European Economic and Financial Exploratory

Silvano Cincotti (UNIGE), Didier Sornette (ETH Zurich), Philip Treleaven (UCL)

(contributions from Stefano Batiston, Guido Caldarelli, Peter Cauwels, Tobias Preis, Frank Schweitzer and Ryan Woodard)

5 September 2011

European Economic and Financial Exploratory

•Interdisciplinary consortium of economists, natural scientists, computer scientists and engineers

•Academic Public facility is intended for
  ⋆economic modeling,
  ⋆investigating all aspects of risk and stability,
  ⋆improving financial technology, and
  ⋆evaluating proposed regulatory and taxation changes.
  ⋆cradle for training and collaboration with the private sector to spur spin-offs and job creations in Europe in the finance and economic sectors.

•Realistic investigations with real economic, financial and social data

•Creation of a new cross-disciplinary research community of social scientists, complexity scientists and computing (ICT) scientists

(i) Continuous monitoring and evaluation of the status of the economies of countries in their various components,
(ii) use, extend and develop a large variety of methods including data mining, process mining, computational and artificial intelligence and every other computer and complex science techniques coupled with economic theory and econometric,
(iii) will provide the framework and infrastructure to perform what-if analysis, scenario evaluations and computational experiments to inform decision makers and help develop innovative policy, market and regulation designs.

Challenges of economics and finance

- sovereign debt,
- leverage,
- liquidity,
- risks (market, operational, systemic...)
- interconnectedness, network of networks
- stability,
- sentiment,
- trust,
- contagion,
- algorithms behavior,
- impact of regulatory and taxation regimes (endogeneity)

Opportunities and targets

EU Communities: identification and understanding of the generating mechanisms, of the interactions and feedbacks involved in the complex adaptive techno-economic-social systems, with attention to safety, mobility, energy, aging, fragility, resilience, contagious and avalanche effects, environmental compatibleness, sustainable growth, and so on.

EU Society: instruments and services that provide concrete exploitable support to policy makers, policy institutions and regulators, e.g., R&D incentives, fiscal policies, regulatory policies, monetary policy, and so on.

EU Citizens: effective and transparent dissemination of knowledge as well as efficient decision making procedures (electronic channels of citizenship and entrepreneurship, including e-participation, e-consultation, e-legislation, e-petition, e-deliberation)
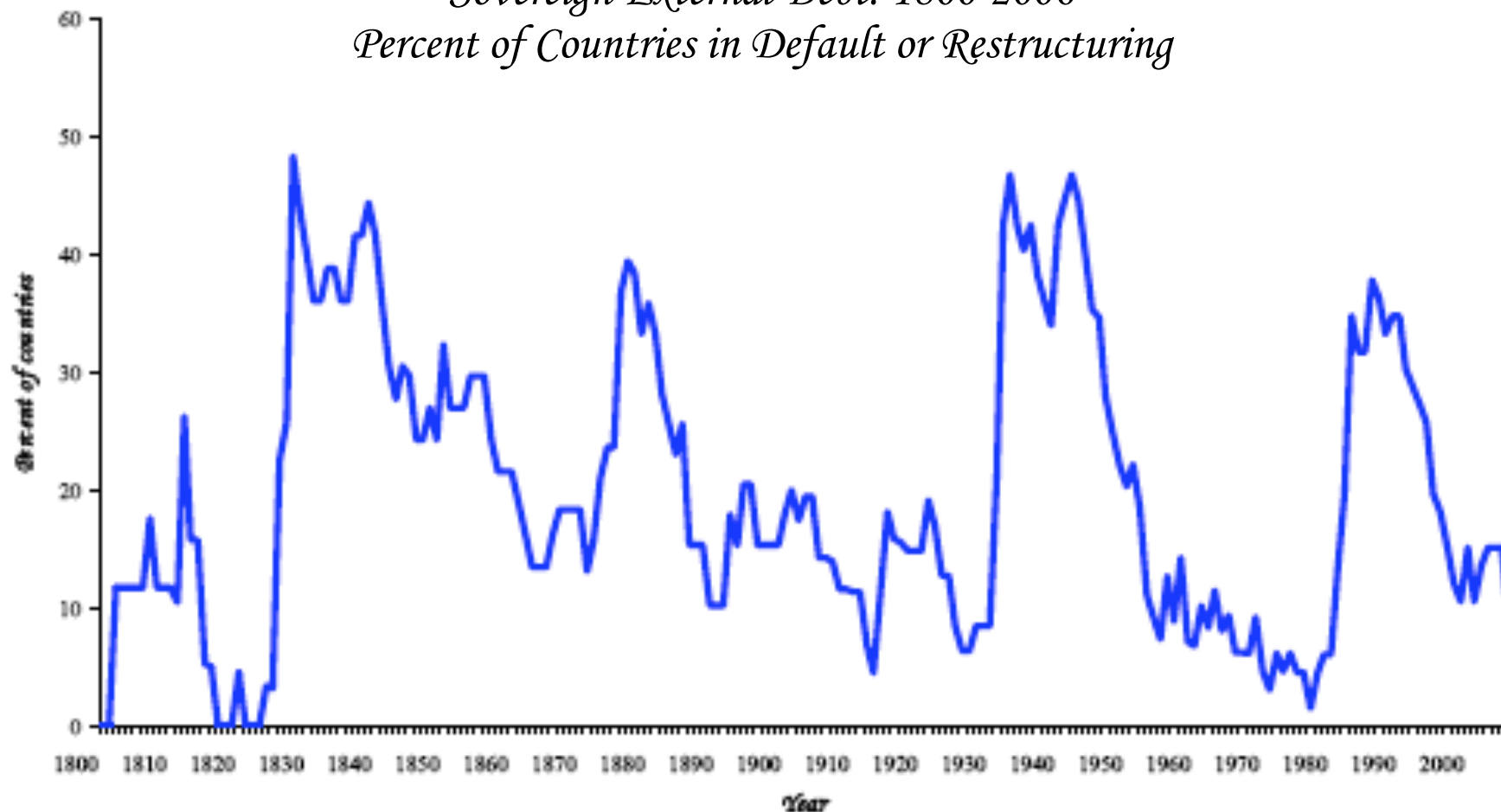
Economic and financial contexts

Liberalization, deregulation and privatization agenda

Global pattern in US, UK, Bretton Woods repeal (1971), China (Deng Xiaoping, 1978=>), India (market-oriented reforms, 1991), Japan enormous double bubble burst in 1991, and so on...
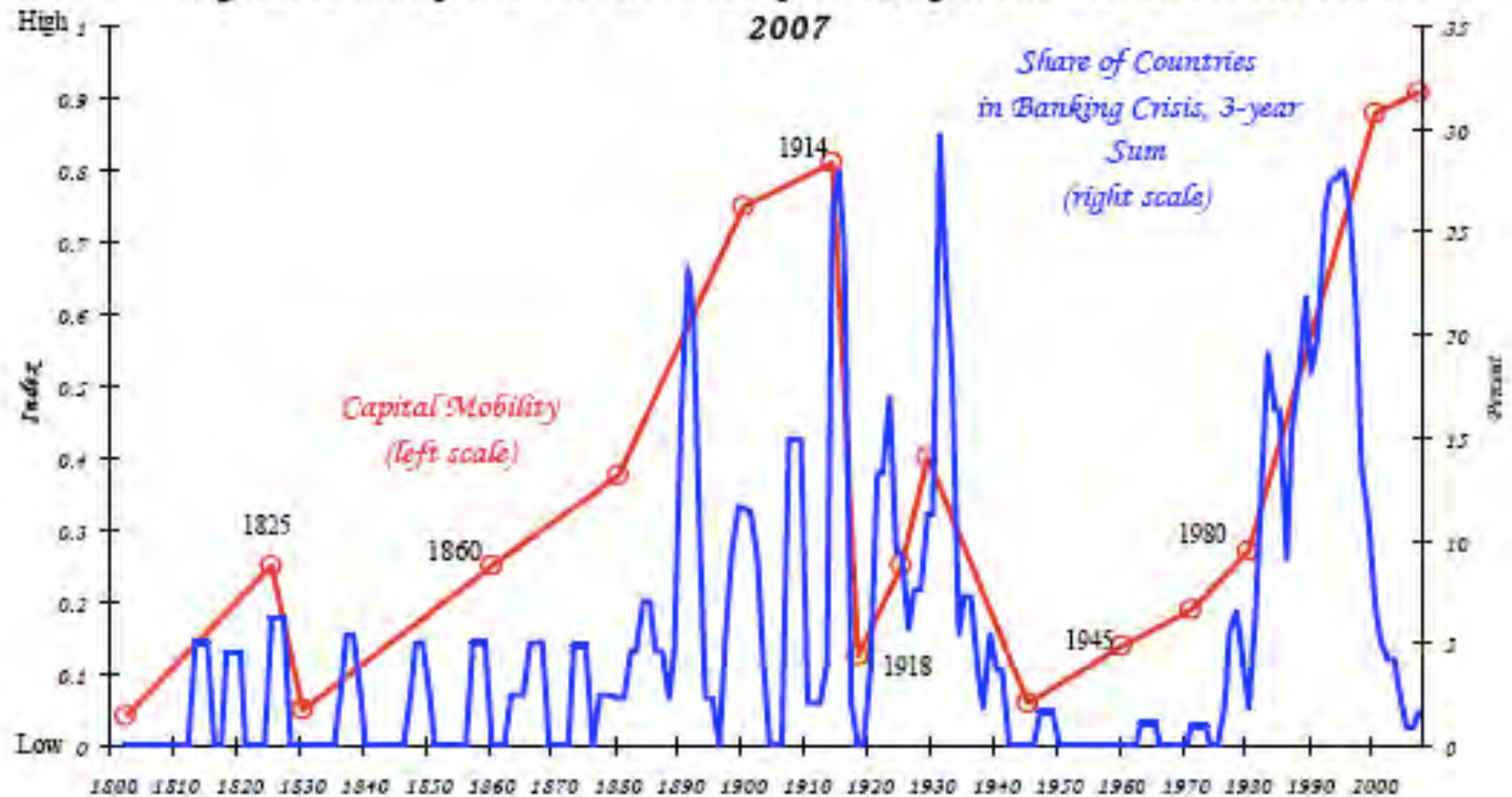
Washington Consensus (promotion of free trade, capital mobility, and financial market deregulation) => South America and Asia.

Crises 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
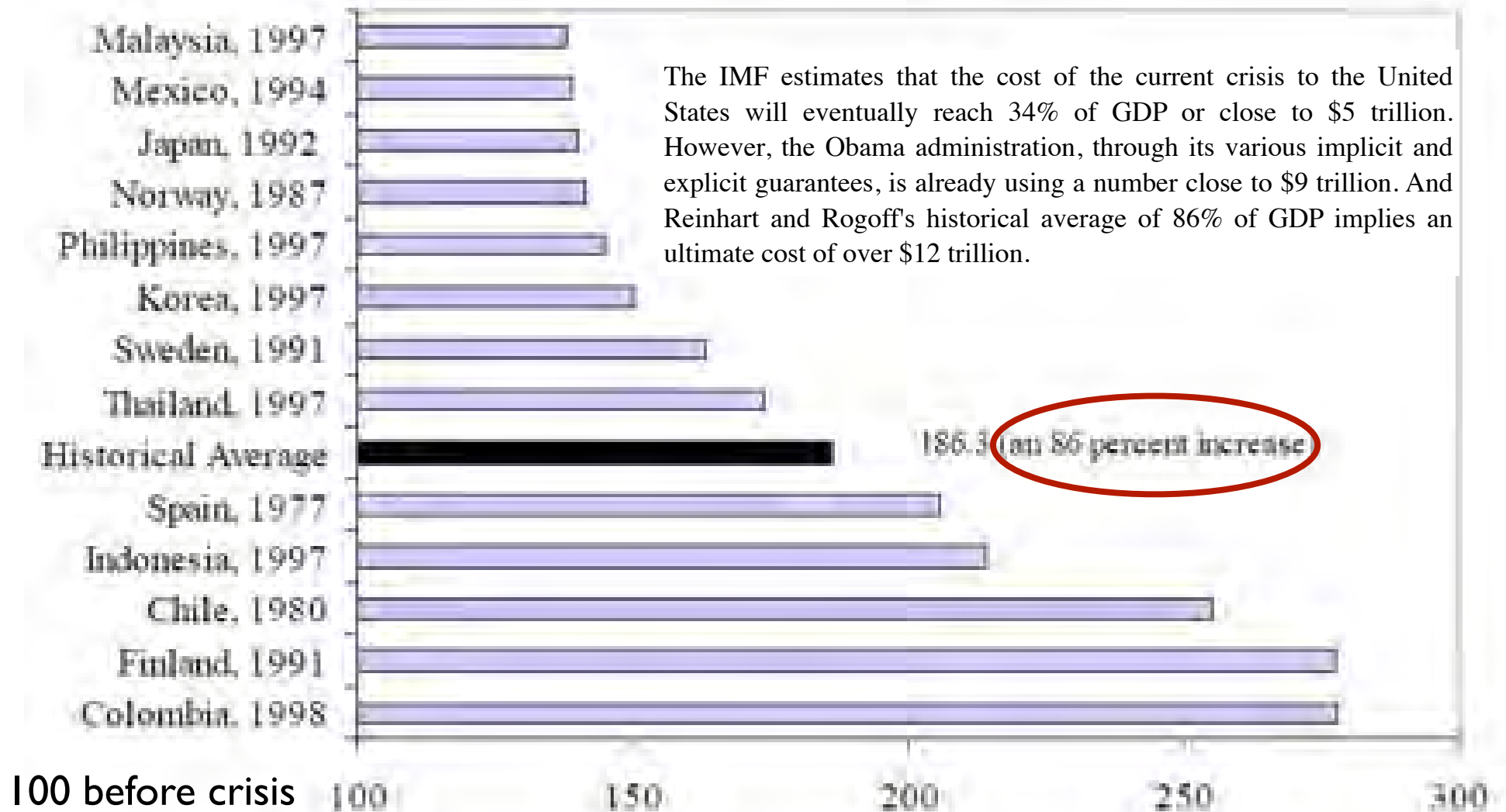*Percent of Countries in Default or Restructuring*

This Time is Different: A Panoramic View of Eight Centuries of Financial Crises
Carmen M. Reinhart and Kenneth S. Rogoff, NBER Working Paper No. 13882, March 2008

Capital Mobility and the Incidence of Banking Crisis: All Countries, 1800-2007

Share of Countries in Banking Crisis, 3-year Sum (right scale)

Capital Mobility (left scale)

1914

1825

1860

1918

1980

1945

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.

