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Eidgenössische Technische Hochschule Zürich
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D MTEC Departement Management, Technology, and Economics

ETH RISK CENTER

Entrepreneurial Risks

FUTURE RESILIENT SYSTEMS 未来风险管理科学

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Structural characteristics of growth

- regime shifts and bimodal patterns
- 1+1=2.5 (superlinear productivity)
- the “social bubble” nature of great innovations

Growth fundamentals

- historical perspective: the four industrial revolutions
- productivity and innovation

Growth since WWII (1945 to present)

- “Les trentes glorieuses” followed by “the illusion of the perpetual money machine”
- The post-2008 crisis and “new normal”
- Propositions to resume a healthy growth

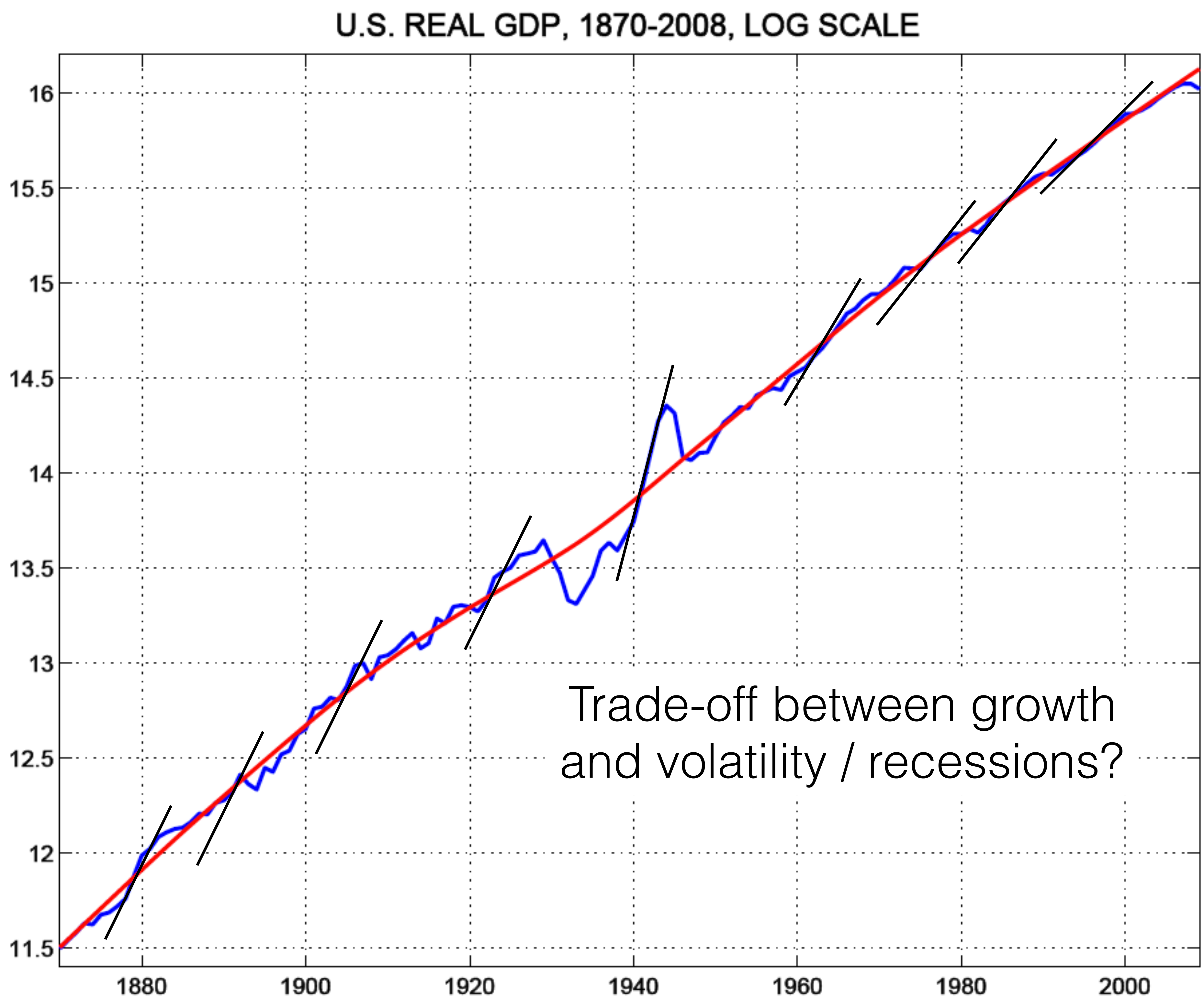
Multi-frequency business cycle analysis and bipolar growth rate of the real US GDP per capita

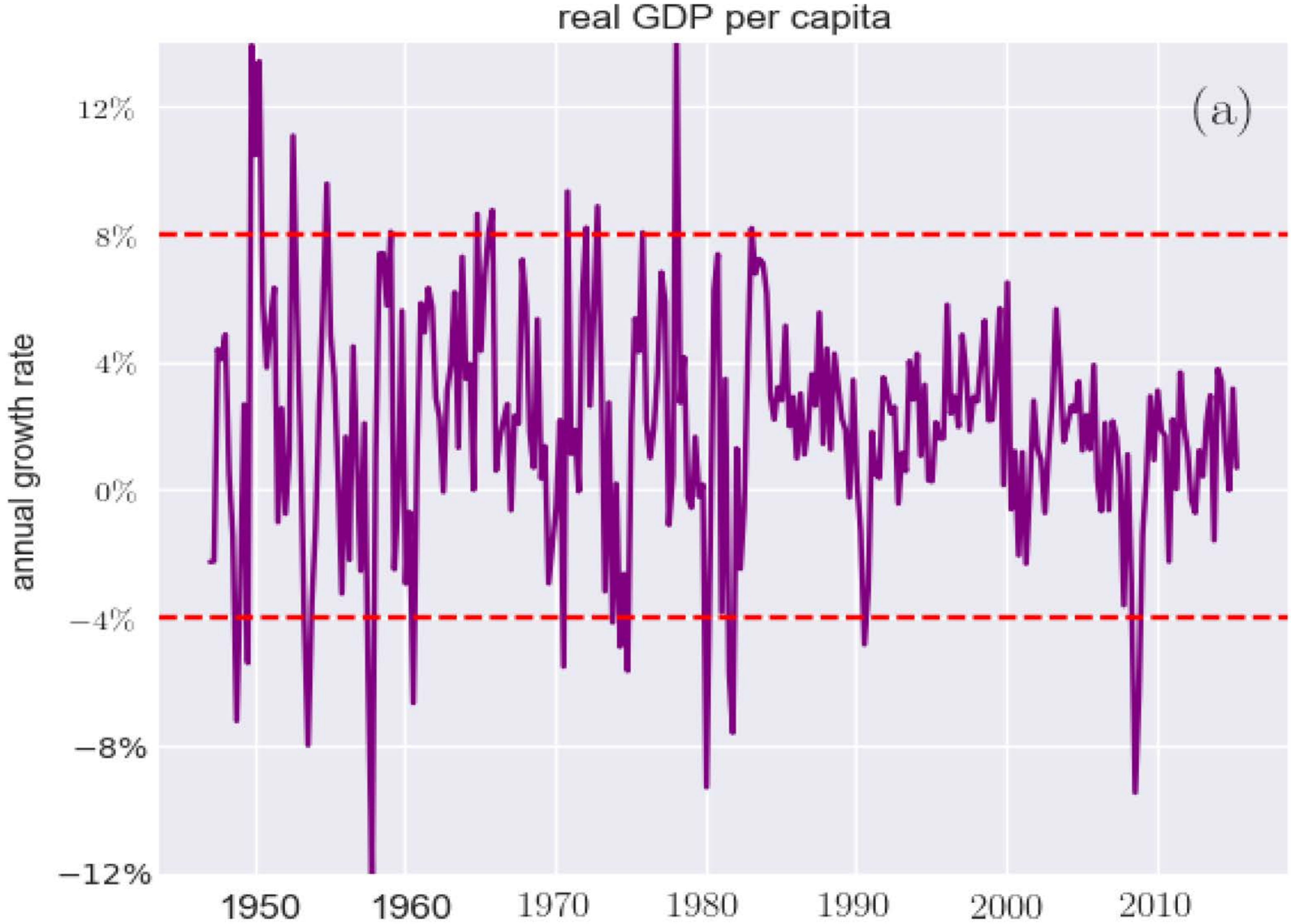
Sandro Claudio Lera[a,b,*], Didier Sornette[a,c]

[a] ETH Zurich, Department of Management, Technology, and Economics, Scheuchzerstrasse 7, 8092 Zurich, Switzerland
[b] ETH Zurich, Singapore-ETH Centre, 1 CREATE Way, #06-01 CREATE Tower, 138602 Singapore
[c] Swiss Finance Institute, c/o University of Geneva, Geneva, Switzerland

What is the "natural" growth rate of an economy?

Sandro Lera and Didier Sornette, Evidence of a bimodal US GDP growth rate distribution: A wavelet approach, Quantitative Finance and Economics 1(1): 26-43 (2017)


U.S. REAL GDP, 1870-2008, LOG SCALE
16
15.5
15
14.5
14
13.5
13
12.5
12
11.5
1880
1900
1920
1940
1960
1980
2000
Trade-off between growth
and volatility / recessions?



real GDP per capita
(a)
annual growth rate
12%
8%
4%
0%
−4%
−8%
−12%
1950
1960
1970
1980
1990
2000
2010

