial Risks
Example of “MORE IS DIFFERENT” transition in Finance:

Instead of Water Level: economic index (Dow-Jones etc…)

Crash = result of collective behavior of individual traders

Apparent unpredictability comes from lack of recognition of collective behavior
Various Bubbles and Crashes

Each bubble has been rescaled vertically and translated to end at the time of the crash.
Many bubbles and crashes

- Hong-Kong crashes: 1987, 1994, 1997 and many others
- October 1997 mini-crash
- August 1998
- Slow crash of spring 1962
- Latin-american crashes
- Asian market crashes
- Russian crashes
- Individual companies
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Investment opportunities, (strategic + tactical) time varying risks
Interaction (coupling) strength

Heterogeneity; level of compartmentalization

Coexistence of SOC and Synchronized behavior

Generic predictability diagram

SYNCHRONIZATION EXTREME RISKS

SELF-ORGANIZED CRITICALITY

INCOHERENT
Methodology for predictability of crises

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

Strategy: look at the forest rather than at the tree

Rocket-science application!

J.-C. Anifrani, C. Le Floc’h, D. Sornette and B. Souillard
A Consistent Model of ‘Explosive’ Financial Bubbles With Mean-Reversing Residuals
L. Lin, R. E. Ren and D. Sornette (2009)

\[
\frac{dI}{I} = \left[ r + \rho \Sigma + k h(t) \right] dt - \alpha \rho_Y Y dt + (\sigma_Y + \sigma_W) dW
\]
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Predictability of the 2007-XXXX crisis: 15y History of bubbles and Dragons

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

Didier Sornette and Ryan Woodard
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.

Nasdaq value

Foreign capital inflow in the USA
Growth of Money supply (M1)
No, Greenspan Was Not Right

http://macromarketmusings.blogspot.com/2009/02/no-greenspan-was-not-right.html  (Nick Rowe, 2009)
Comparison of the Federal funds rate, the S&P 500 Index $x(t)$, and the NASDAQ composite $z(t)$, from 1999 to mid-2003.

Cross-correlation coefficient $C(n)$ between the increments of the logarithm of the S&P 500 Index and the increments of the Federal funds rate as a function of time lag $n$ in days. The three curves correspond to three different time steps used to calculate the increments: weekly, monthly and quarterly. A positive lag $n$ corresponds to having the Federal funds rate posterior to the stock market.

Real-estate bubbles

Percentage change in real housing prices 2002–2006

Sources: Shiller; BIS.
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.
Our study in 2005 identifies the bubble states

Local bubbles (Froths) of Housing Markets in US, 1998-2006
One prominent financial figure held the greatest sway in debates about the regulation and use of derivatives — exotic contracts that promised to protect investors from losses, thereby stimulating riskier practices that led to the financial crisis. For more than a decade, the former Federal Reserve Chairman Alan Greenspan has fiercely objected whenever derivatives have come under scrutiny in Congress or on Wall Street. “What we have found over the years in the marketplace is that derivatives have been an extraordinarily useful vehicle to transfer risk from those who shouldn’t be taking it to those who are willing to and are capable of doing so,” Mr. Greenspan told the Senate Banking Committee in 2003. “We think it would be a mistake” to more deeply regulate the contracts, he added.

“Not only have individual financial institutions become less vulnerable to shocks from underlying risk factors, but also the financial system as a whole has become more resilient.” — Alan Greenspan in 2004
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
Separation of financial and credit risks

Securitization leads to larger inter-connectivity

Coupling strength increases
• W. Brock, C. Hommes and F. Wagener (2006) More hedging instruments may destabilize markets (Need for learning to invest optimally increases without bound with market completeness)

• M. Marsili (2008) Spiraling toward complete markets and financial instability (General Equilibrium framework with heterogeneous portfolios with utility maximization: global instability from “soft-modes” associated with global symmetry appearing due to completeness (=replication))

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 $t_{\text{last}} = \text{May 27, 2008}$.

Index price vs. time, S&P 500

bubble peaking in Oct. 2007

Source: R. Woodard (FCO, ETH Zurich)
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)
In summary

Each excess is partially “solved” by the subsequent excess... leading to a succession of
- unsustainable 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
The illusionary “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
Over the past decade and a half, \( (B - F) \) has been closely correlated with realized capital gains on the sale of homes. \( B - F = \text{change in home equity debt outstanding less unscheduled repayment on RMDO} \)

Mortgage Equity Withdrawal impact on GDP

source: John Mauldin (April 09)
Financial investments accounted for >1/3 of corporate profits
• 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.
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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.

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

August 2009
Impact on risk allocation in portfolios and portfolio optimization (II)

- Diagnostic of Dragons
  (out of equities in Dec. 2007)
  Diagnostic of impending crisis is possible

Need to combine
strategic + tactical + time-varying risk analysis
Index price vs. time, Hang Seng

PDF of crash dates, Hang Seng

Source: R. Woodard (FCO, ETH Zurich)
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.
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 crossed on 5 December, a level...
Questions?

- How to measure risks? Illusion of low risks...
- Moral hazard and conflict of interest
- Development of culture of integrity and ethical behavior (informed by behavioral psychology)
- Melting the cash-flow freeze (ex: WIR direct network banking in Switzerland (www.wir.ch))
- Preventing other financial bubbles: a new definition of inflation for macro and monetary policies (Financial Ratio Index (FRI), total fixed assets + working capital, excess supply of money...)
- Regulations: illusion of control and law of unintended consequences
- How to preserve innovations/creativity while mastering instabilities?
Further Reading