186.3 (an 86 percent increase)

100 before crisis

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*".
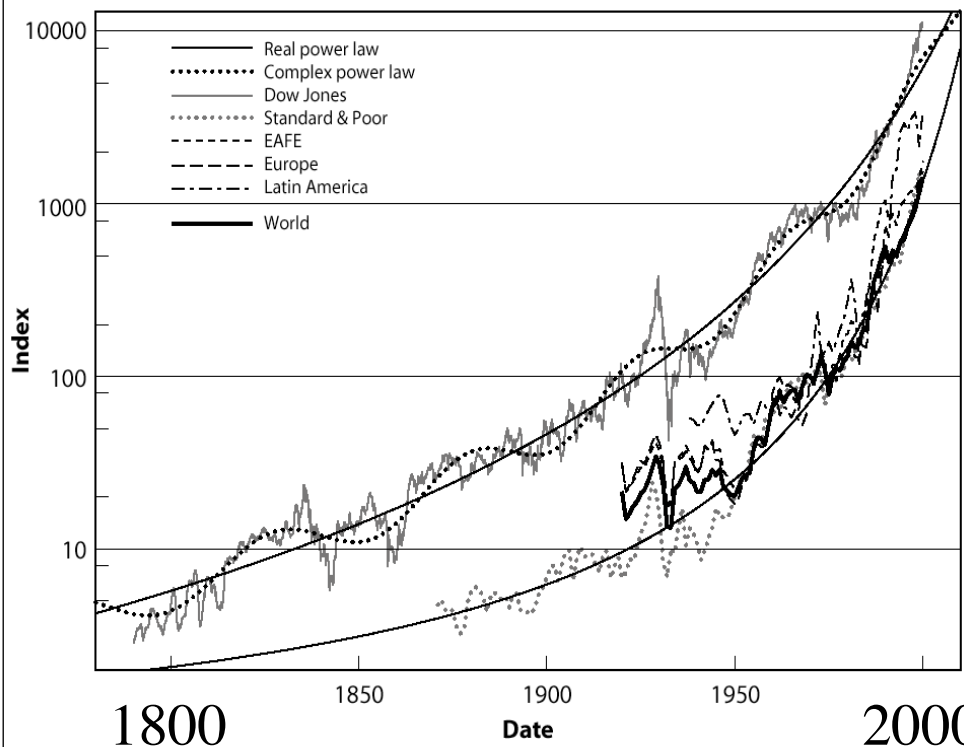
(Reinhart and Rogoff)
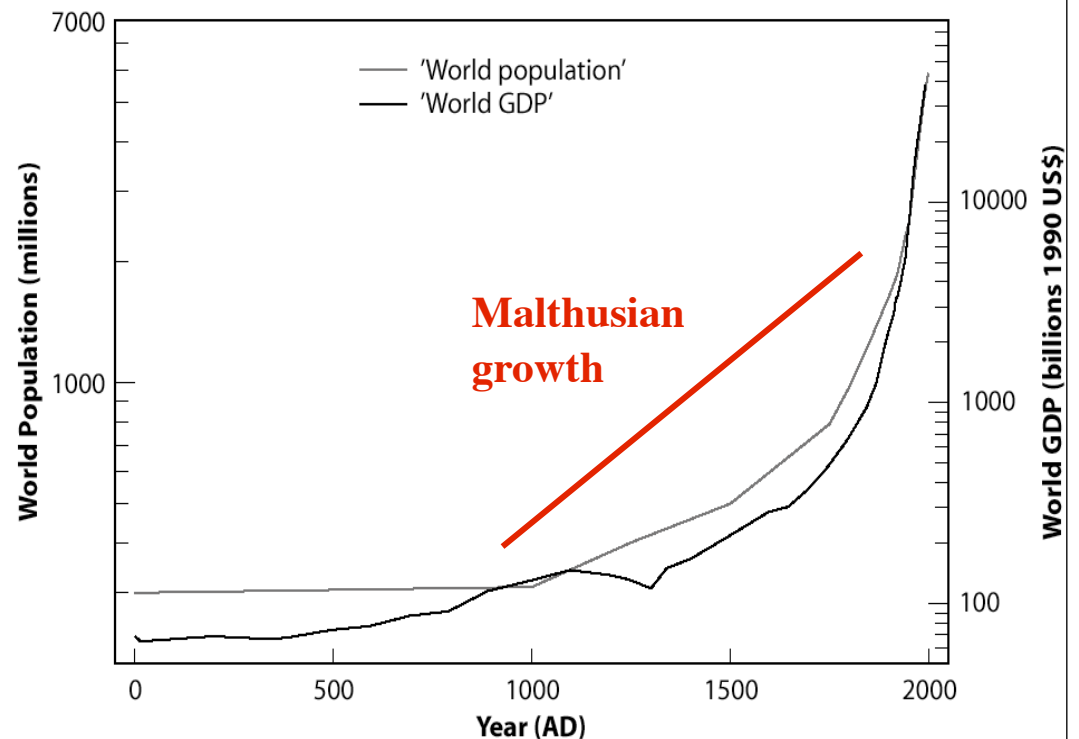
IMMENSE PROGRESS and INNOVATION

Financial innovations have fostered the use of capital for
- economic development,
- welfare,
- education...

super-exponential growth of financial wealth

super-exponential growth of population and GDP

CONFLICTS OF INTERESTS

Loss of "Fiduciary Principle"

'*no man can serve two masters*'
(J. Bogle, former CEO Vanguard group, JPM 2009)

Loss of "Legal relationship of confidence or trust between two parties"

The issue of "moral relativism"
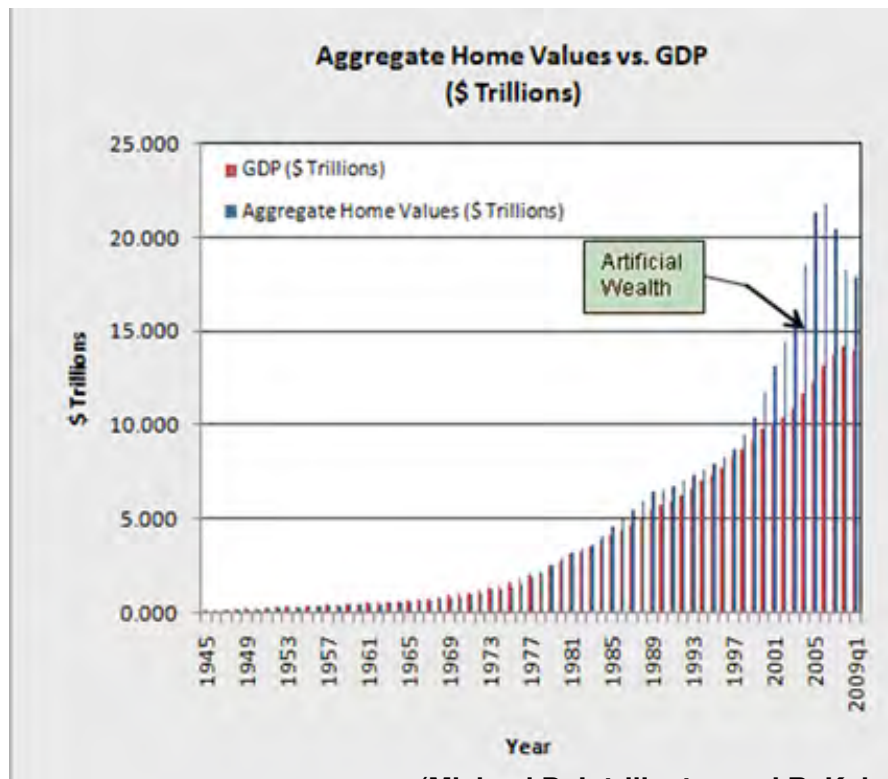
Moral hazard

Misaligned Incentives

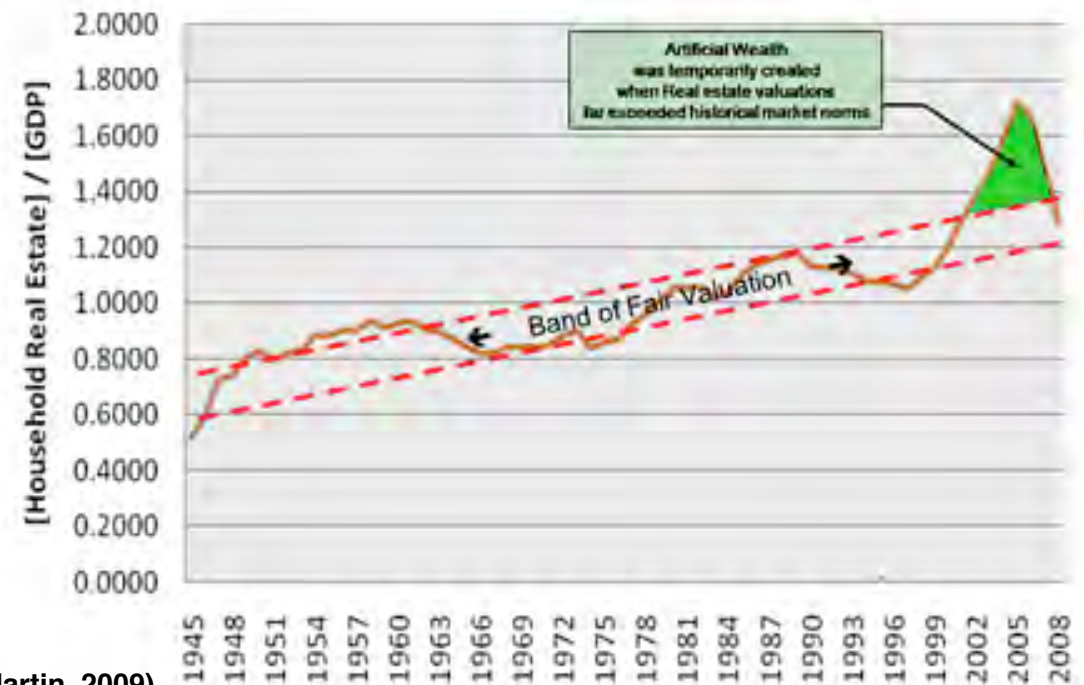# Fundamental Origin of the Crises

- 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).**

Aggregate Residential Housing Values compared with GDP

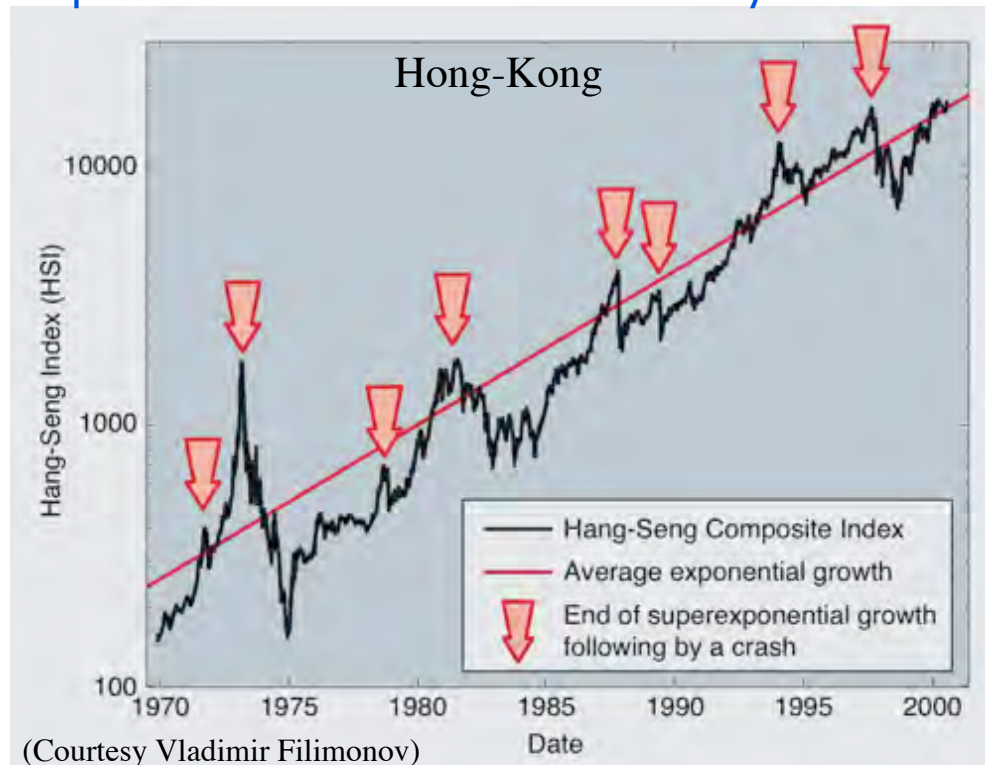Aggregate Value of Household Real Estate Relative to Economic Output (GDP)