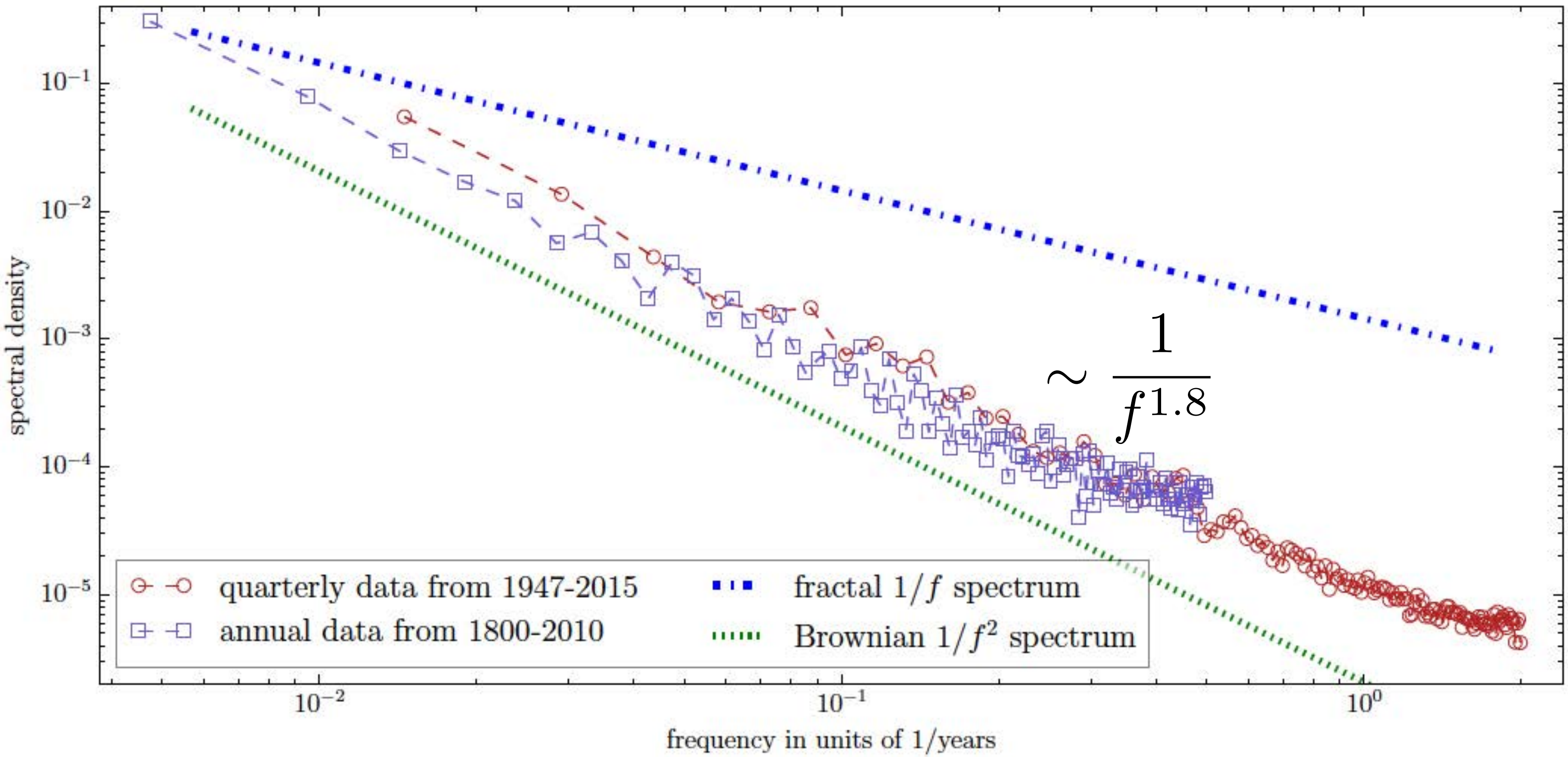
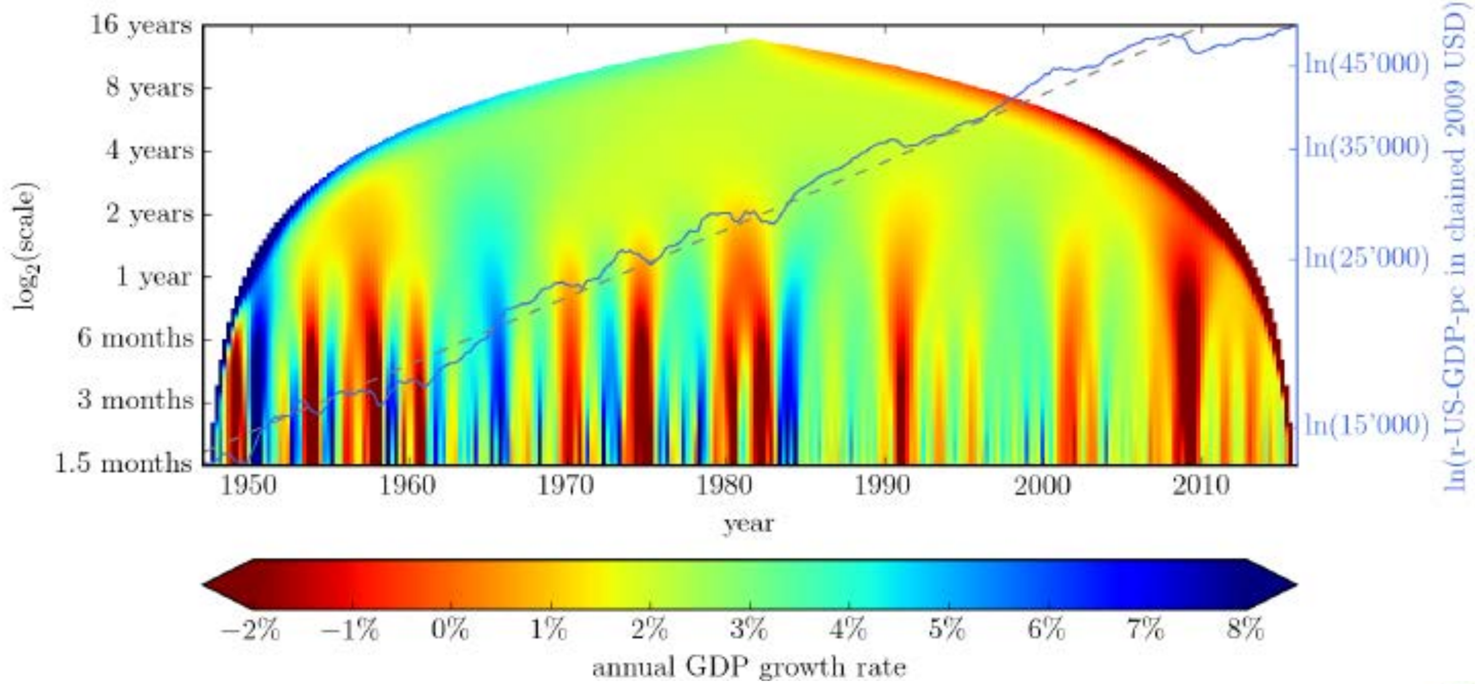
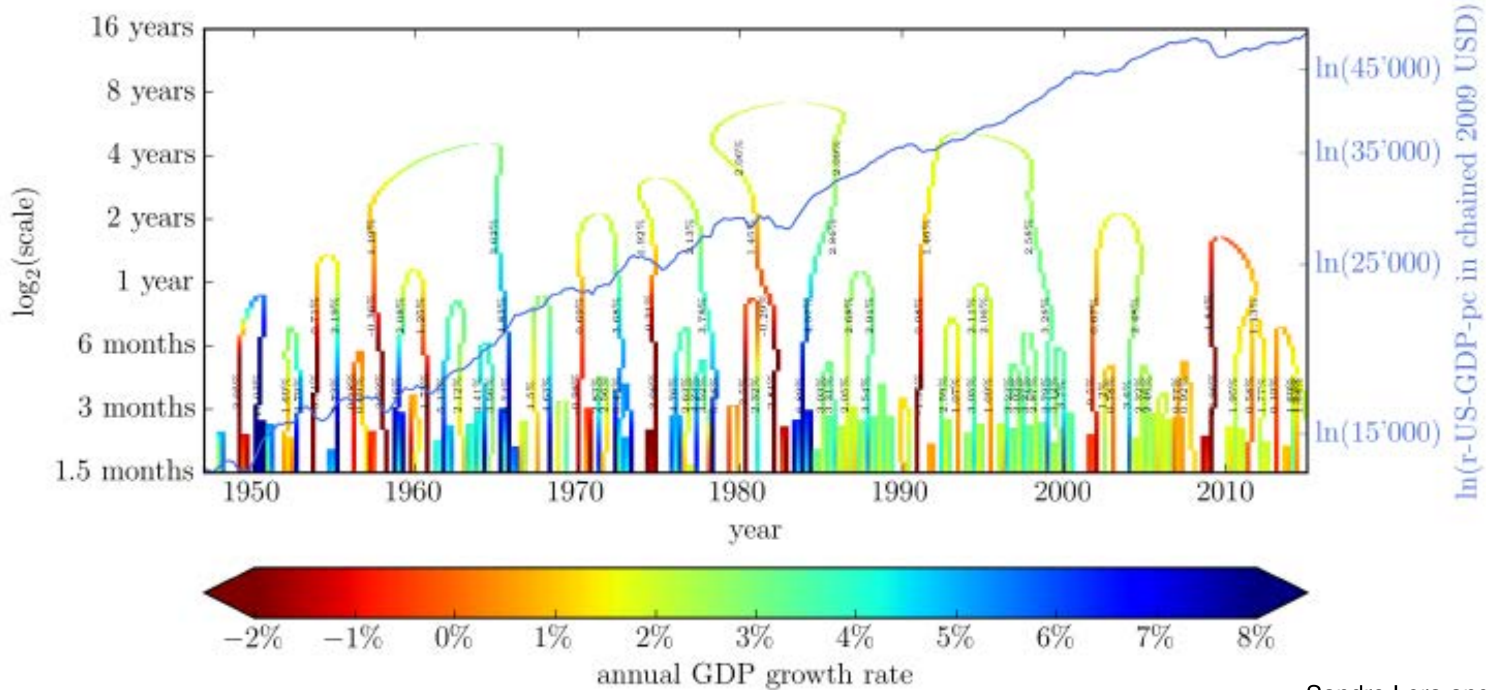


Figure 1: Spectral density of r-US-GDP-pc data. We observe a scale-free continuum of scales with no clear peaks. A least squares fit determines an exponent of ≈ -1.80 for both the quarterly and the annual data set, thus classifying the GDP as a long-memory process.

mother wavelet: $$\psi^{(1)}(t;s) = \frac{t}{\sqrt{2\pi}s^3}\exp\left(-\frac{1}{2}\left(\frac{t}{s}\right)^2\right)$$





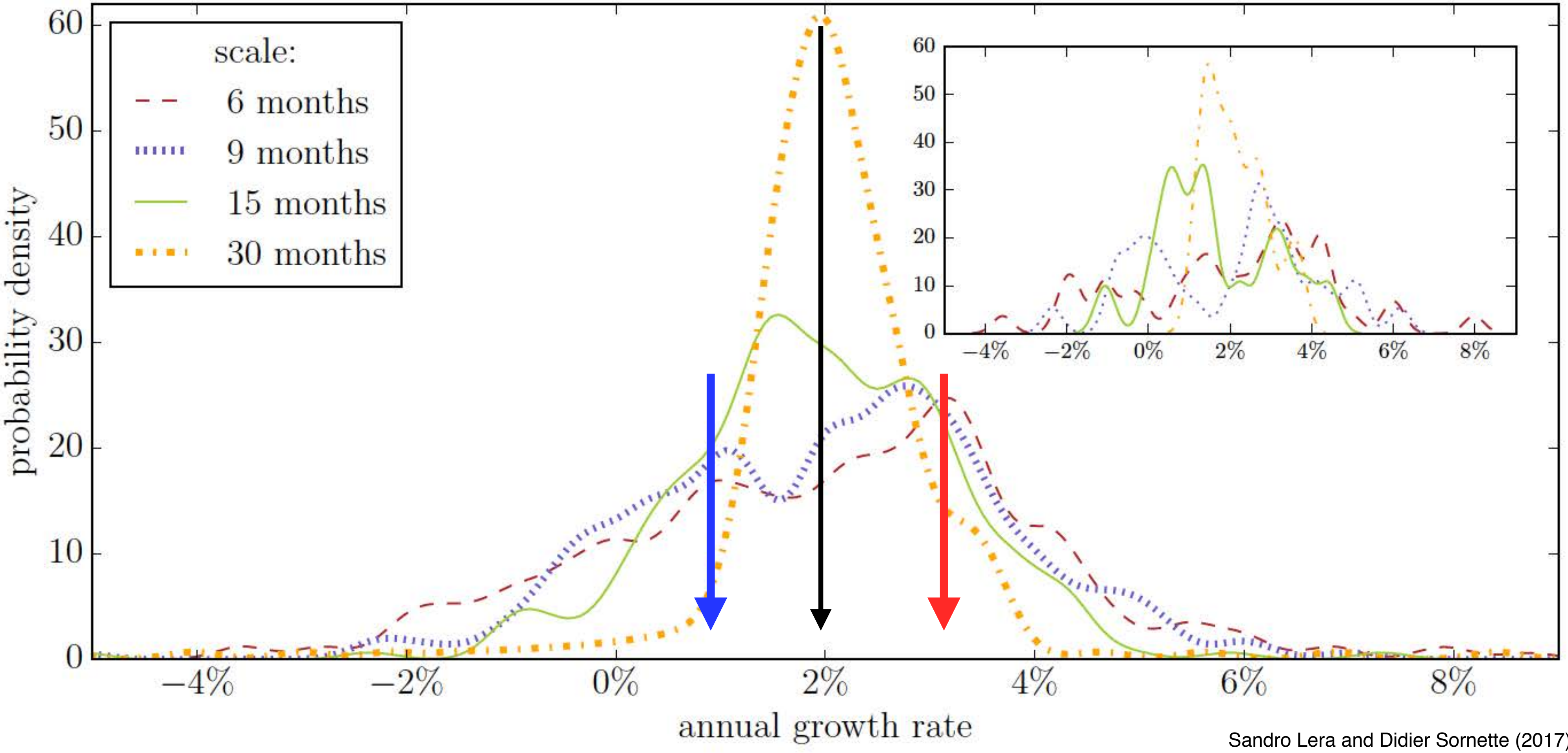
Sandro Lera and Didier Sornette (2017)

Secular bipolar growth rate of the real US GDP per capita

A long term average growth rate of real GDP per capita of 2% per year is obtained by regime shifts between regimes of high growth (~3% per year) and regimes of low growth (<1% per year).

$$\rho_{\mathrm{low}}(6\text{ months}) \approx 1\% \lesssim \rho_{\mathrm{low}}(9\text{ months}) \approx 1.1\% \lesssim \rho_{\mathrm{low}}(15\text{ months}) \approx 1.5\% \lesssim \rho_{\mathrm{lt}} \approx 2\%$$

$$\rho_{\mathrm{high}}(6\text{ months}) \approx 3.1\% \gtrsim \rho_{\mathrm{high}}(9\text{ months}) \approx 2.8\% \approx \rho_{\mathrm{high}}(15\text{ months}) \approx 2.8\% \gtrsim \rho_{\mathrm{lt}} \approx 2\%.$$



Sandro Lera and Didier Sornette (2017)

Structural characteristics of growth

- regime shifts and bimodal patterns

Lesson 1: growth occurs in cycles and there is persistent hubris in extrapolating the high-growth regimes

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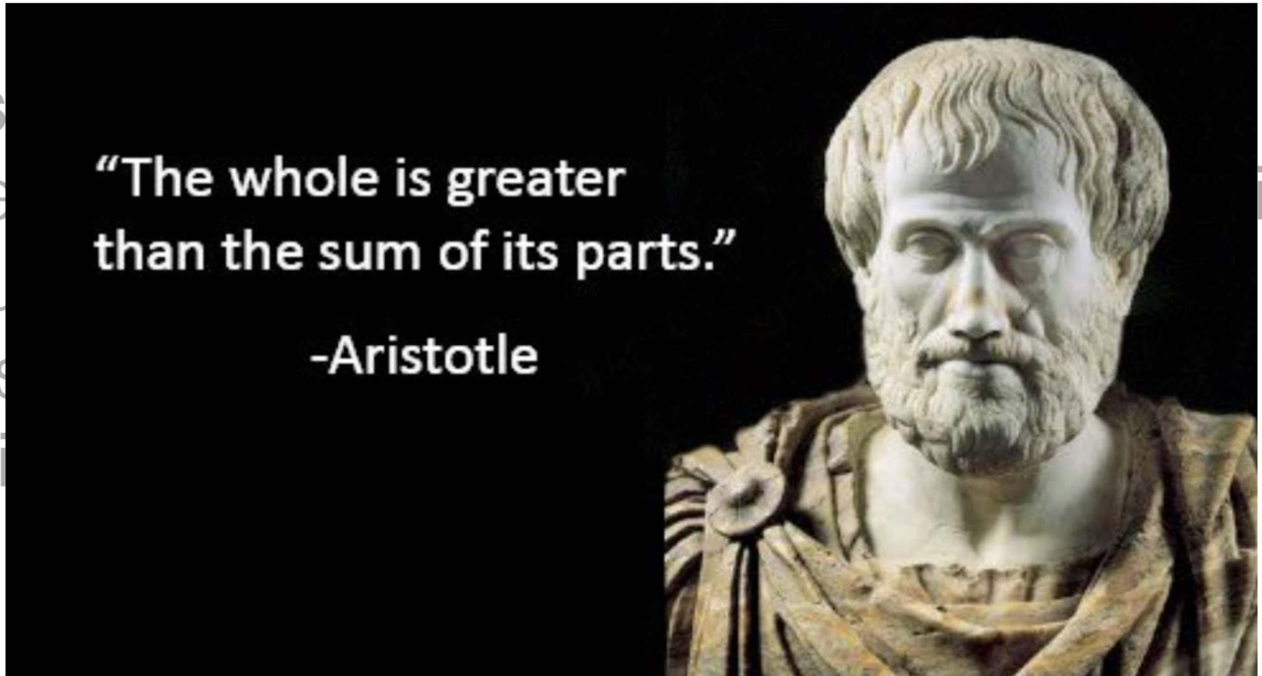
Growth s