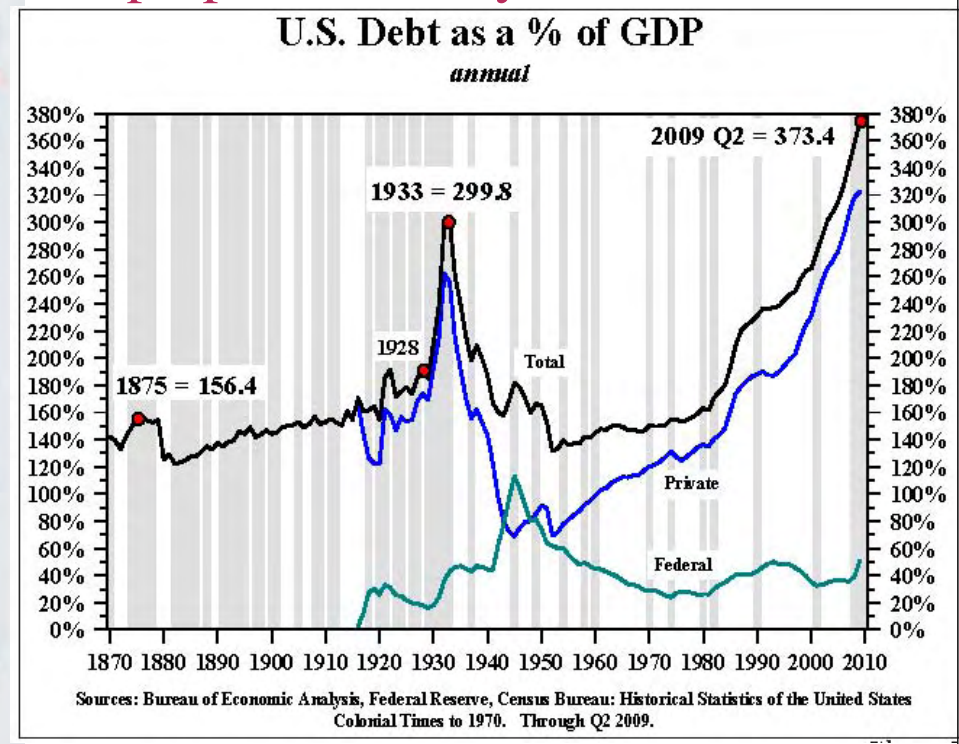**(Michael D. Intriligator and R. Kyle Martin, 2009)**

HUMAN INTRINSIC WEAKNESSES

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

- The banking industry is a seller of dreams.

- The banking industry exploits our illusions and cognitive limitations... like casinos and lotteries...

Textbook example of a series of super-exponential acceleration followed by crashes
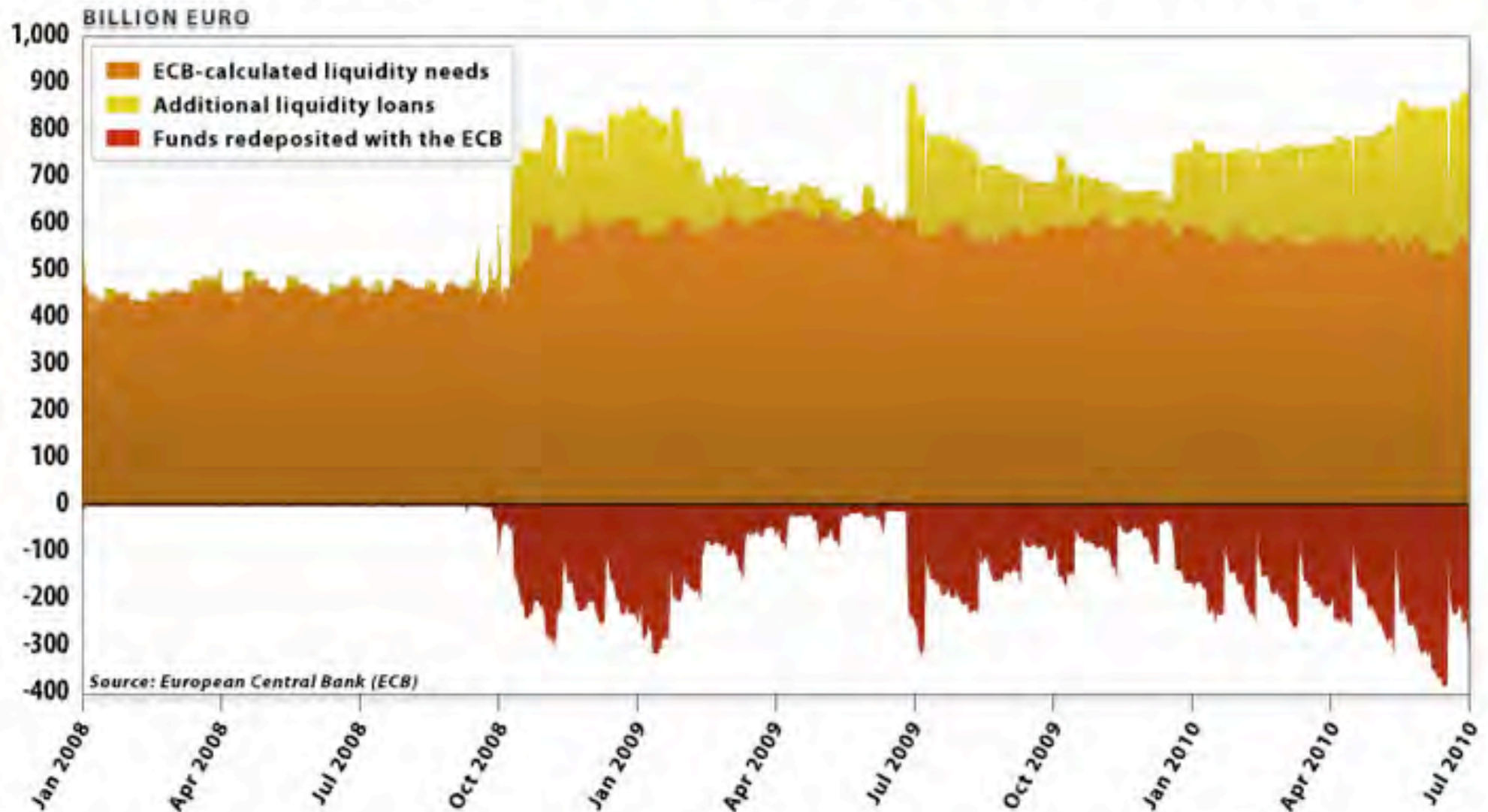
Leverage and the illusion of the perpetual money machine

(Courtesy Vladimir Filimonov)

Two Mammoth European problems:
bank exposures and Sovereign debts

EUROZONE BANKS: LIQUIDITY SUPPLY AND DEMAND

BILLION EURO

Legend:
- ECB-calculated liquidity needs
- Additional liquidity loans
- Funds redeposited with the ECB

Source: European Central Bank (ECB)

Federal Reserve balance sheet

Source: Federal Reserve; as of 9/30/2010

New risks to consider

- Inflation and Deflation

- Bank failures

- "Government risks"

- Economic Slowdown (China)

- Energy risks…

• Financial instabilities are developing everywhere and will develop even more than in the past.
• Systemic risks are rising planet-wise, with entangling of many risk components (everything is linked).

How to avoid our own lost decade
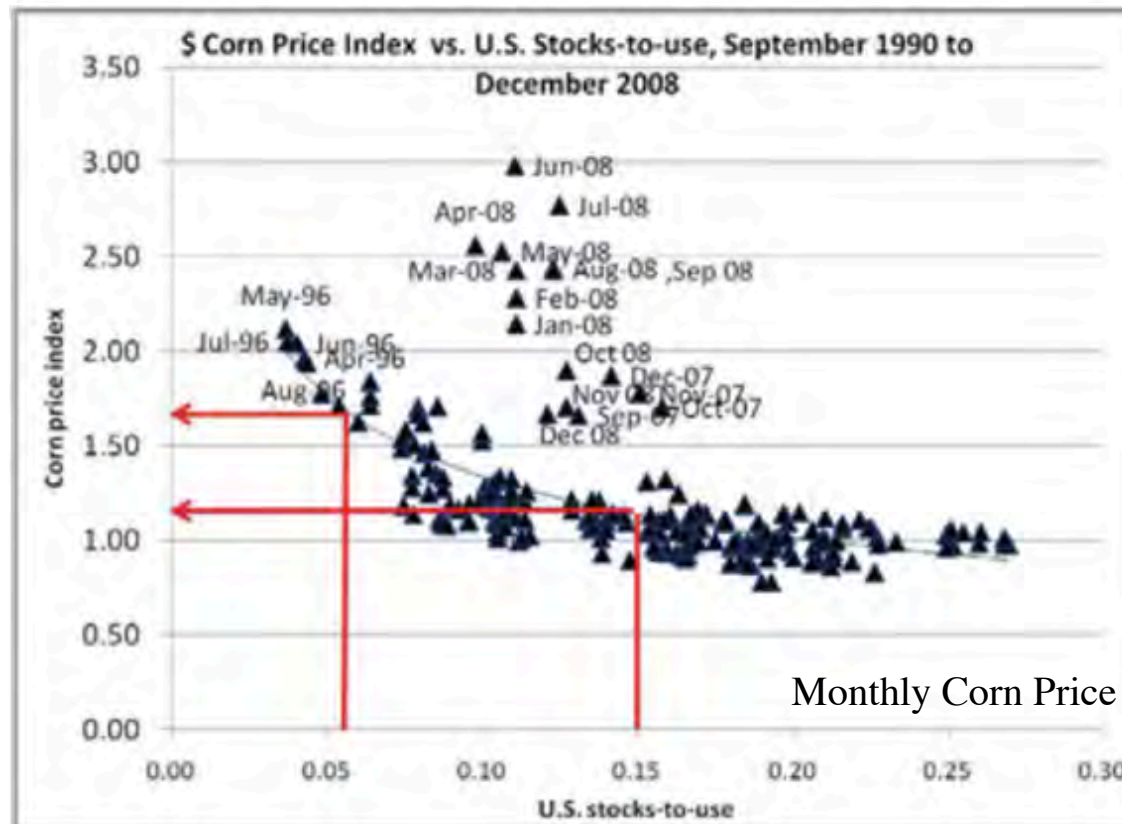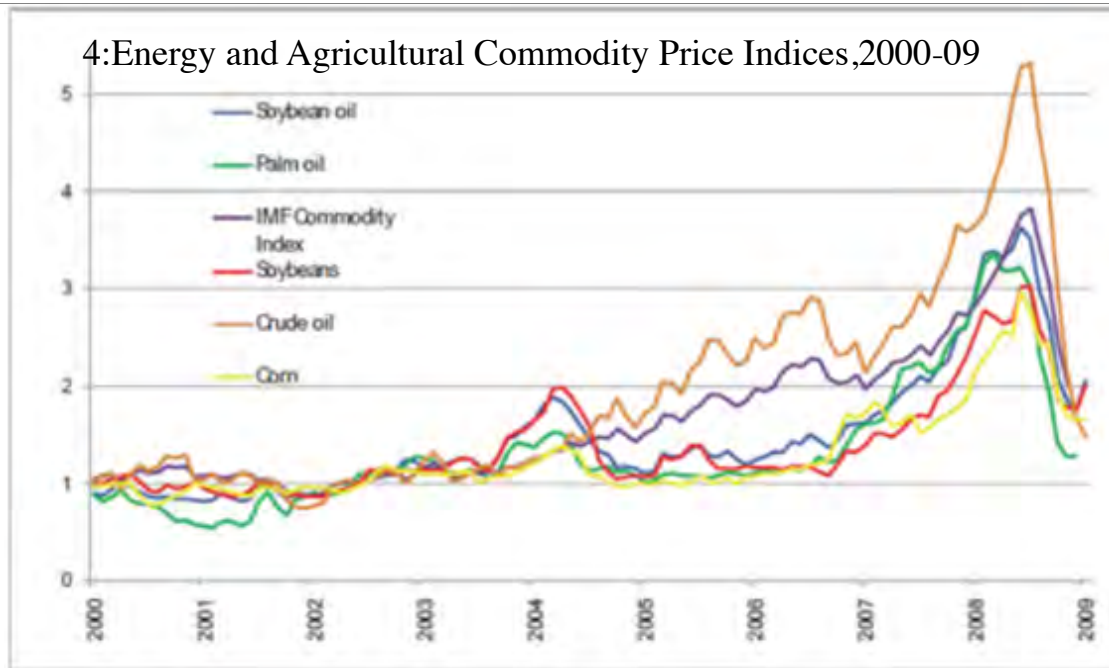**By Lawrence Summers**
Financial Times   June 12 2011

Even with the 2008-2009 policy effort that successfully prevented financial collapse, the US is now halfway to a lost economic decade. In the past five years, our economy's growth rate averaged less than one per cent a year, **similar to Japan when its bubble burst**. At the same time, the fraction of the population working has fallen from 63.1 per cent to 58.4 per cent, reducing the number of those in jobs by more than 10m. Reports suggest growth is slowing.

This is no time for fatalism or for traditional political agendas.

The central irony of financial crisis is that while it is caused by too much confidence, borrowing and lending, and spending, it is only resolved by increases in confidence, borrowing and lending, and spending.

4:Energy and Agricultural Commodity Price Indices,2000-09

$ Corn Price Index vs. U.S. Stocks-to-use, September 1990 to December 2008

Monthly Corn Price Index and USDA Stocks
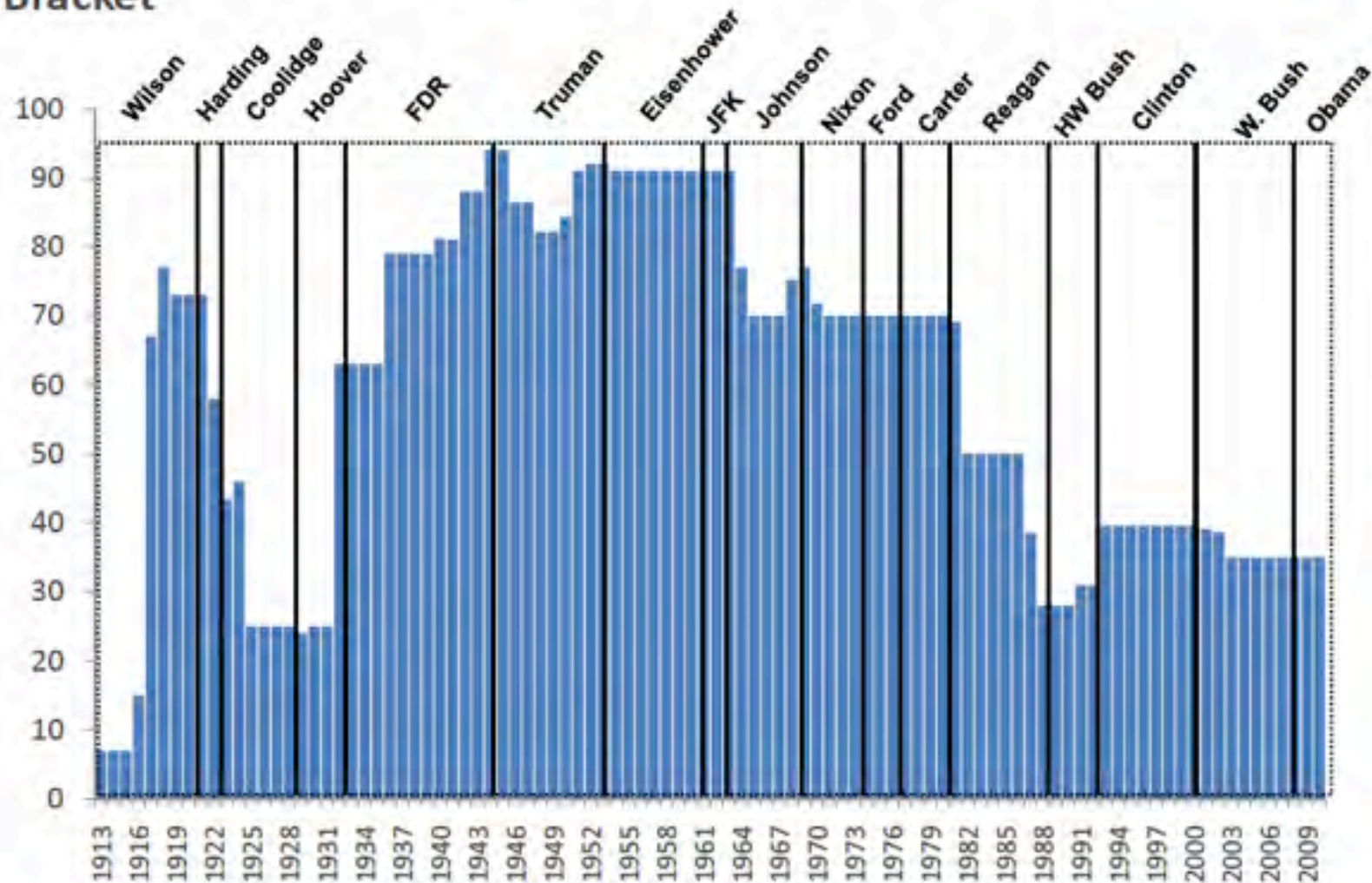
Time dependence of FAO Food Price Index from January 2004 to May 2011. Red dashed vertical lines correspond to beginning dates of "food riots" and protests associated with the major recent unrest in North Africa and the Middle East. The overall death toll is reported in parentheses. Inset shows FAO Food Price Index from 1990 to 2011.

Marco Lagi, Karla Z. Bertrand and Yaneer Bar-Yam (2011)

Marginal Tax Rate on Highest Individual Income Bracket

Wilson · Harding · Coolidge · Hoover · FDR · Truman · Eisenhower · JFK · Johnson · Nixon · Ford · Carter · Reagan · HW Bush · Clinton · W. Bush · Obama

Source: Internal Revenue Service, DoubleLine Capital LP as of December 31, 2009

Figure 2 from Paul Kedrosky.

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U.S. Treasury CDS vs. corporates

5 year CDS - basis points

— U.S. Treasury   — Exxon   — Johnson & Johnson

2010   2011

Source: Thomson Reuters Datastream   Reuters graphic/Scott Barber 8/1/2011

According to Reuters, in the United States, the cost of insuring the debt (i.e. CDS or credit default swap) of Automatic Data Processing (ADP), Exxon Mobile (XOM), Johnson & Johnson (JNJ) and Microsoft (MSFT) against default on a five-year horizon is at least 20 basis points lower than that of the U.S. government

"Globally, 107 corporate and local governments have higher ratings than those of the sovereign in their country of domicile on a foreign currency basis, Standard & Poor's says. That means these entities are seen as likely to be able to cover their debt obligations even when the central government of the country they are based in cannot."
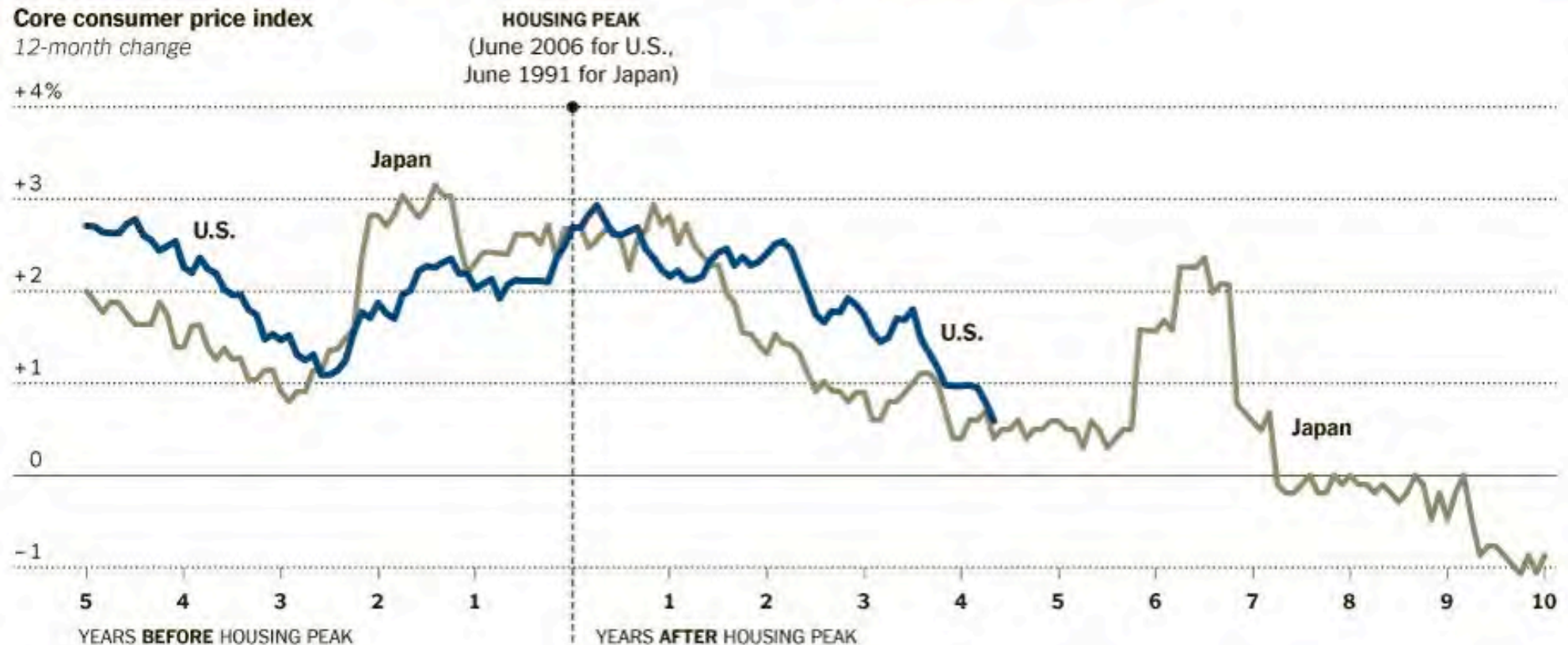
3 Aug. 2011

Deflation: Japan versus USA

Following Japan's Path, So Far

In the United States, the core consumer price index, which excludes food and energy prices, rose 0.6 percent in the 12 months through October. That was the smallest 12-month gain since the government began calculating the figure in the 1950s. The chart shows the 12-month changes in core C.P.I. for the United States and Japan, in the years before and after housing prices peaked in each country.

Core consumer price index
12-month change

HOUSING PEAK
(June 2006 for U.S.,
June 1991 for Japan)

YEARS **BEFORE** HOUSING PEAK   YEARS **AFTER** HOUSING PEAK

European Economic and Financial Exploratory

Four prong action

1. **Economic policy and regulation exploratory**

(after the UNIGE Centre for Interdisciplinary Research on Economics and Financial Engineering in Genoa)

2. **Financial crisis observatory**

(after the Financial Crisis Observatory at ETH Zurich)

3. **Network-based forecasting of financial crises**

(after the EU consortium on forecasting financial crises)

4. **Computational platform and data facility for economic and financial modeling**

(after the Algorithmic Trading and Risk Platform at University College London)

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Main vision for the Economic policy and regulation exploratory

- to provide an innovative, effective and usable tools for approaching macroeconomic modeling and economic policy design questions

- to explain socio-economic phenomena by constructing artificial societies that 'grow' explanations from the bottom-up

- to generate an agent-based platform that integrates different models, sectors and markets (in particular, goods markets, labour markets, financial markets and credit markets) calibrated on economic data.

- to apply the analysis for relevant policy questions and to the exploration of scalability of large economic models

- to serve as facility for what-if analysis, scenario evaluations and computational experiments focussed on policy, market and regulation design.

Extension of European Project EURACE, launched in 2006 and coordinated by the University of Genoa [Cincotti et al. (2010, 2011),

Main vision for the Economic policy and regulation exploratory

♣   To instruct by promoting and disseminating innovative theory, models and methodologies;

♣   To inform by disseminating all the results;

♣   To alert when signs of increased risk and policy effects are found;

♣   To advise by elaborating recommendations that may decrease risk and stabilize the economics.

Methodology

♣   The closure of the economic system, i.e., fully-specified models of a complete economy that explicitly specify all real and financial stocks and flows and allow to aggregate upward from the micro-specifications to the macroeconomic variables of interest;

♣   The encompassing types of real and financial markets and economic agents;

♣   The wide use of empirically documented behavioral rules;

♣   The different levels of time and space granularity. It is possible to investigate the impact of real-life granularity on the economic outcomes, and to analyze the consequences of a modification of this granularity;

♣   The asynchronous decision-making across different agents;

♣   The explicit spatial structure, allowing to take into account not only regional and land-use aspects, but also more generally the fact that all human activities are localized in geographical and/or network space;

♣   The evolving social network structure linking the different economic agents and institutions;

♣   The large number of agents, allowing to discover emerging phenomena and/or rare events that would not occur with a smaller population;

♣   The analysis of economic, financial and social data;

♣   The analysis of financial data stored in ICT environments (Queries, Blogs)

♣   The calibration on European economic data and the focus on European policy analysis.