- “Les tre ion of the perpetu
- The pos
- Proposi



How Much Is the Whole Really More than the Sum of Its Parts? 1⊞1 = 2.5: Superlinear Productivity in Collective Group Actions

PLoS ONE 9(8): e103023. doi:10.1371/journal.pone.0103023 (2014)

Didier Sornette[1*], Thomas Maillart[2], Giacomo Ghezzi[3]

1 Department of Management, Technology and Economics, ETH Zurich, Zurich, Switzerland, **2** School of Information, UC Berkeley, Berkeley, California, United States of America, **3** Department of Informatics, University of Zurich, Zurich, Switzerland

$$R \sim c^{\beta}$$

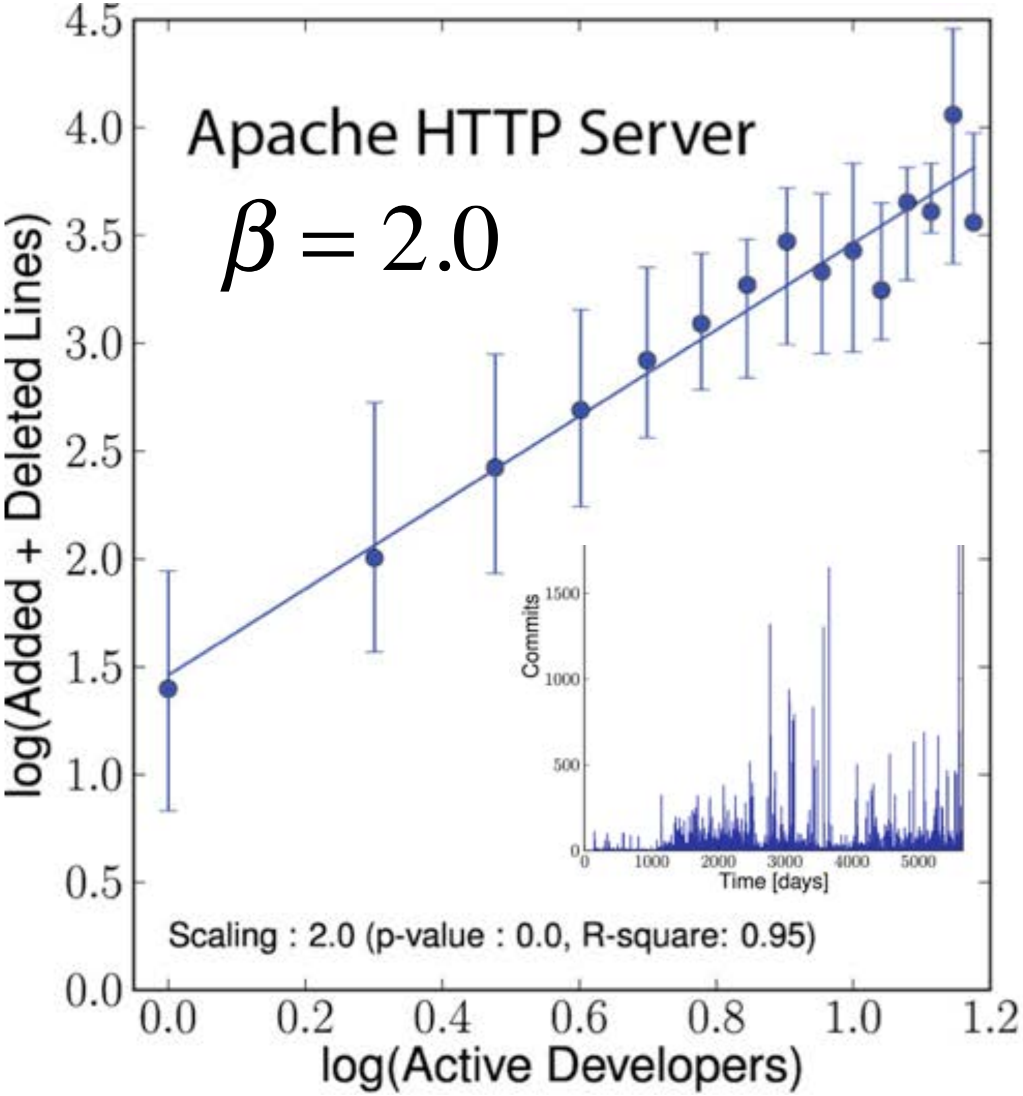
the production R is defined as the total number of commits measured per 5-day time windows for the Apache Web Server (http://httpd.apache.org/)

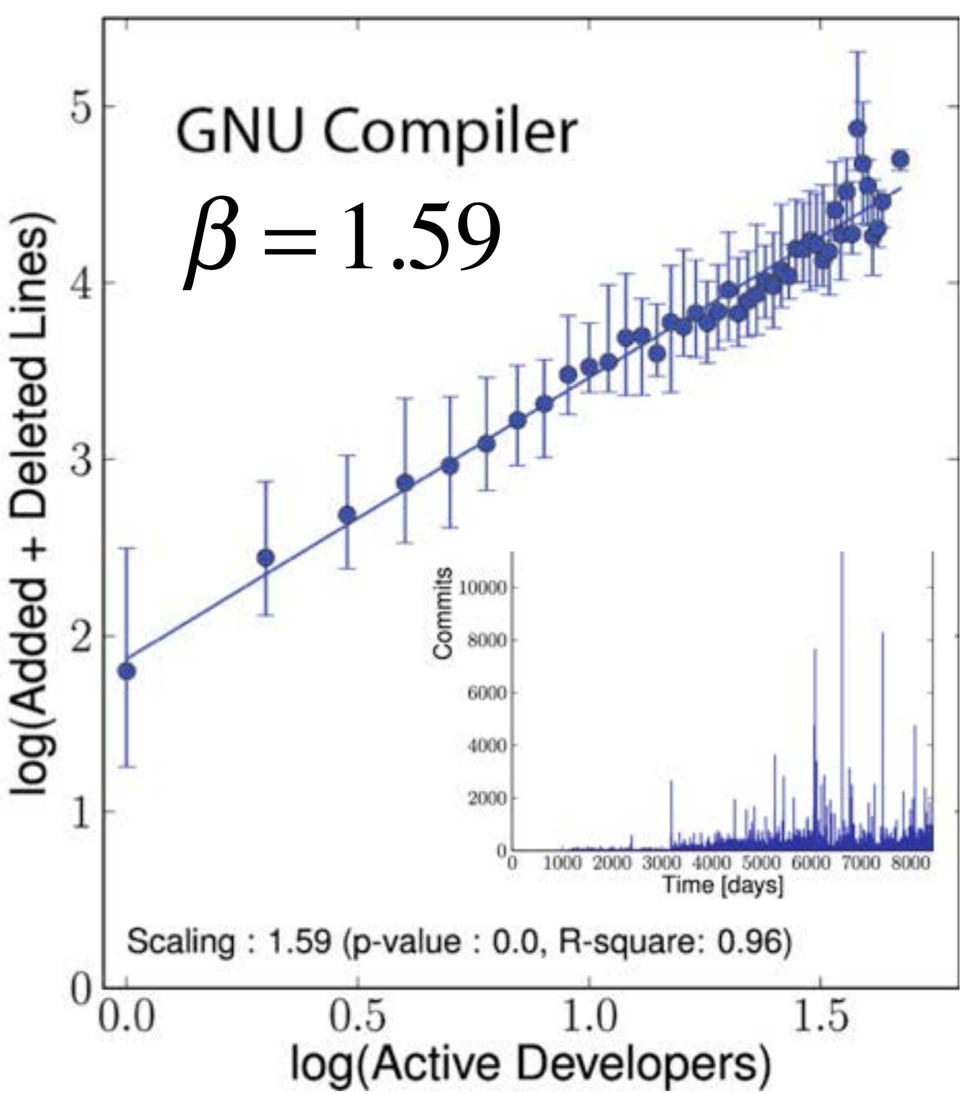
c is the number of active contributors in the same 5-day time windows.

1+1=2.5-3.5 !

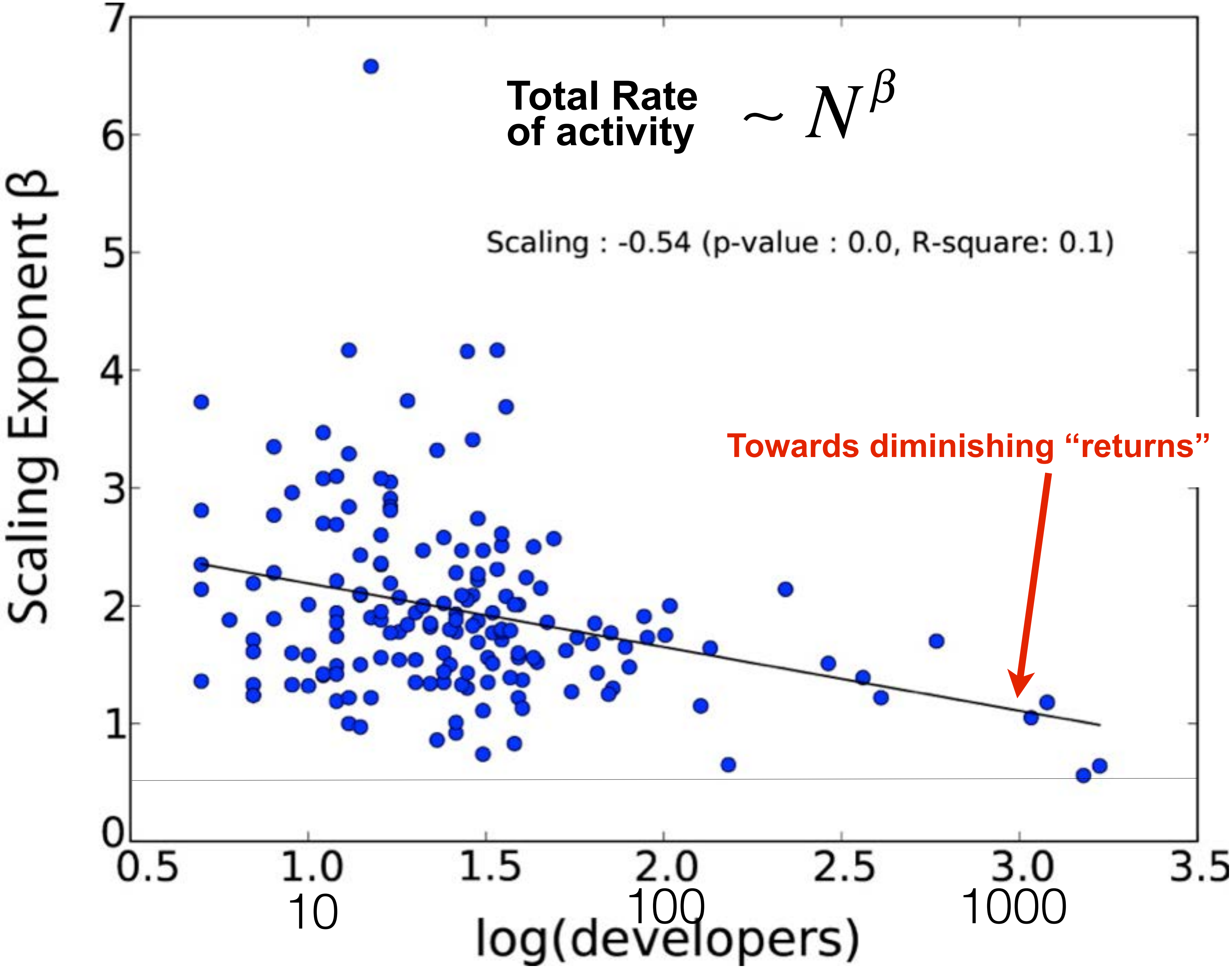
D. Sornette, T. Maillart and G. Ghezzi: How Much is the Whole Really More than the Sum of its Parts? 1 + 1 = 2.5: Superlinear Productivity in Collective Group Actions, PLoS ONE 9(8): e103023. doi:10.1371/journal.pone.0103023 (15 pp)