Reverse-engineering with Agent-Based Models

Goals

- Get a scientific understanding of the generating process of a time series by finding 3rd Party Games (3rdPG) which produce similar timeseries to the one which is fed (insample)
  → *Reverse Engineering*

- Test the robustness of the reconstruction by predicting with the 3rdPGs the next step of the previously fed timeseries (out-of-sample)

D. Lamper, S. D. Howison, N. F. Johnson (2001)
Andersen, D. Sornette (2004)

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- What are the determinants of crises?

- Can crises be forecasted?

- With what head time?

- Can crises be avoided with sufficient early warning and/or by a suitable understanding of their generating processes?

- What are the role of bubbles?

- Are often are crises associated with bubbles?

- Can bubbles be diagnosed ex-ante?

- Can their termination time be predicted?

Primary Objectives of the EEFE

1. identify current and forecasting future financial and economic risks or instabilities, including looming systemic risks;

2. analyze in an integrative manner the time series of financial, economic as well as balance-sheet indicators for tens of thousands of assets around the world, on a daily basis;

3. Serve as a global destination for scientists and policy makers to collaborate, to test ideas and to compare theories in real time in a supportive competitive environment;

4. Support the first three objectives by creating a storehouse of useful, global economic and financial data.

European Financial Crisis Observatory (EFCO)

(1) How should scientific prediction experiments be conducted and evaluated in economics and finance?

(2) What is the intrinsic predictability of financial and economic systems?

(3) How can the predictions be used for the development of macroprudential early warning systems?

European Financial Crisis Observatory (EFCO)

communicates results to policy makers such as regulators, the research community, the media and the general public with the goals:

- To instruct by promoting and illuminating new technologies and methodologies;
- To inform by distributing all the results;
- To alert when signs of increased risk are found;
- To advise by elaborating recommendations that may decrease risk or stabilize the system.
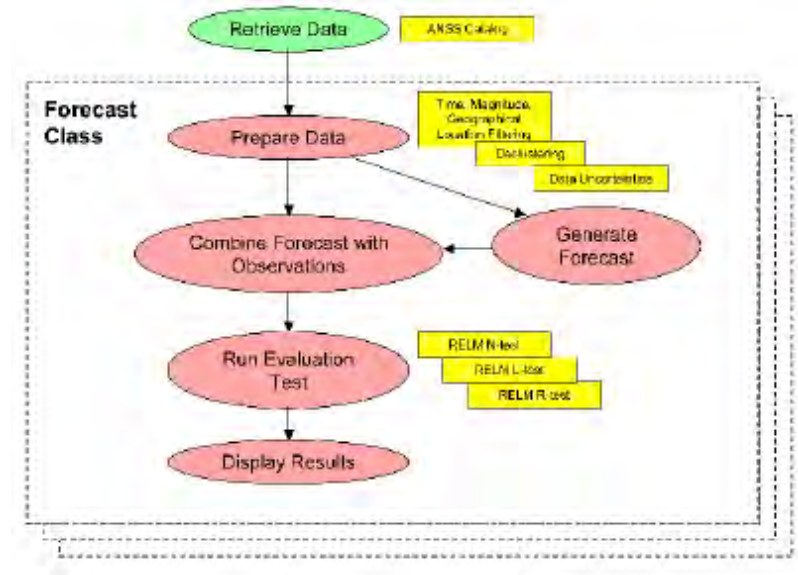
Four Essential EFCO Components

— **Testing centers**: facilities with validated procedures for conducting and evaluating prediction experiments

— **Community standards**: rules for the registration and evaluation of scientific prediction experiments

— **Communication protocols**: procedures for conveying scientific results and their significance
  — the scientific community, including professional societies
  — government agencies responsible for risk management
  — the general public and other end-users

— **Testing targets**: developed and developing markets, types of assets, time-scales... for conducting prediction experiments

EFCO Testing Center Software

— Daily Automated Crisis Forecast Generation
  — bubble forecast models, volatility models, ABM models...

— Automated Crisis Forecast Evaluation
  — statistical tests, error diagrams, trading tests...

EFCO v1.0 Dispatcher

— Automated Testing Framework
  — Acceptance tests

— Reproducibility of Results
  — Software version control
  — System configuration archive
  — Data set archive

— Identical Integration and Operational Systems
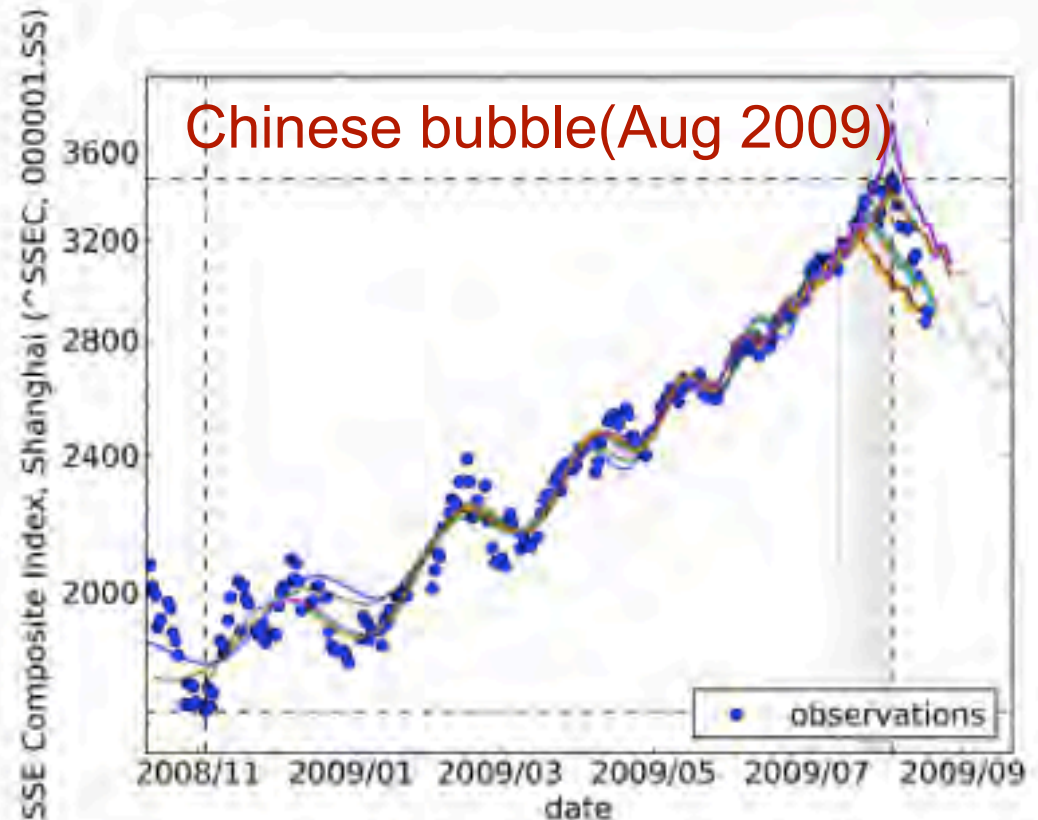 — Common, standardized open-source software stack

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

CHAIR OF ENTREPRENEURIAL RISKS

About us | People
Research | Teaching | Publications | Seminars | CCSS | Financial Crisis Observatory
Books | Interviews | Essays | Presentations | Inspiring Articles

FCO@ETH: Towards operational science of financial instabilities

Didier Sornette, Ryan Woodard, Peter Cauwels, Vladimir Filimonov, Wanfeng Yan, Qunzhi Zhang, Wei-Xing Zhou

- Main mission:
  - Identify bubbles
- Theory:
  - Positive feedback
- Deliverables
  - Weekly global bubble scan
  - Research, papers
  - Public forecasts
  - Digital timestamps

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.*

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

D
MTEC

Entrepreneurial
Risks

Methodology for diagnosing bubbles

- Positive feedbacks of higher return anticipation
  - ✳ Super exponential price
  - ✳ Power law "Finite-time singularity"

- Negative feedback spirals of crash expectation
  - ✳ Accelerating large-scale financial volatility
  - ✳ Log-periodic discrete scale-invariant patterns

Methodology for diagnosing bubbles
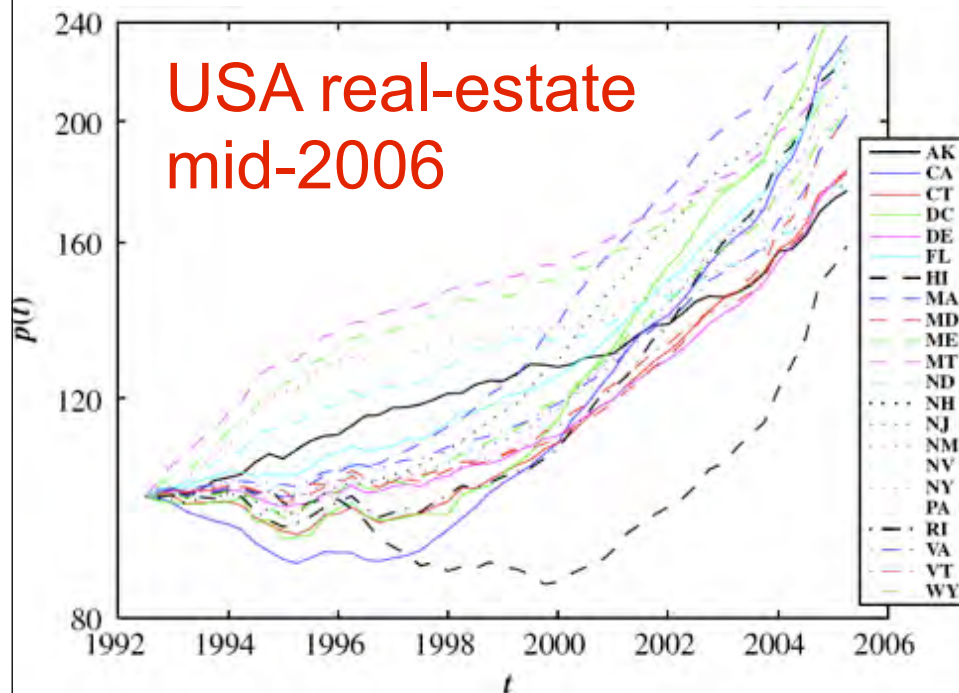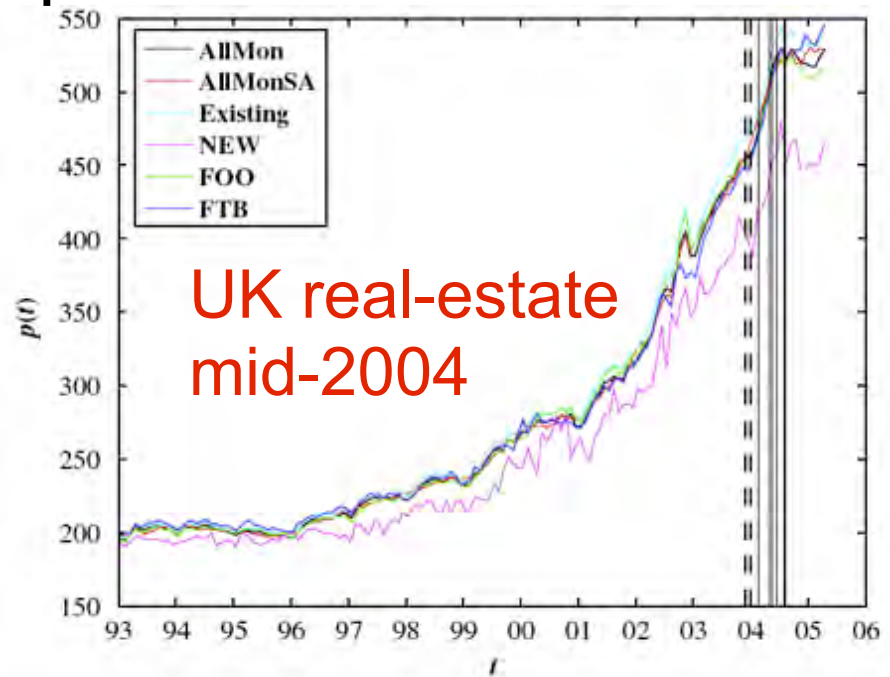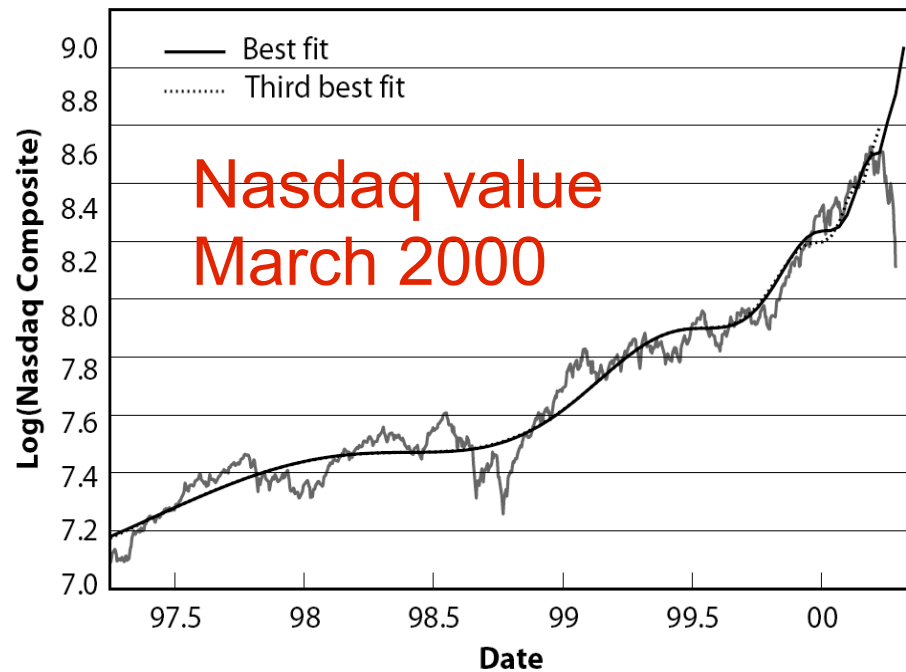
Inputs:

-prices, volumes

-factors (interest rates, interest spread, historical and implied volatility, exchange rates)
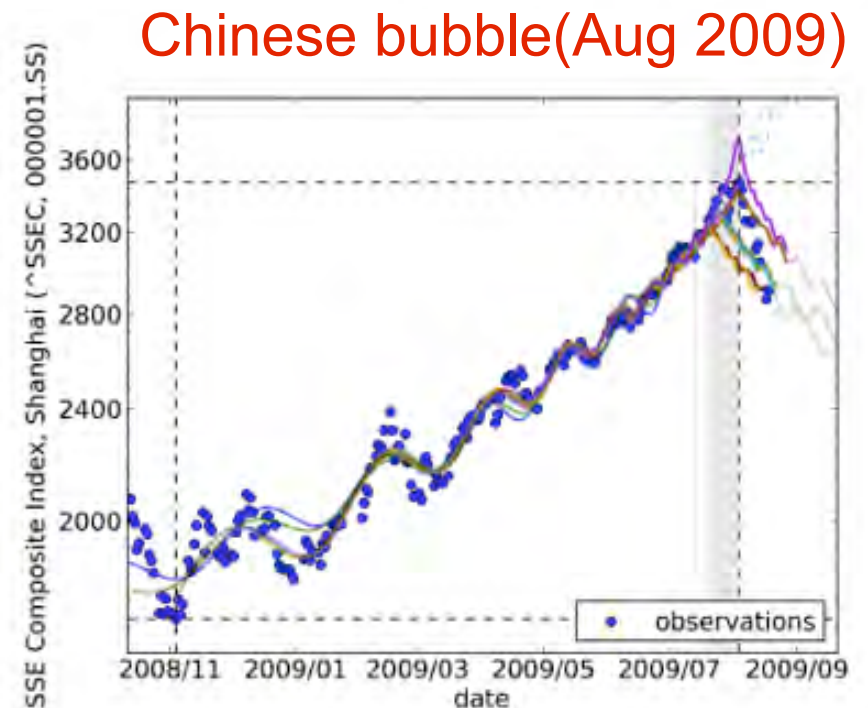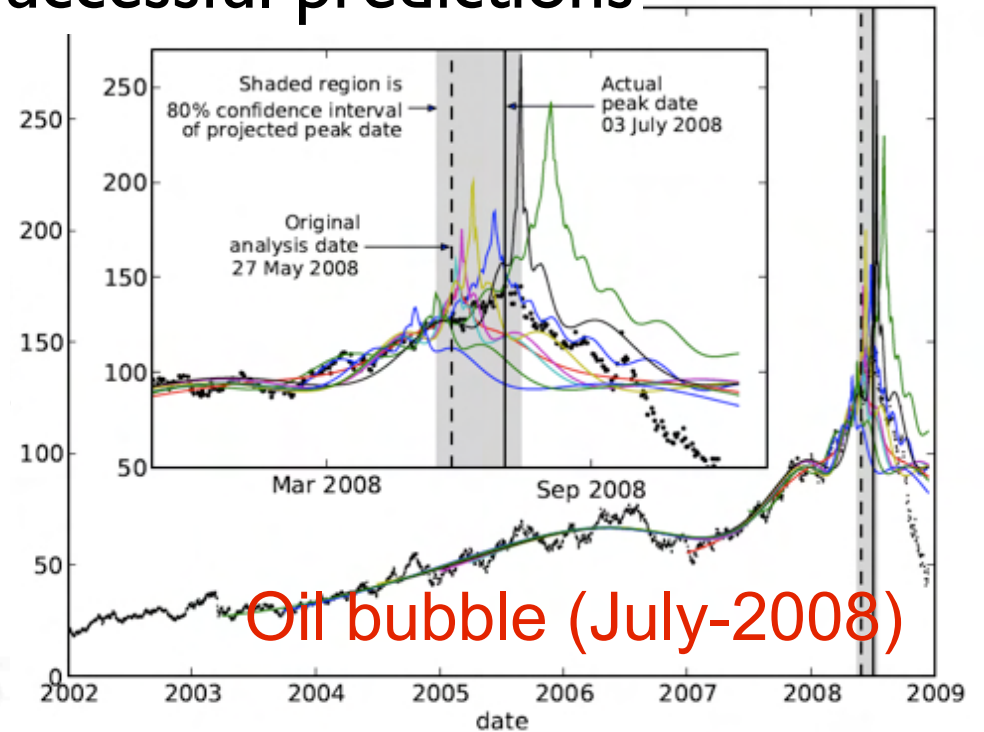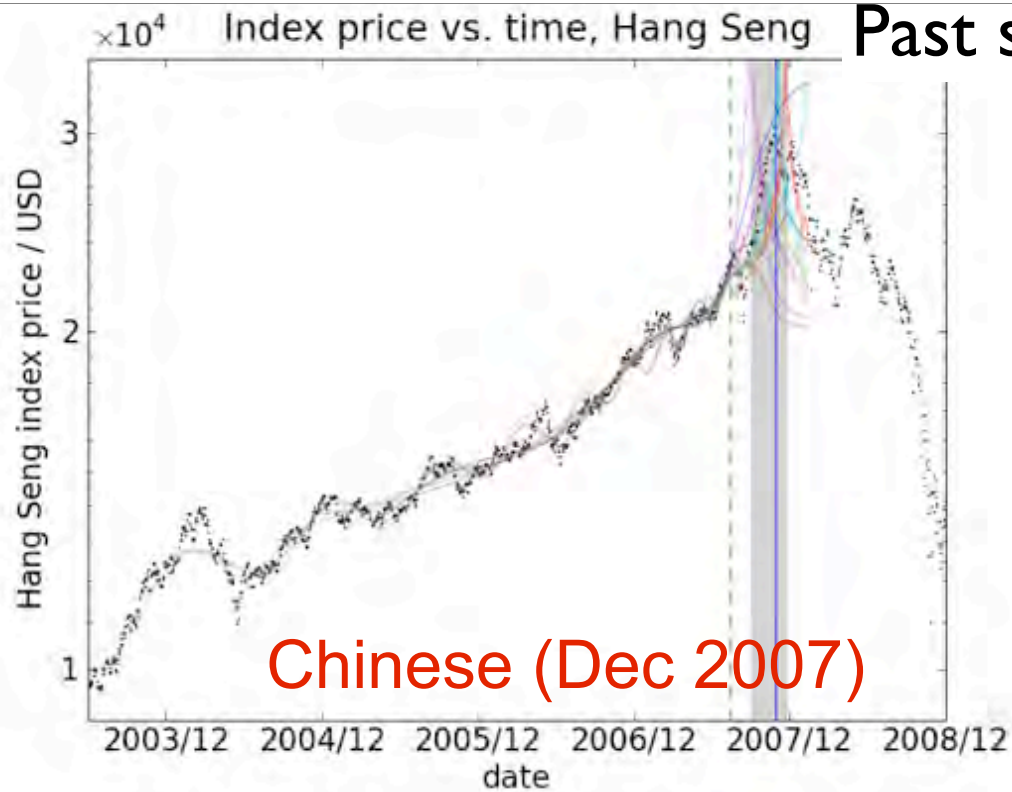
Methods:

-Self-consistent calibration of prices (not returns)

-Portfolio of methods to identify transient bubble regimes (entropy, hierarchical analysis, reverse engineering with ABM...)

Past successful predictions

Nasdaq value
March 2000

UK real-estate
mid-2004

USA real-estate
mid-2006

S&P500
Oct-2007

Past successful predictions

Chinese (Dec 2007)

Oil bubble (July-2008)

The Global Bubble (Oct 2007)

Chinese bubble(Aug 2009)

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

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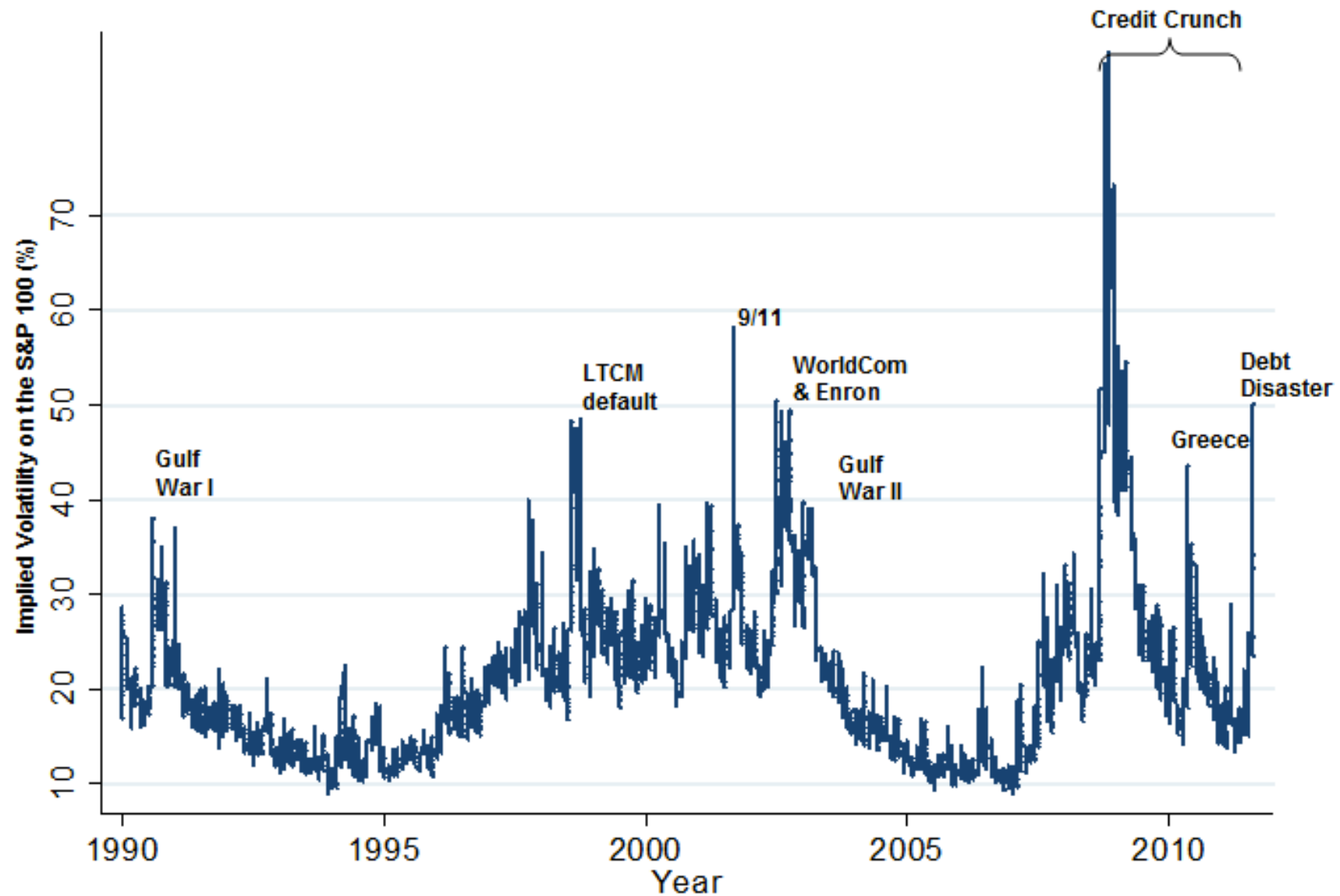3. **Network-based forecasting of financial crises**

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Global "fear" index

Daily US implied stock market volatility (VIX index, commonly known as the "financial fear factor")
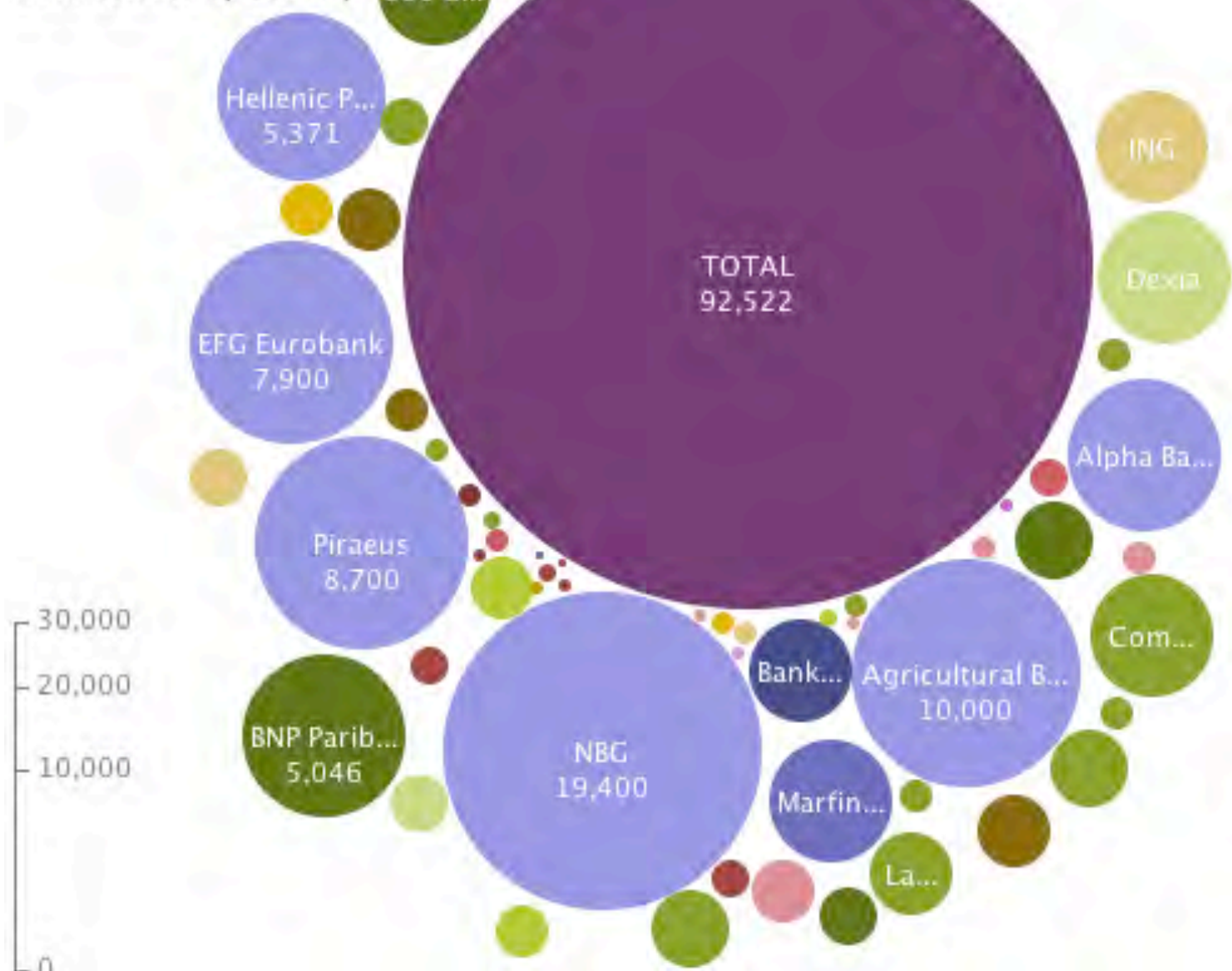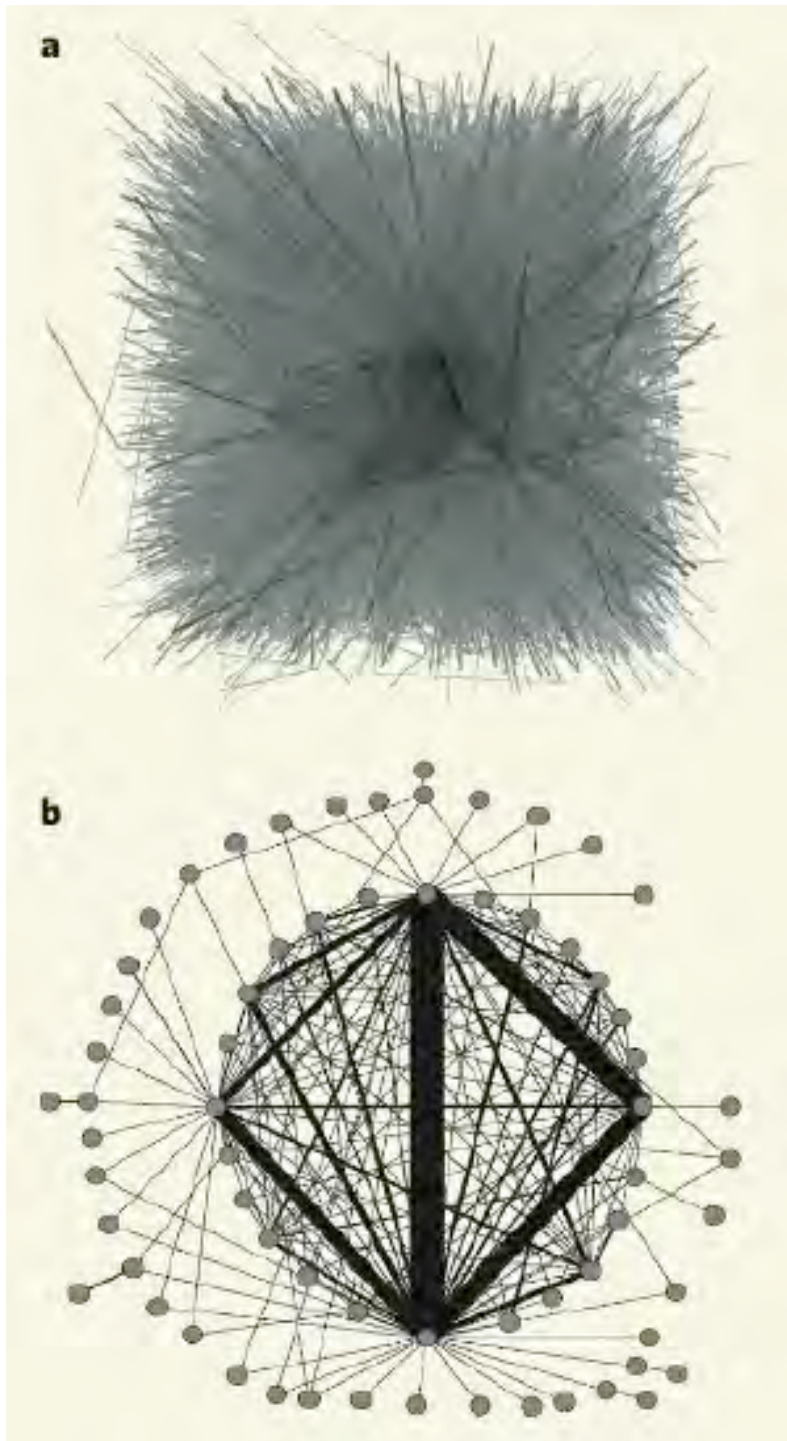

Bloom, Nick (2009), "The Impact of Uncertainty Shocks", *Econometrica*, May 623-685.

Bank exposure to Greece

Legend (Disks colored by Country):
- Greece
- Cyprus/Gre
- Cyprus
- Belgium
- Portugal
- Germany
- France
- Holland
- Austria
- Slovenia
- United King
- Italy
- Sweden
- Spain
- Denmark
- Ireland
- Finland
- Malta

Net Sovereign Exposure to Greece
Disks colored by Country

- Soc G...
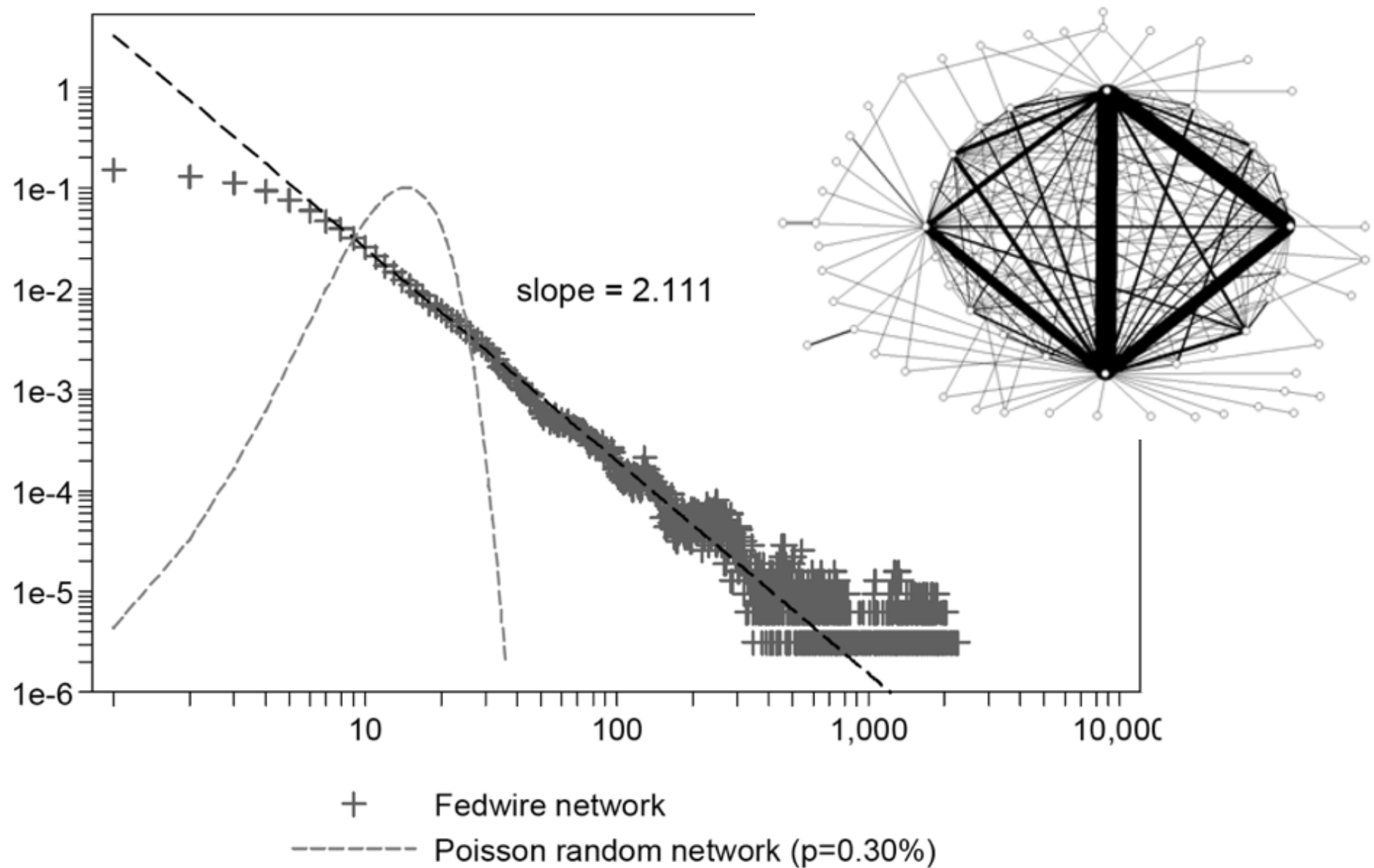- Hellenic P... 5,371
- EFG Eurobank 7,900
- Piraeus 8,700
- BNP Parib... 5,046
- NBG 19,400
- TOTAL 92,522
- ING
- Dexia
- Alpha Ba...
- Com...
- Bank...
- Agricultural B... 10,000
- Marfin...
- La...

Axis scale: 30,000 / 20,000 / 10,000 / 0

The Fedwire interbank payment network.

a, This 'furball' depiction takes in thousands of banks and tens of thousands of links representing US$1.2 trillion in daily transactions.

b, The core of the network, with 66 banks accounting for 75% of the daily value of transfers, and with 25 of the banks being completely connected. Every participating bank, and every transaction, in the full network is known (akin to an ecologist knowing all species in an ecosystem, and all flows of energy and nutrients). So the behavior of the system can be analysed in great detail, on different timescales and, for example, in response to events such as 9/11.

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Soramäki, K. *et al. Physica A* 379, 317–333 (2007).

network topology of the interbank payments transferred between commercial banks over the Fedwire® Funds Service

slope = 2.111

+ Fedwire network

------ Poisson random network (p=0.30%)

Kimmo Soramäki, Morten L. Bech, Jeffrey Arnold, Robert J. Glass, and Walter E. Beyeler, Physica A 379, 317–333 (2006)
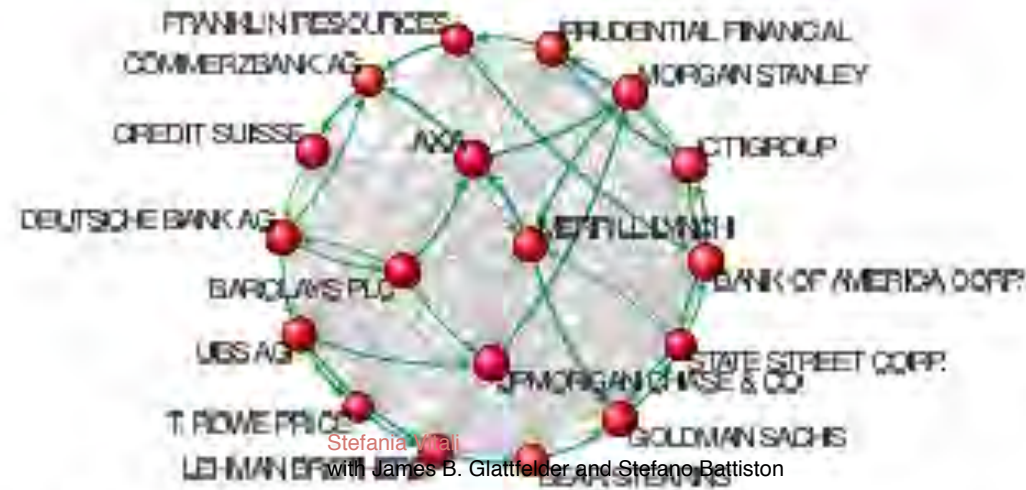
Network of Global Corporate Control

Figure: Subset of the largest strongly connected component. Some links among a few major TNCs in the financial sector are highlighted.