Total Rate of activity $\sim c^{\beta}$





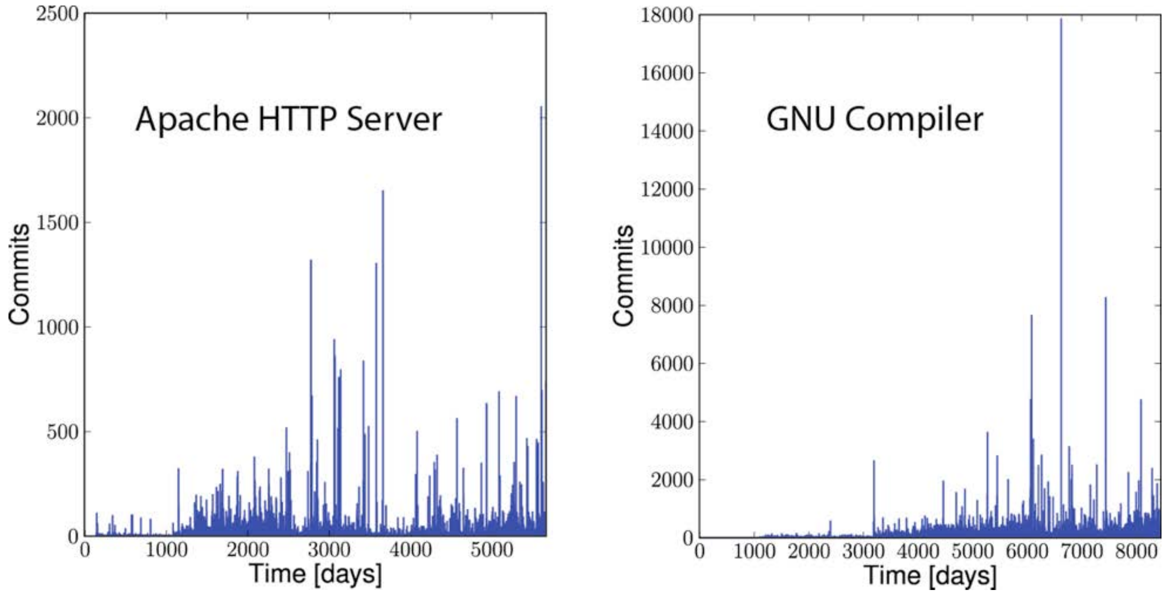
Total rate of activity (number of lines changed, added and/or deleted) as a function of the number N of active developers per three-day time bins for the projects



Sornette D, Maillart T, Ghezzi G (2014) How Much Is the Whole Really More than the Sum of Its Parts? 1+1= 2.5: Superlinear Productivity in Collective Group Actions. PLoS ONE 9(8): e103023. doi:10.1371/journal.pone.0103023

Designing Organizations for Productive/Creative Bursts

Georg von Krogh, Thomas Maillart, Stefan Haefliger, Didier Sornette



Six design principles to help managers deal with this challenge:

1) transparency;
2) bottom-up incentives and self-censored clans;
3) emergent technology;
4) problem front-loading;
5) distributed screening;
6) modularity

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The “Social Useful Bubble” Hypothesis

“Enthusiastic supporters of an idea / a project / an opportunity weave a network of reinforcing feedbacks based on exuberant anticipation that lead to widespread endorsement and extraordinary commitment beyond what would be rationalized by a standard cost-benefit analysis.”

How to engineer “useful bubbles” for innovation !

Monika Gisler and Didier Sornette (forthcoming). Early dynamics of a major scientific project: Testing the social bubble hypothesis. Science Technology and Innovation Studies, available at SSRN: (http://ssrn.com/abstract=2289226) (2016)

Monika Gisler and Didier Sornette, Bubbles Everywhere in Human Affairs, chapter in book entitled "Modern RISC-Societies. Towards a New Framework for Societal Evolution", L. Kajfez Bogataj, K.H. Mueller, I. Svetlik, N. Tos (eds.), Wien, edition echoraum: 137-153 (2010) (http://ssrn.com/abstract=1590816)

Monika Gisler, Didier Sornette and Ryan Woodard, Innovation as a Social Bubble: The Example of the Human Genome Project, Research Policy 40, 1412-1425 (2011) (http://arxiv.org/abs/1003.2882 and http://ssrn.com/abstract=1573682)

Monika Gisler and Didier Sornette, Exuberant Innovations: The Apollo Program, Society 46, 55-68 (2009), DOI: 10.1007/s12115-008-9163-8 (http://arxiv.org/abs/0806.0273 and http://ssrn.com/abstract=1139807)

D. Sornette, Nurturing Breakthroughs; Lessons from Complexity Theory, Journal of Economic Interaction and Coordination 3, 165-181 (2008), DOI: 10.1007/s11403-008-0040-8 (http://arxiv.org/abs/0706.1839)

The social Useful Bubble Hypothesis: “innovation accelerator”

DEFINITION: a social bubble developing during a technological project is defined when several of the following symptoms are simultaneously present:

(i) strong growth of presence in the media, newspapers, books, blogs, gossips, cocktails... ,

(ii) flow of venture capital and Wall Street investments,

(iii) accelerated price growth of corresponding firms trading on organized stock markets,

(iv) proliferation of ventures of all kinds (South Sea Bubble in 1720 and the ICT bubble crashing in 2000, Blockchain bubble since 2015…)

Four Case Studies So Far

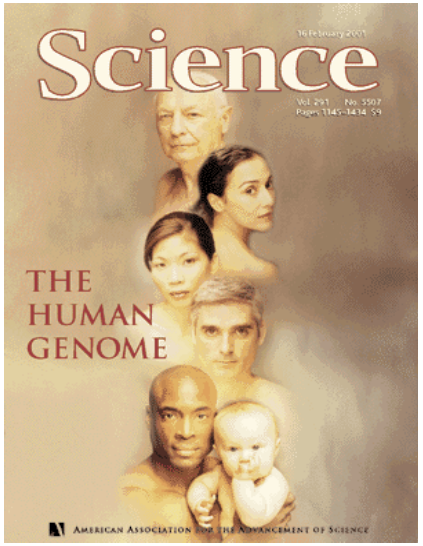
- The US Apollo Program (1960-1969)

- The Human Genome Project (1990-2003)

- The FuturICT Project (2010-2013)

- Green technologies (2003-2008)

The Human Genome Project (1990–2003)



- In February 2001, Celera and HGP scientists published details of their drafts (in *Science* and *Nature* respectively), describing the methods used and offering analysis of the sequence
- Improved drafts were announced and presented to the public in 2003, filling the open gaps

THE HUMAN GENOME

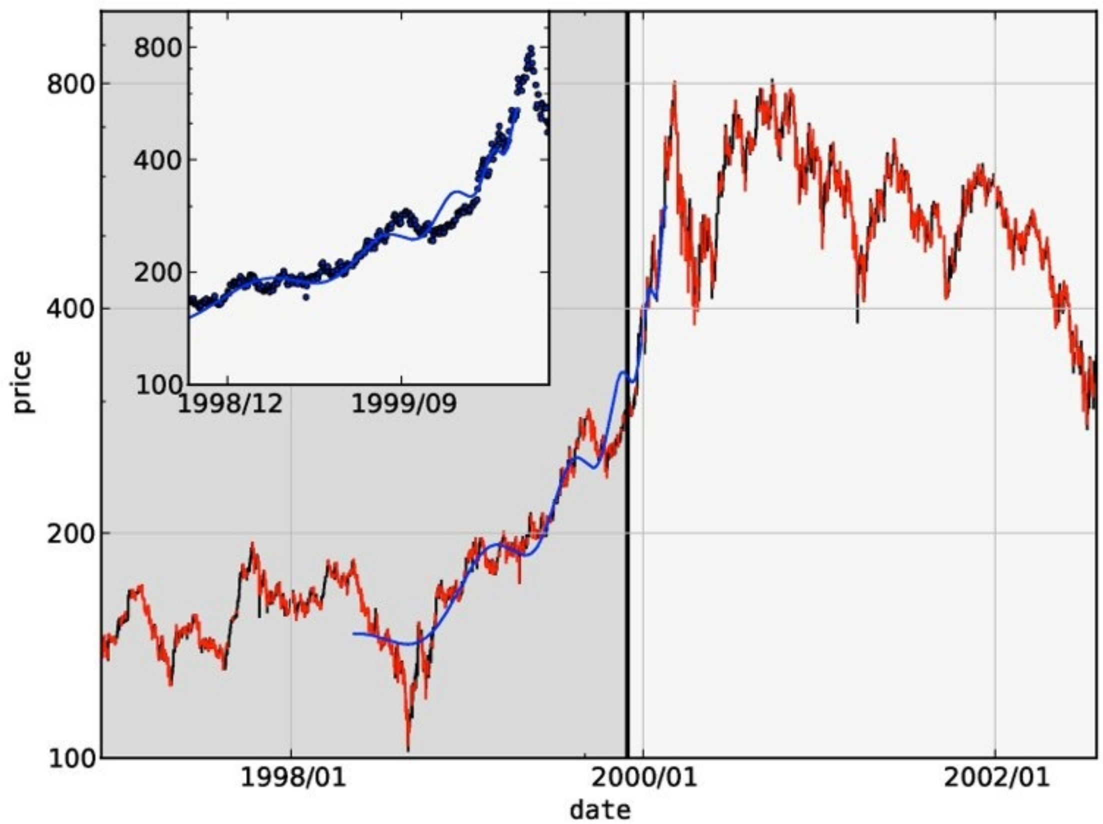
The Sequence of the Human Genome

J. Craig Venter,[1*] Mark D. Adams,[1] Eugene W. Myers,[1] Peter W. Li,[1] Richard J. Mural,[1] Granger G. Sutton,[1] Hamilton O. Smith,[1] Mark Yandell,[1] Cheryl A. Evans,[1] Robert A. Holt,[1] Jeannine D. Gocayne,[1] Peter Amanatides,[1] Richard M. Ballew,[1] Daniel H. Huson,[1] Jennifer Russo Wortman,[1] Qing Zhang,[1] Chinnappa D. Kodira,[1] Xiangqun H. Zheng,[1] Lin Chen,[1] Marian Skupski,[1] Gangadharan Subramanian,[1] Paul D. Thomas,[1] Jinghui Zhang,[1] George L. Gabor Miklos,[2] Catherine Nelson,[3] Samuel Broder,[1] Andrew G. Clark,[4] Joe Nadeau,[5] Victor A. McKusick,[6] Norton Zinder,[7] Arnold J. Levine,[7] Richard J. Roberts,[8] Mel Simon,[9] Carolyn Slayman,[10] Michael Hunkapiller,[11] Randall Bolanos,[1] Arthur Delcher,[1] Ian Dew,[1] Daniel Fasulo,[1] Michael Flanigan,[1] Liliana Florea,[1] Aaron Halpern,[1] Sridhar Hannenhalli,[1] Saul Kravitz,[1] Samuel Levy,[1] Clark Mobarry,[1] Knut Reinert,[1] Karin Remington,[1] Jane Abu-Threideh,[1] Ellen Beasley,[1] Kendra Biddick,[1] Vivien Bonazzi,[1] Rhonda Brandon,[1] Michele Cargill,[1] Ishwar Chandramouliswaran,[1] Rosane Charlab,[1] Kabir Chaturvedi,[1] Zuoming Deng,[1] Valentina Di Francesco,[1] Patrick Dunn,[1] Karen Eilbeck,[1] Carlos Evangelista,[1] Andrei E. Gabrielian,[1] Weiniu Gan,[1] Wangmao Ge,[1] Fangcheng Gong,[1] Zhiping Gu,[1] Ping Guan,[1] Thomas J. Heiman,[1] Maureen E. Higgins,[1] Rui-Ru Ji,[1] Zhaoxi Ke,[1] Karen A. Ketchum,[1] Zhongwu Lai,[1] Yiding Lei,[1] Zhenya Li,[1] Jiayin Li,[1] Yong Liang,[1] Xiaoying Lin,[1] Fu Lu,[1] Gennady V. Merkulov,[1] Natalia Milshina,[1] Helen M. Moore,[1] Ashwinikumar K Naik,[1] Vaibhav A. Narayan,[1] Beena Neelam,[1] Deborah Nusskern,[1] Douglas B. Rusch,[1] Steven Salzberg,[12] Wei Shao,[1] Bixiong Shue,[1] Jingtao Sun,[1] Zhen Yuan Wang,[1] Aihui Wang,[1] Xin Wang,[1] Jian Wang,[1] Ming-Hui Wei,[1] Ron Wides,[13] Chunlin Xiao,[1] Chunhua Yan,[1] Alison Yao,[1] Jane Ye,[1] Ming Zhan,[1] Weiqing Zhang,[1] Hongyu Zhang,[1] Qi Zhao,[1] Liansheng Zheng,[1] Fei Zhong,[1] Wenyan Zhong,[1] Shiaoping C. Zhu,[1] Shaying Zhao,[12] Dennis Gilbert,[1] Suzanna Baumhueter,[1] Gene Spier,[1] Christine Carter,[1] Anibal Cravchik,[1] Trevor Woodage,[1] Feroze Ali,[1] Huijin An,[1] Aderonke Awe,[1] Danita Baldwin,[1] Holly Baden,[1] Mary Barnstead,[1] Ian Barrow,[1] Karen Beeson,[1] Dana Busam,[1] Amy Carver,[1] Angela Center,[1] Ming Lai Cheng,[1] Liz Curry,[1] Steve Danaher,[1] Lionel Davenport,[1] Raymond Desilets,[1] Susanne Dietz,[1] Kristina Dodson,[1] Lisa Doup,[1] Steven Ferriera,[1] Neha Garg,[1] Andres Gluecksmann,[1] Brit Hart,[1] Jason Haynes,[1] Charles Haynes,[1] Cheryl Heiner,[1] Suzanne Hladun,[1] Damon Hostin,[1] Jarrett Houck,[1] Timothy Howland,[1] Chinyere Ibegwam,[1] Jeffery Johnson,[1] Francis Kalush,[1] Lesley Kline,[1] Shashi Koduru,[1] Amy Love,[1] Felecia Mann,[1] David May,[1] Steven McCawley,[1] Tina McIntosh,[1] Ivy McMullen,[1] Mee Moy,[1] Linda Moy,[1] Brian Murphy,[1] Keith Nelson,[1] Cynthia Pfannkoch,[1] Eric Pratts,[1] Vinita Puri,[1] Hina Qureshi,[1] Matthew Reardon,[1] Robert Rodriguez,[1] Yu-Hui Rogers,[1] Deanna Romblad,[1] Bob Ruhfel,[1] Richard Scott,[1] Cynthia Sitter,[1] Michelle Smallwood,[1] Erin Stewart,[1] Renee Strong,[1] Ellen Suh,[1] Reginald Thomas,[1] Ni Ni Tint,[1] Sukyee Tse,[1] Claire Vech,[1] Gary Wang,[1] Jeremy Wetter,[1] Sherita Williams,[1] Monica Williams,[1] Sandra Windsor,[1] Emily Winn-Deen,[1] Keriellen Wolfe,[1] Jayshree Zaveri,[1] Karena Zaveri,[1] Josep F. Abril,[14] Roderic Guigó,[14] Michael J. Campbell,[1] Kimmen V. Sjolander,[1] Brian Karlak,[1] Anish Kejariwal,[1] Huaiyu Mi,[1] Betty Lazareva,[1] Thomas Hatton,[1] Apurva Narechania,[1] Karen Diemer,[1] Anushya Muruganujan,[1] Nan Guo,[1] Shinji Sato,[1] Vineet Bafna,[1] Sorin Istrail,[1] Ross Lippert,[1] Russell Schwartz,[1] Brian Walenz,[1] Shibu Yooseph,[1] David Allen,[1] Anand Basu,[1] James Baxendale,[1] Louis Blick,[1] Marcelo Caminha,[1] John Carnes-Stine,[1] Parris Caulk,[1] Yen-Hui Chiang,[1] My Coyne,[1] Carl Dahlke,[1] Anne Deslattes Mays,[1] Maria Dombroski,[1] Michael Donnelly,[1] Dale Ely,[1] Shiva Esparham,[1] Carl Fosler,[1] Harold Gire,[1] Stephen Glanowski,[1] Kenneth Glasser,[1] Anna Glodek,[1] Mark Gorokhov,[1] Ken Graham,[1] Barry Gropman,[1] Michael Harris,[1] Jeremy Heil,[1] Scott Henderson,[1] Jeffrey Hoover,[1] Donald Jennings,[1] Catherine Jordan,[1] James Jordan,[1] John Kasha,[1] Leonid Kagan,[1] Cheryl Kraft,[1] Alexander Levitsky,[1] Mark Lewis,[1] Xiangjun Liu,[1] John Lopez,[1] Daniel Ma,[1] William Majoros,[1] Joe McDaniel,[1] Sean Murphy,[1] Matthew Newman,[1] Trung Nguyen,[1] Ngoc Nguyen,[1] Marc Nodell,[1] Sue Pan,[1] Jim Peck,[1] Marshall Peterson,[1] William Rowe,[1] Robert Sanders,[1] John Scott,[1] Michael Simpson,[1] Thomas Smith,[1] Arlan Sprague,[1] Timothy Stockwell,[1] Russell Turner,[1] Eli Venter,[1] Mei Wang,[1] Meiyuan Wen,[1] David Wu,[1] Mitchell Wu,[1] Ashley Xia,[1] Ali Zandieh,[1] Xiaohong Zhu[1]

1304 16 FEBRUARY 2001 VOL 291 SCIENCE www.sciencemag.org

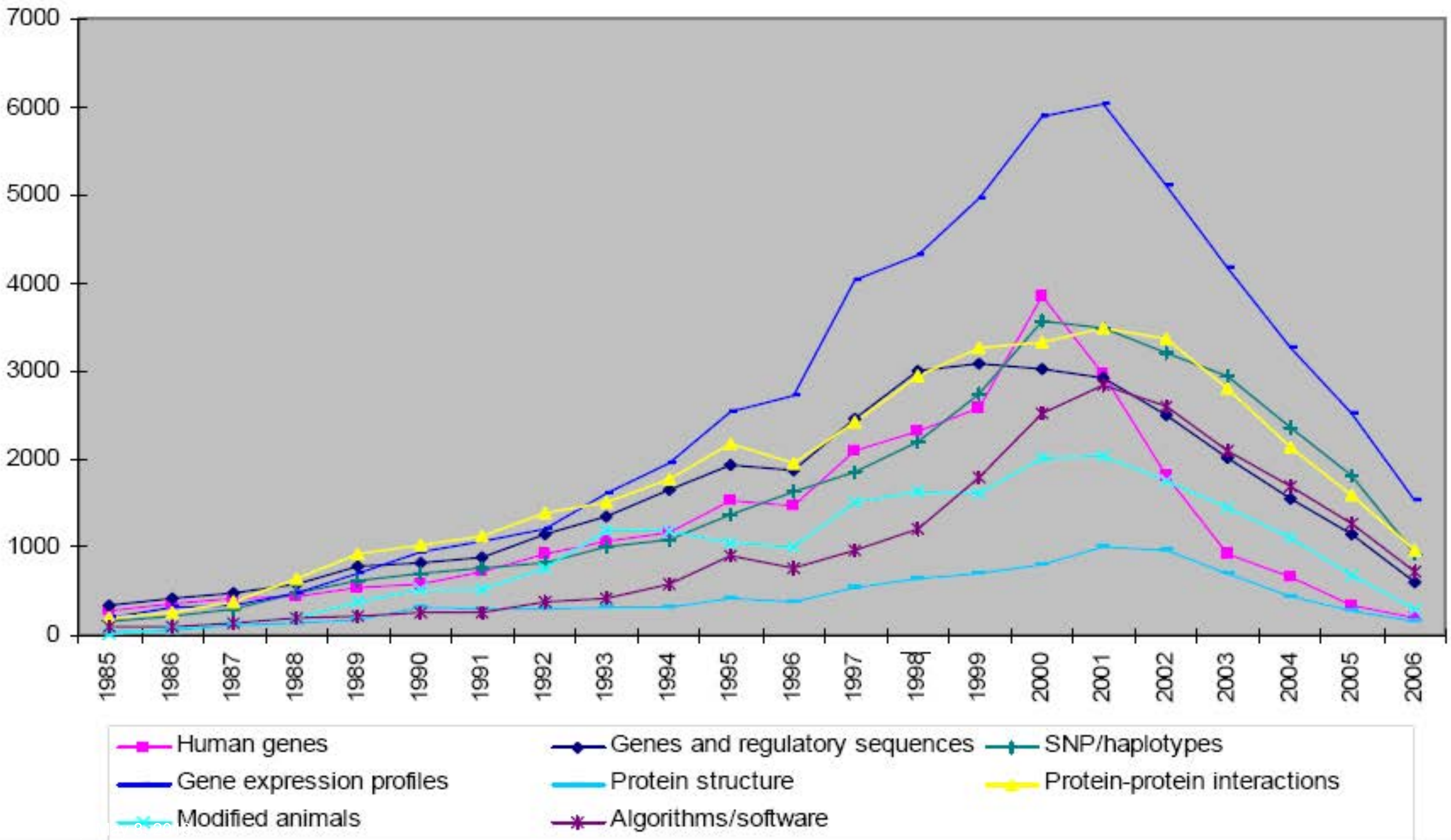
Financial bubble in biotech

The Figure provides the Biotech index over the time interval from (January) 1997 to (June) 2002. Its inset shows the same data magnified from June 1998 to April 2000. One can observe a more than quadrupling of the index from 1998 to the peak occurring in early March 2000



Genome patent applications

Patent applications p/y (1985-2006), peaking in late 2000/ early 2001



The Human Genome Project (1990–2003)

Anticipations of the commercial and medical applications of the HGP were highly inflated

Today, it is acknowledged that insight into the genetic mapping and sequencing effort is only seen as a starting point for future research in biology and medicine.

Contrary to claims during its development, the main fruits of the Human Genome Project have been **accruing to the research community, and almost nothing to medicine and the general public**.

But indirect technological gains values at >750 Billions USD by Obama's administration

The picture shows DNA Sequencing Machines at TIGR (downloaded from Independent Science News, May 8, 2013)

Present and future useful Social Bubbles

•biotech and nanotech, genomics, proteomics, personalised medicine

•Apps revolution

•open and big data revolution (+3-5 Trillion$ annually, McKinsey Oct. 2013)

•Blockchain v1.0 and v2.0 (“Internet of value”)

•Green tech revolution

•Gas and oil Fracking

•Space frontier (SpaceX, Orbital Science Corp., Virgin Galactic…)

•Ocean frontier

•Nuclear energy technology revolution

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The four industrial revolutions

Progress in the last 250 years has been marked by a series of "industrial revolutions" (IR):

- **Industrial Revolution #1** (1750 to 1850): coal, steel, steam and railroads;

- **Industrial Revolution #2** (1870 to 1930): electricity, internal combustion engine, cars, running water, indoor toilets, telephone, wireless telegraphy and radio, movies, petroleum, chemical:

- **Industrial Revolution #3** (1960 to 2000): electronics, computers, the web, the Internet, mobile phones;

- **Industrial Revolution #4** (on-going, from 2000 to the uncharted future): the progressive fusion of the physical, digital and biological worlds with cloud computing, information storage, the Internet of things, the blockchain technology revolution, artificial intelligence, intelligent robots, self-driving cars, genomics and gene editing, neuro-technological developments, enhanced humans…

(http://euanmearns.com/energy-and-mankind-part-3/).

Watt = unit of power
Joule = unit of work or energy

Energy Slaves

J = W * sec

1 average Man = 35 watt for 8 hours = 1.01 MJ
1 average draft horse = 746 watts for 8 hours = 21.5 MJ
1 "average" tractor = 200 hp = 149,200 watts (for 8 hours) = 4,296MJ
1 tonne oil equivalent = 12,000,000 watt hours = 43,000 MJ
23.5 grams of oil equivalent = 1 average man working for 8 hours

(1.01 / 43,000) * 10^6

OECD uses 5.5 billion toe per annum
Population = 1.179 billion
Per capita energy use = 4.7 toe per annum
= 197 GJ per capita per annum

giga = 10^9; mega = 10^6

197 GJ / 1.01 MJ = 195,000

195,000 slave days (8 hours) per person per annum

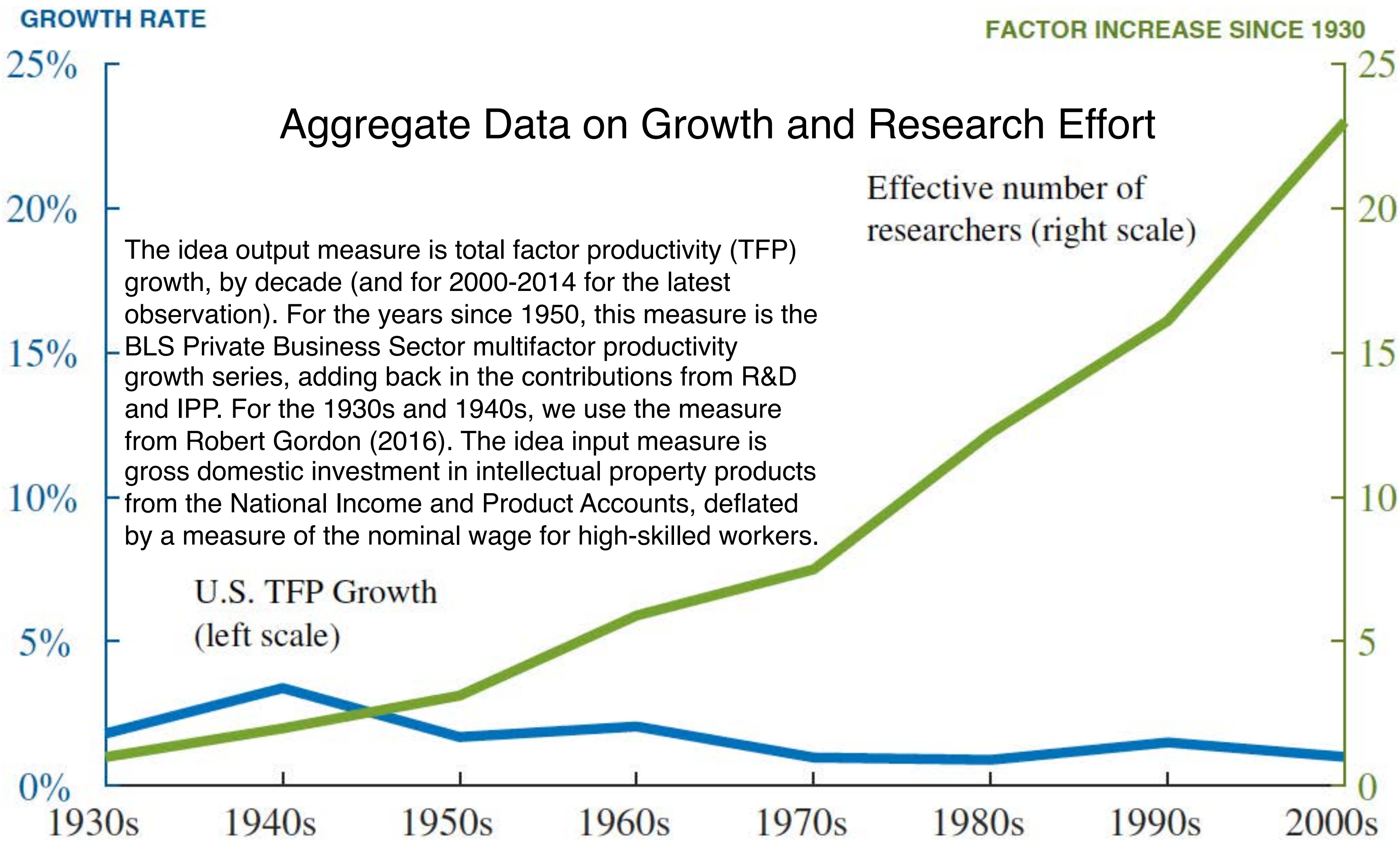
But we waste 2/3 of the energy we use
= 65,000 slave days per annum