- Tightly-knit group of corporations
- Many mutual cross-shareholdings and longer cycles
- 75% of the ownership of the SCC firms stays within the SCC
- The core is dominated by financial institutions from US and GB

(Stefania Vitali, James B. Glattfelder and Stefano Battiston)

Novel *integrated* and network-oriented approach

Lowering Competition

Trivieri (2007) finds that cross-ownership decreases competition in Italian banks. It is plausible that similar mechanisms are working globally in the SCC core representing a "super-conglomerate"

Systemic Risk

Dense networks of relations, and even more dense SCC, can favor the propagation of financial stress

Individual Decisions with the Potential for Sudden Global Impact

Facing a crisis, an economic actor with high global control could unexpectedly change his policy with significant consequences

(Stefania Vitali, James B. Glattfelder and Stefano Battiston)

Novel *integrated* and network-oriented approach

Expected Breakthroughs:

1. Provide a theoretical framework to measure systemic risk in global financial market and financial networks.

2. Provide an ICT collaborative platform for monitoring global systemic risk.

3. Provide algorithms and models to forecast and visualise interactively possible future scenarios

Novel *integrated* and network-oriented approach

- … Correlations of MBS due to a common dependence on the same underlying factors (Interest Rates, Real Estate Prices)
- … Correlations between counterparty credit risks and underlying risks in hedge contracts
- … system risk exposure due to (unknown) excessive maturity transformation and leveraging at investment banks, conduits, etc.

Novel *integrated* and network-oriented approach

to address Procyclicality such as in 2007 - 2008

- Price declines in (malfunctioning) markets
- Fair value accounting
- Lack of equity buffers
- Deleveraging
- Further price declines
- Solvency problems
- Breakdown of refinancing mechanisms

Highly nonlinear system, high dimensionality, many endogenous moving parts, ... and the regulator is part of the system!

Four prong action

1. **Economic policy and regulation exploratory**

   (after the UNIGE Centre for Interdisciplinary Research on Economics and Financial Engineering in Genoa)

2. **Financial crisis observatory**

   (after the Financial Crisis Observatory at ETH Zurich)

3. **Network-based forecasting of financial crises**

   (after the EU consortium on forecasting financial crises)

4. **Computational platform and data facility for economic and financial modeling**
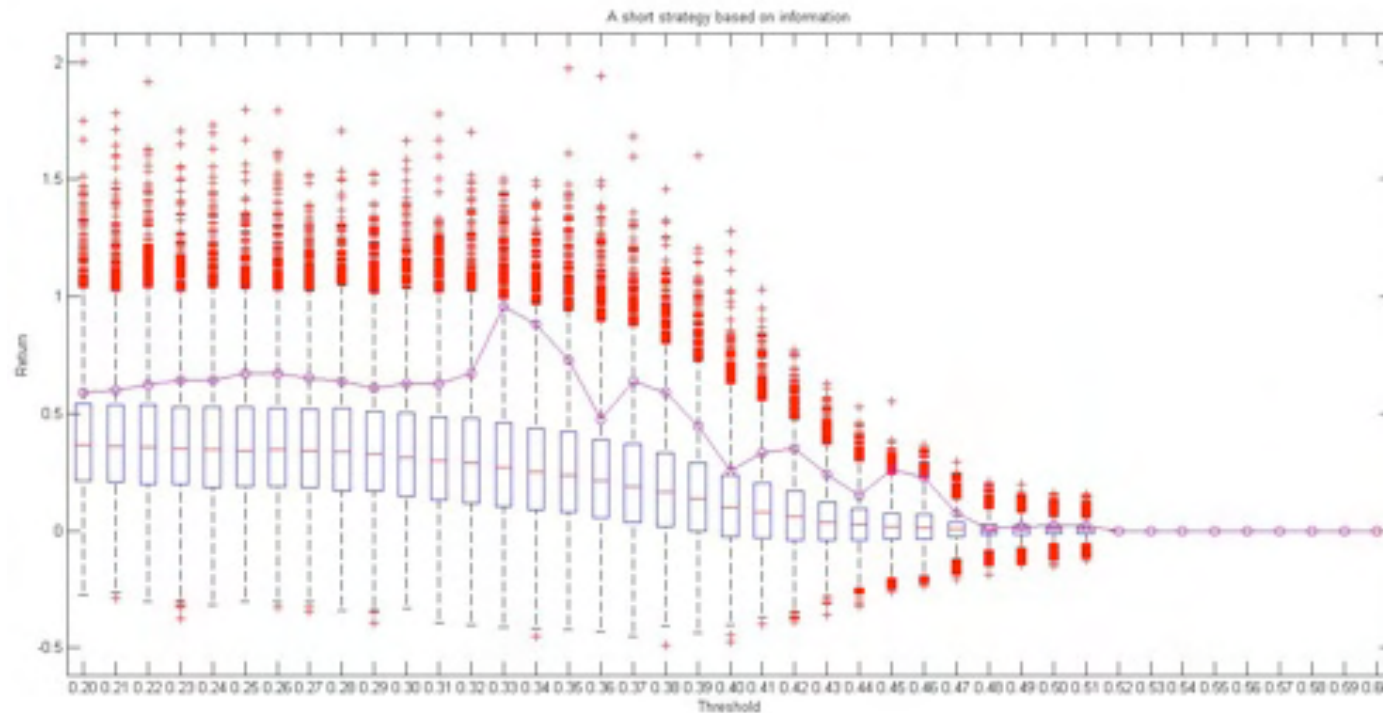
   (after the Algorithmic Trading and Risk Platform at University College London)

Extensive database and innovative metrics

♣ Equities: important or representative stocks, indices or sectors;

♣ Commodities: energy and fuels, base metals, precious metals, soft commodities and their representative futures and indices;

♣ Credit: corporate bonds, government bonds and their representative CDS spreads, indices and sectors, fiat money;

♣ Rates: yield curves, currency exchange rate pairs, swap rates, futures (e.g. bund, treasuries, ...);

♣ Risk gauges: implied volatilities (e.g. VIX, VDAX, ...), LIBOR-OIS spread, TED spread,

♣ Goods: Consumable, capital and durable goods (raw data, indices or sectors), inflation and consumption;

♣ Labour: unemployment, skills distribution, aging

♣ Industrial production, productivity, manufacturing and inventories;

♣ GDP and GDP growth;

♣ Inflation (CPI, PPI) and consumption;

♣ Government debt, banks' and firms' leverages, insolvency bankruptcies;

♣ Current account and trade balances;

♣ Balance sheets: firms, banks, etc.

♣ Real estate prices (both private and commercial);

♣ Logistics/supply chains/material + money flows;

♣ Network of interactions: production supply chain, credit supply chain, financial supply chain.

Semantic Language coding of news and Neural Networks

- Collecting news stories from Internet
  - Websites of different sources such as NY Times, Reuters, etc
  - Yahoo Finance
  - Google
- Extracting information from News stories
- The preliminary results show some interesting relationships between information and stock prices. The following figure shows a short strategy based on information outperforms random trading on S&P500 index.
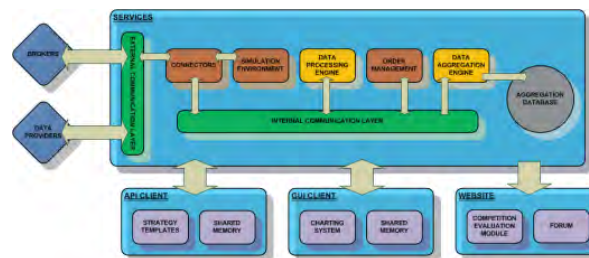

A short strategy based on information

Q. Zhang and D. Sornette

UCL-LSE-LBS Centre for Financial Computing

Human Resources

35+20 PhD Students working on Computational Finance & Financial IT

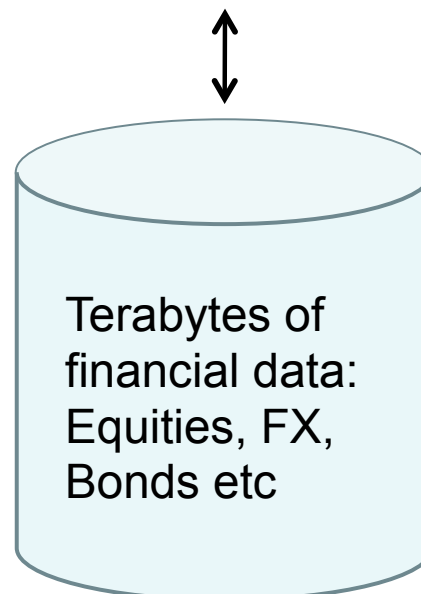## Trading & Risk Platform

Terabytes of financial data: Equities, FX, Bonds etc

Trading Room
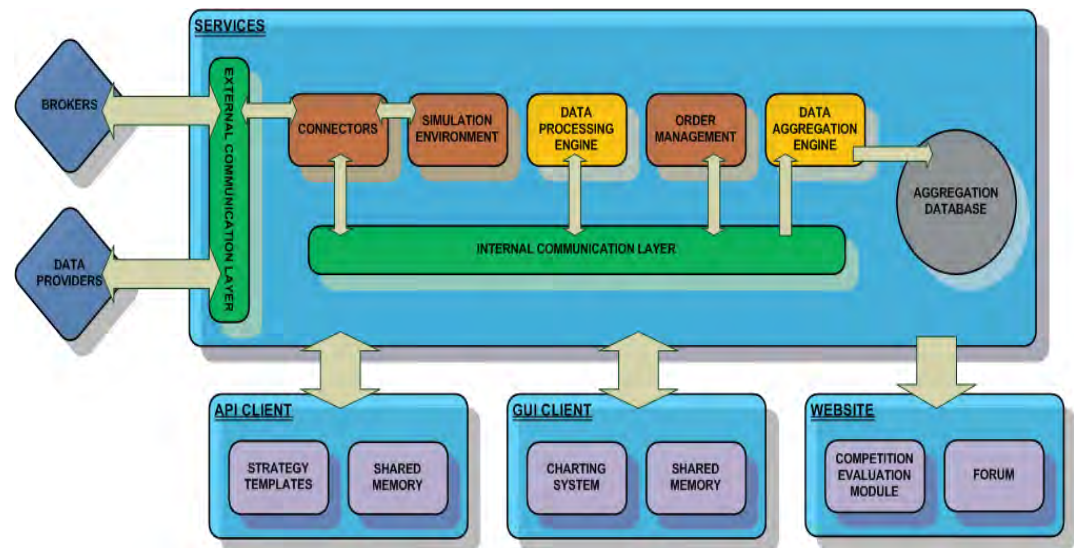
- Real-time data
- Virtual trading

Vision - *Financial Wind Tunnel*

- A *CERN*-like facility for Academics, Regulators and Financial Services Industry

- Remote access for Academics (economists, computer scientists), Regulators and Industry professionals

- Petabytes of financial data to support research
- Providing world-class technology for Risk and the Capital Marks:
    - Systemic risk
    - Institutional risk
    - High-frequency trading
- Linking the Academic Community (e.g. PhD students)

UCL ATRADE Platform Capabilities

❑**Simulation & Real Trading** – the platform allows users to trade virtually or with real money.

❑**Rapid Prototyping** – the platform is a framework for developing, trading, testing and evaluating the 'algorithm' risk.

❑**Data Processing & Aggregation** – it's capable of aggregating and processing data in real-time.

❑**R & Matlab** – incorporation of statistical/mathematical computing environments.

❑**Black Box Models** – the platform evaluates risk of black box models, without a need of handing the source of the model to anyone.

❑**Multiple Models** –the platform supports automated evaluation of multiple models concurrently, and generates statistical performance reports.

❑**Secure Remote Access** – it provides an API that allows remote access to major functionalities of the platform.

FuturICT Knowledge Accelerator - Financial (Risk) Observatory

- Modify and extend our Financial Simulation Environment to support the FuturICT community and academics across Europe.
- Host financial data for experimentation (with support from Microsoft etc.)
- Provide PhD students to help social scientists and complexity scientists develop their simulations.
- Areas of Research – risk, regulation and trading:
  - Financial and Economic instabilities
  - Systemic risk (Bank of England looking at Computational Ecology models)
  - High-frequency trading systems
  - Potential Impact of Regulation
- Financial Wind Tunnel
  - Social Scientists (hypotheses)
  - Complexity Scientists (models)
  - ICT(simulation environment)

European Economic and Financial Exploratory

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