178 energy slaves working for every OECD citizen every day

65,000 / 365 = 178

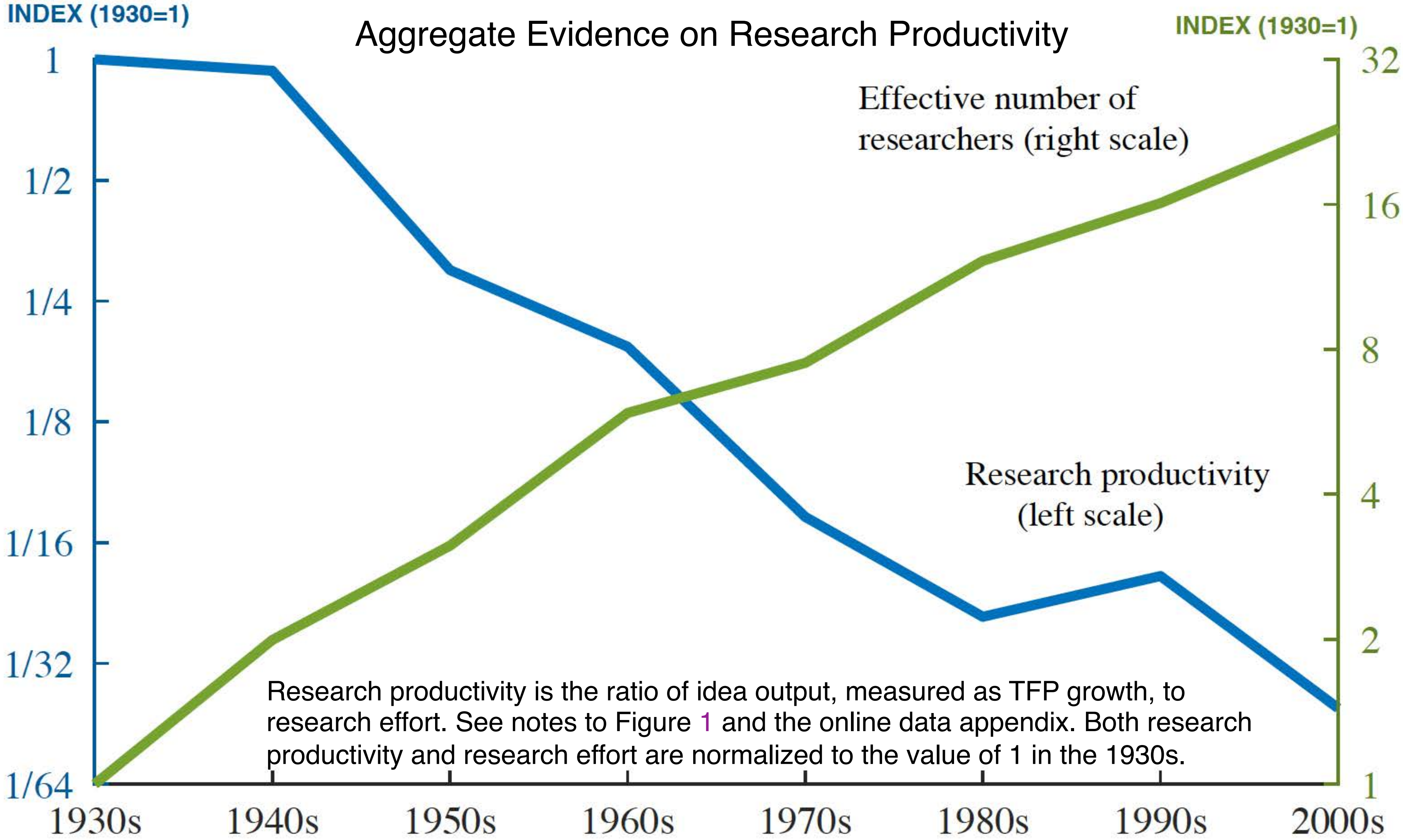
Economic growth = Research productivity × Number of researchers

e.g. 2% or 5% | ↓(falling) | ↑(rising)



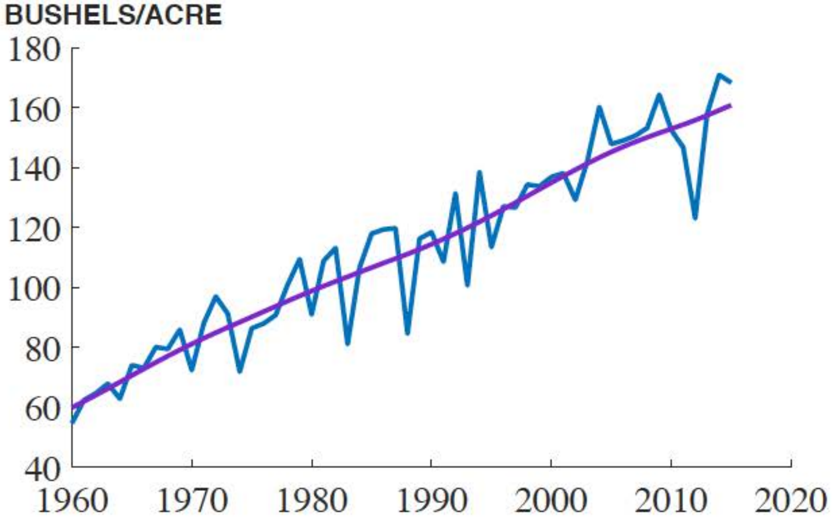
(Bloom et al., NBER Working Paper 23782 (2017))

Economic growth	=	Research productivity	×	Number of researchers
e.g. 2% or 5%		↓(falling)		↑(rising)

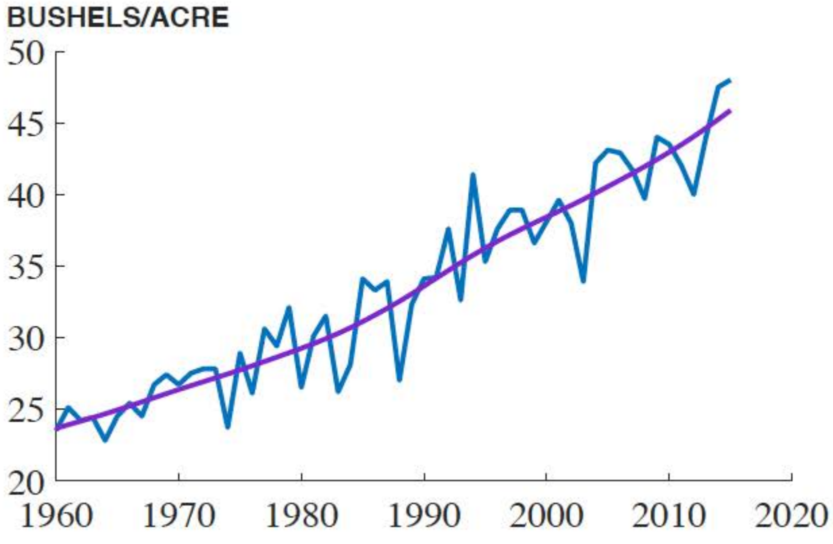


(Bloom et al., NBER Working Paper 23782 (2017))

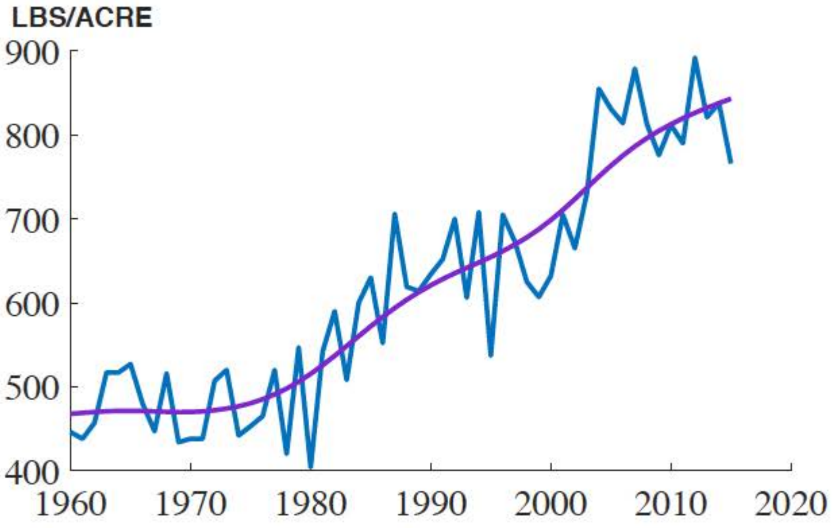
U.S. Crop Yields



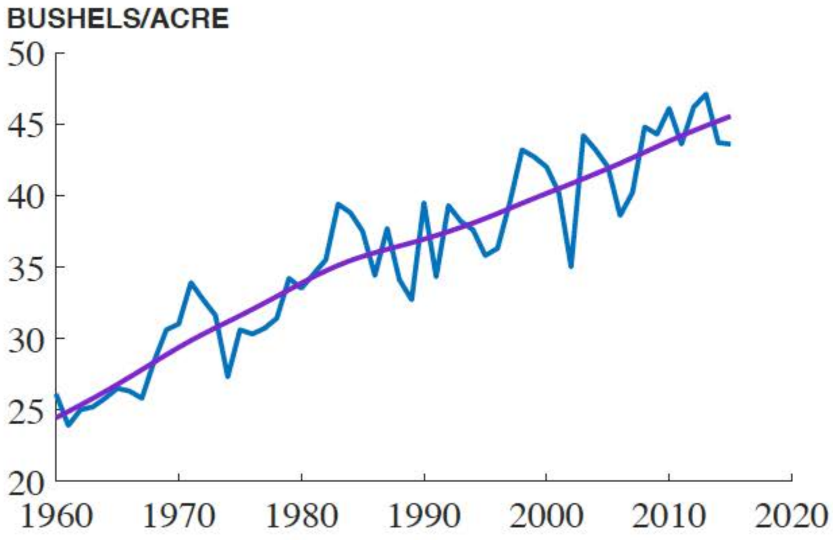
(a) Corn



(b) Soybeans



(c) Cotton

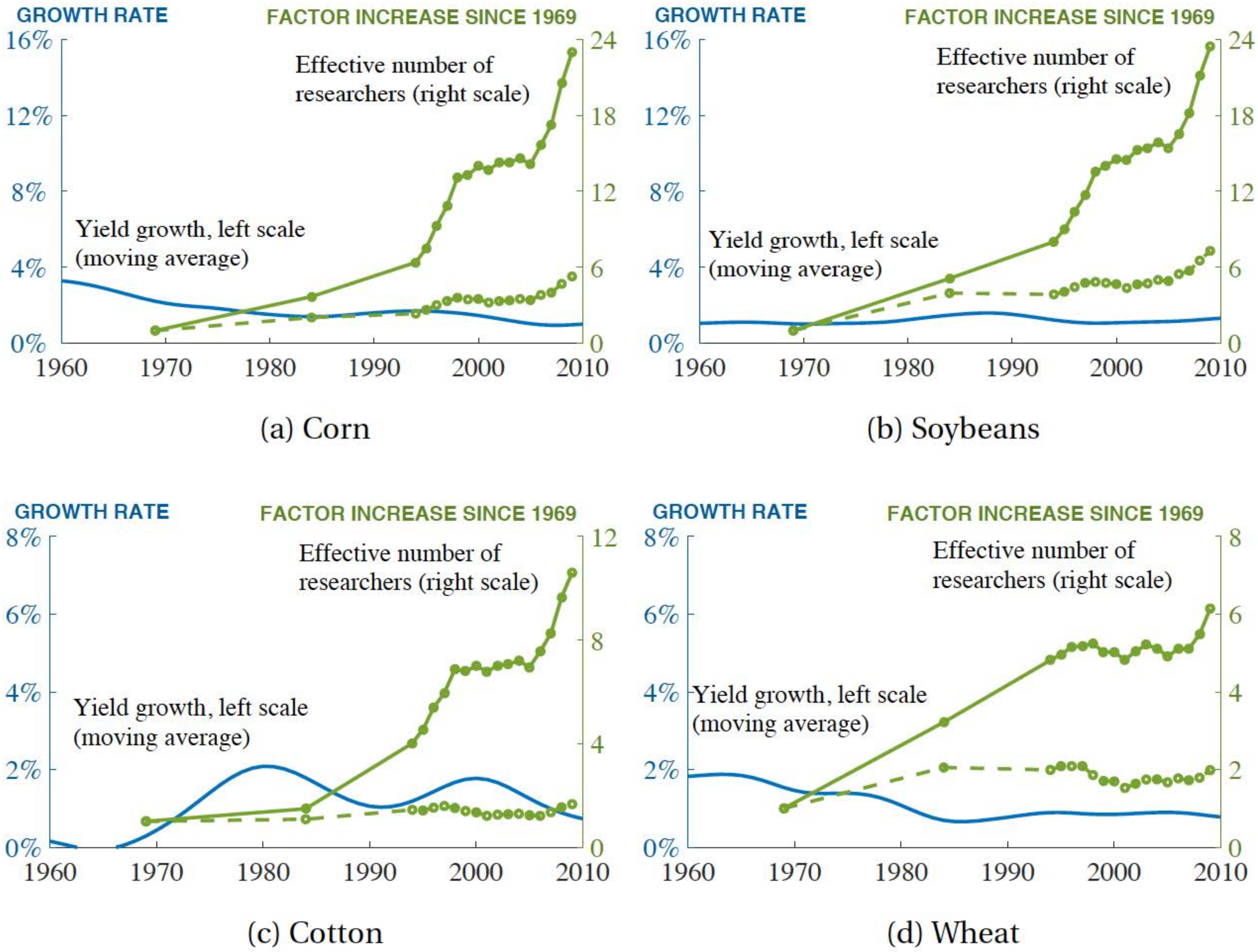


(d) Wheat

Smoothed yields are computed using an HP filter with a smoothing parameter of 400.

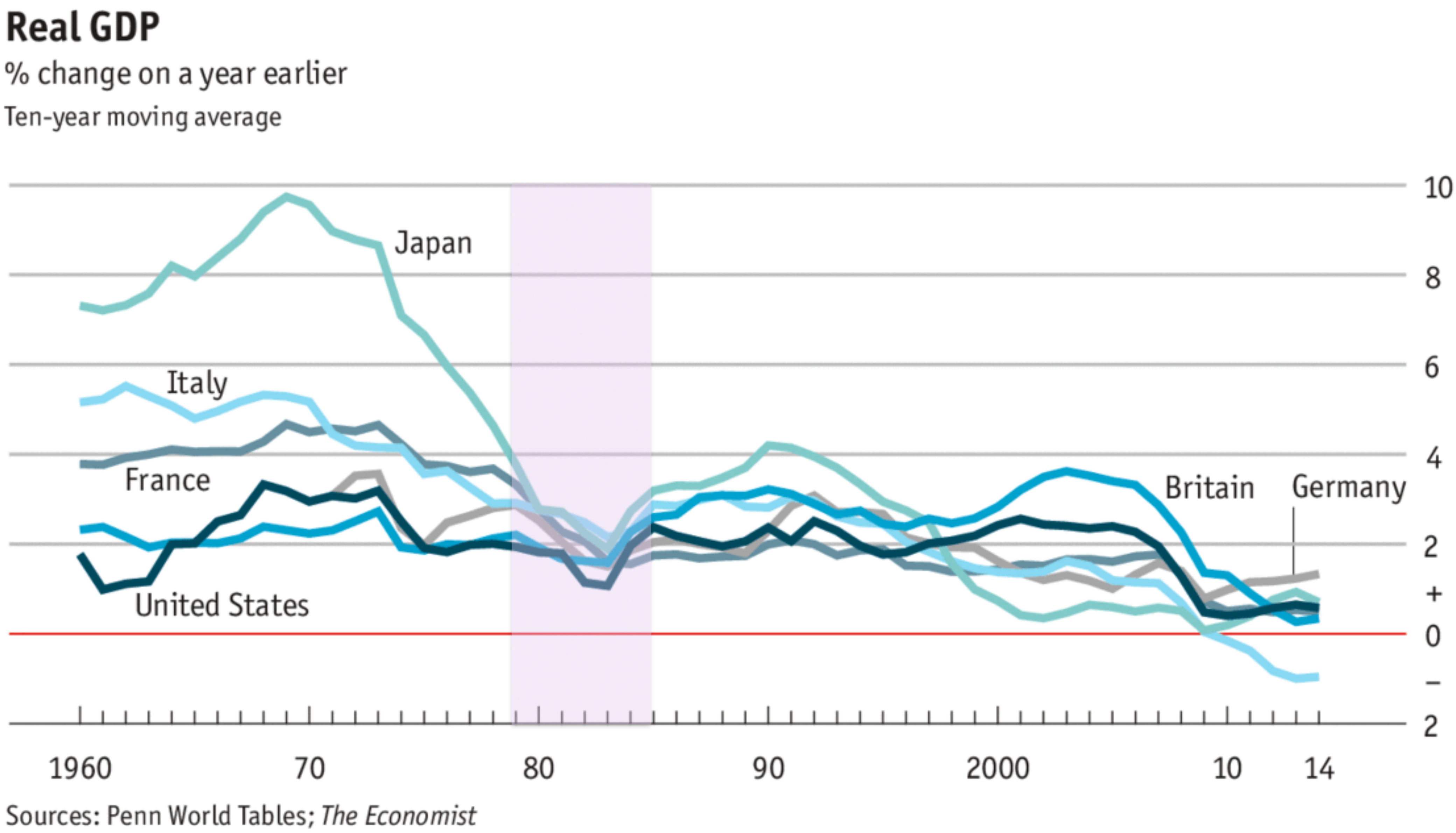
(Bloom et al., NBER Working Paper 23782 (2017))

Yield Growth and Research Effort by Crop



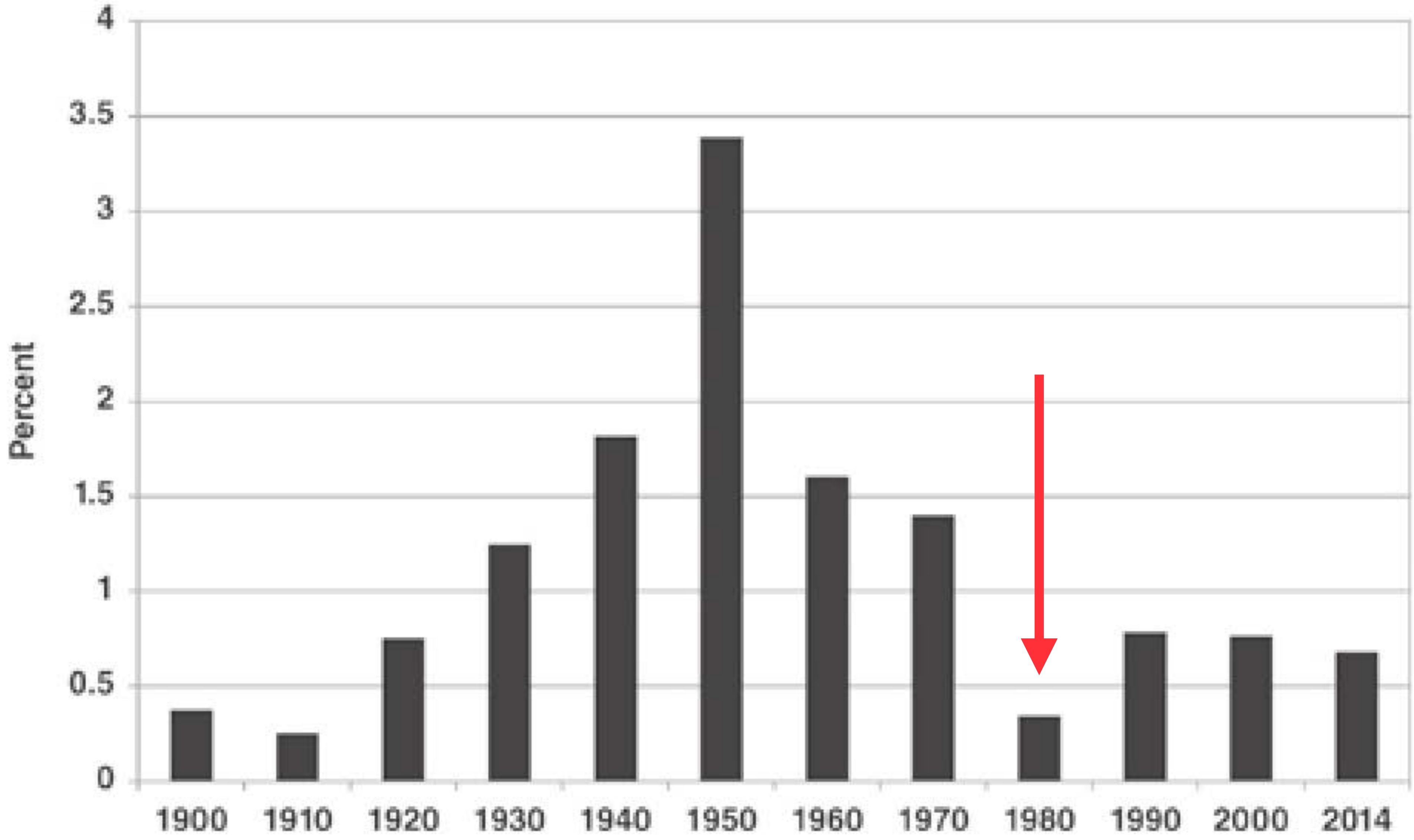
The blue line is the annual growth rate of the smoothed yields over the following 5 years, from the previous figure. The two green lines report "Effective Research": the solid line is based on R&D targeting seed efficiency only; the dashed line additionally includes research on crop protection. Both are normalized to one in 1969. R&Dexpenditures are deflated by a measure of the nominal wage for high-skilled workers.

decreasing productivity growth



10-Year Average Annual Growth in Total Factor Productivity, US, 1900–2014

Note: The average annual growth rate is over the ten years prior to year shown. The bar labelled 2014 shows the average annual growth rate for 2001–14



(Robert J. Gordon, The Rise and Fall of American Growth, 2016)

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- regime shifts and bimodal patterns
- 1+1=2.5 (superlinear productivity)
- the “social bubble” nature of great innovations

Growth fundamentals

- historical perspective: the four industrial revolutions
- productivity and innovation

Growth since WWII (1945 to present)

- “Les trentes glorieuses” followed by “the illusion of the perpetual money machine”
- The post-2008 crisis and “new normal”
- Propositions to resume a healthy growth

Fundamental origins of the on-going economic crises

1945-1970: reconstruction boom and consumerism

1971-1980: Bretton Woods system termination and oil shocks / inflation shocks

1981-2007: Illusion of the "perpetual money machine" and virtual financial wealth

2008-2020s: New era of pseudo growth fueled by QEs and other Central Banks+Treasuries actions

-very low interest rate for a very long time (decades)
-net erosion even in the presence of apparent low (disguised) inflation
-reassessment of expectation for the social and retirement liabilities
-a turbulent future with many transient bubbles
-need to capture value and be contrarian => exploit herding and fear

2020s-20xx: Interconnection of many systemic risks

Change from productivity-based growth to virtual-based growth around 1980

-direct evidence on productivity

-stock market is king

-financialisation

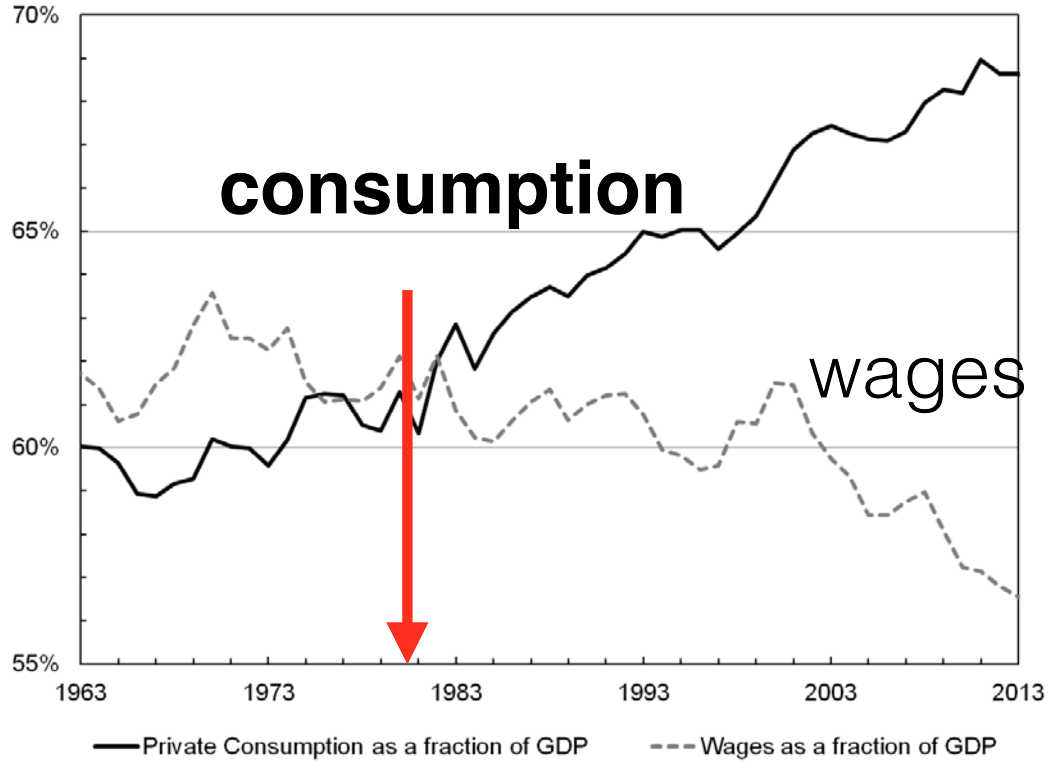
-debt

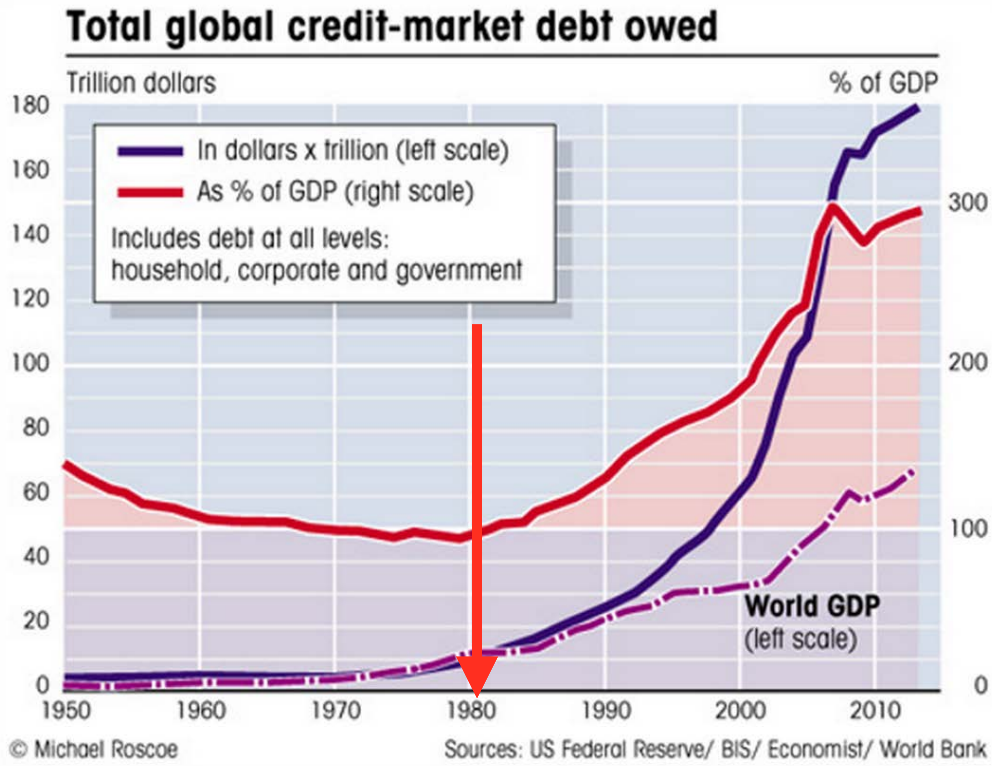
all change around 1980 !

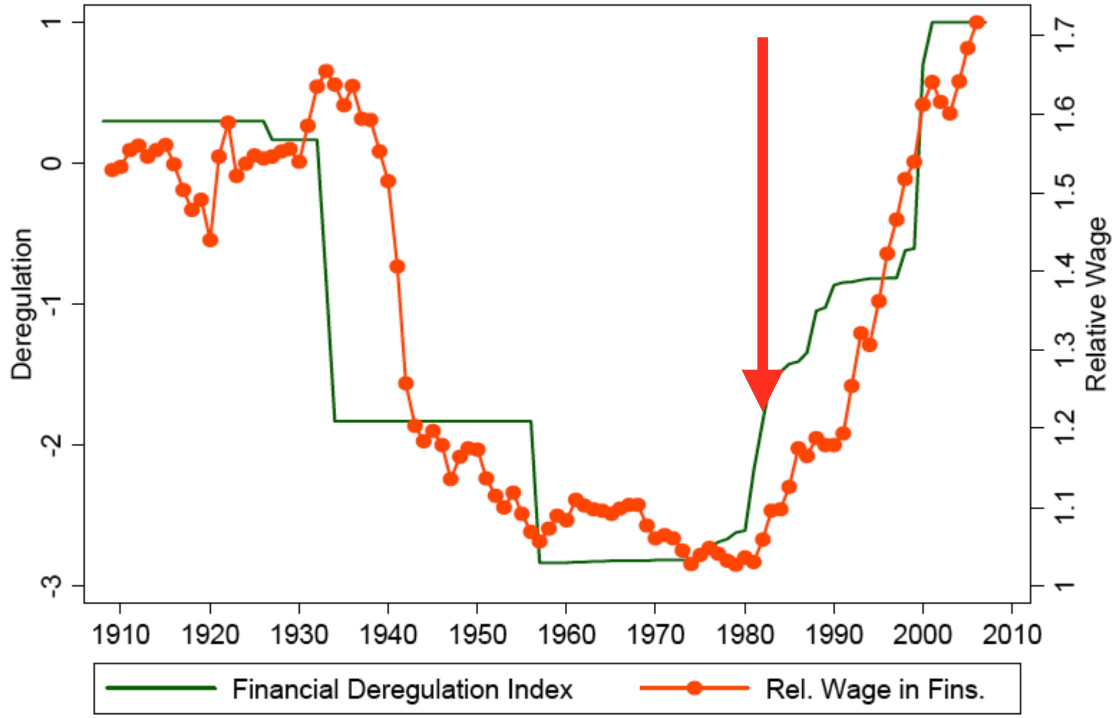
-monetary policies

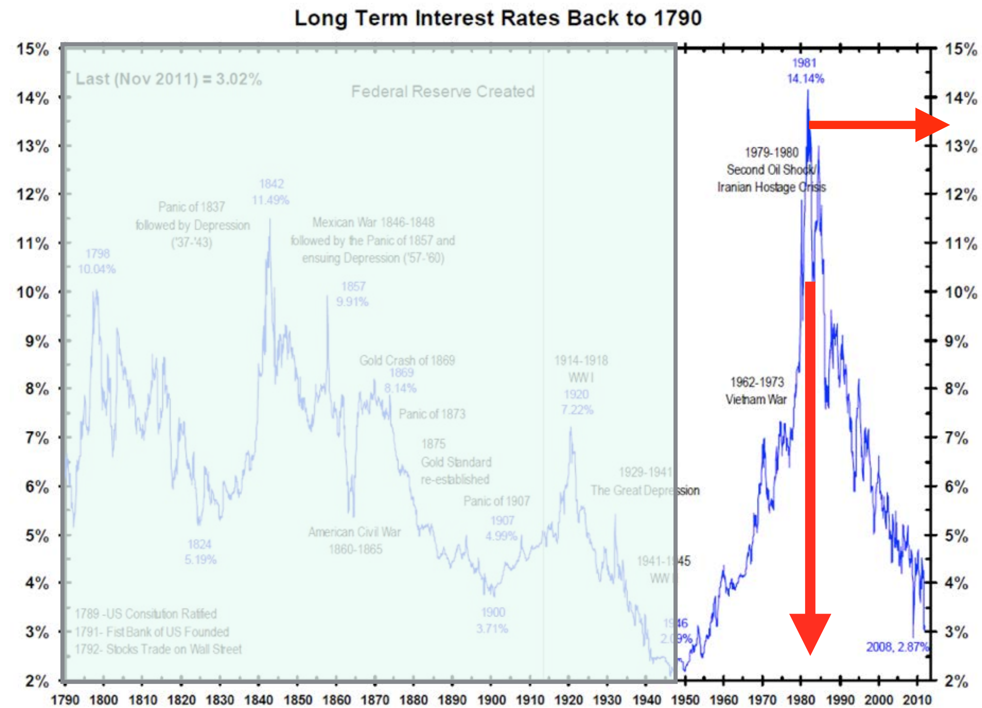
-government and fiscal policies

-inequality

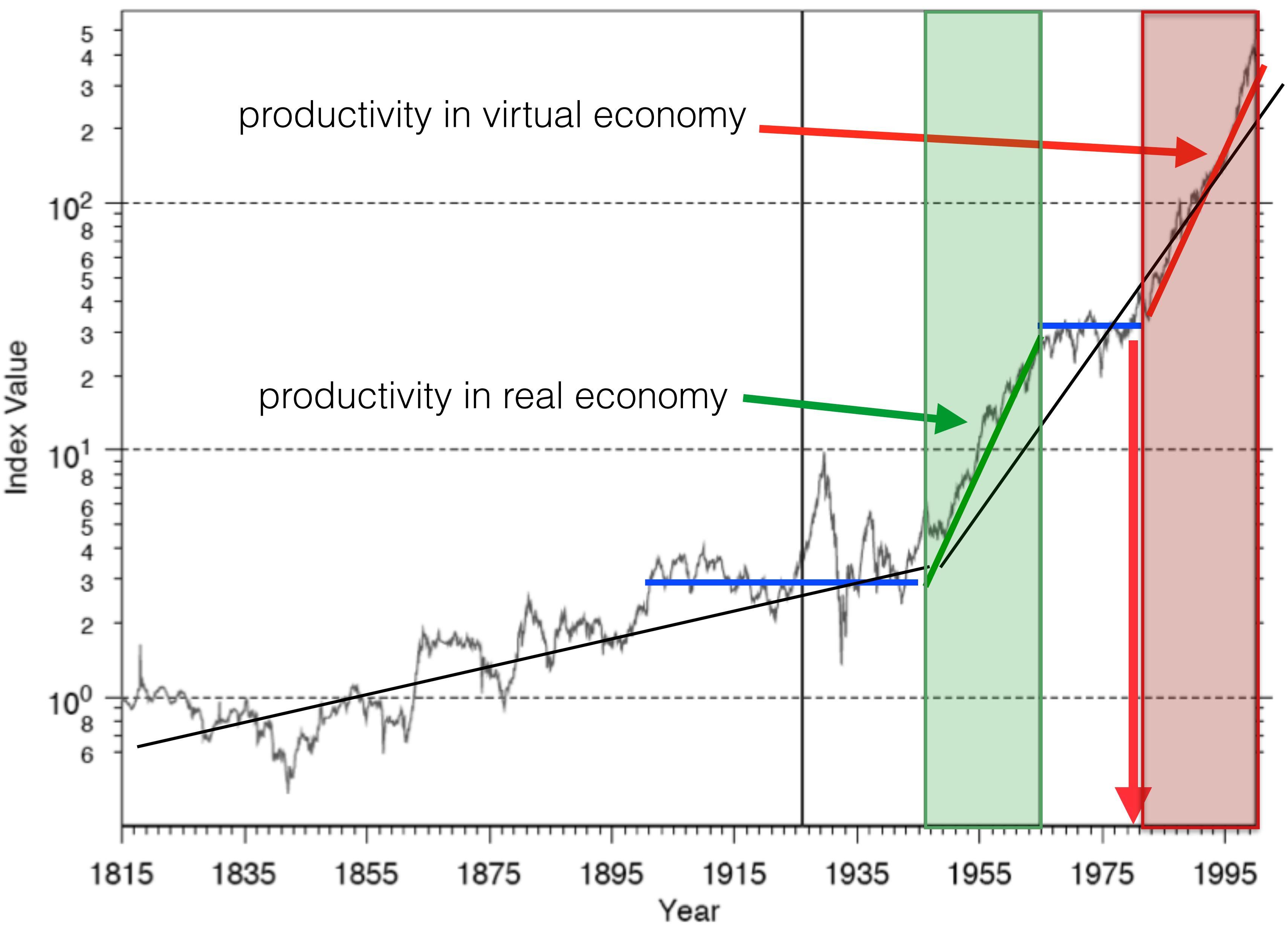

consumption
wages
70%
65%
60%
55%
1963
1973
1983
1993
2003
2013
Private Consumption as a fraction of GDP
Wages as a fraction of GDP


Total global credit-market debt owed
Trillion dollars
% of GDP
In dollars x trillion (left scale)
As % of GDP (right scale)
Includes debt at all levels:
household, corporate and government
World GDP
(left scale)
© Michael Roscoe
Sources: US Federal Reserve/ BIS/ Economist/ World Bank


Deregulation
Relative Wage
Financial Deregulation Index
Rel. Wage in Fins.


Long Term Interest Rates Back to 1790
Last (Nov 2011) = 3.02%
Federal Reserve Created
1981
14.14%
1979-1980
Second Oil Shock/
Iranian Hostage Crisis
1962-1973
Vietnam War
2008, 2.87%

Monthly capital appreciation index 1/1815-12/1999

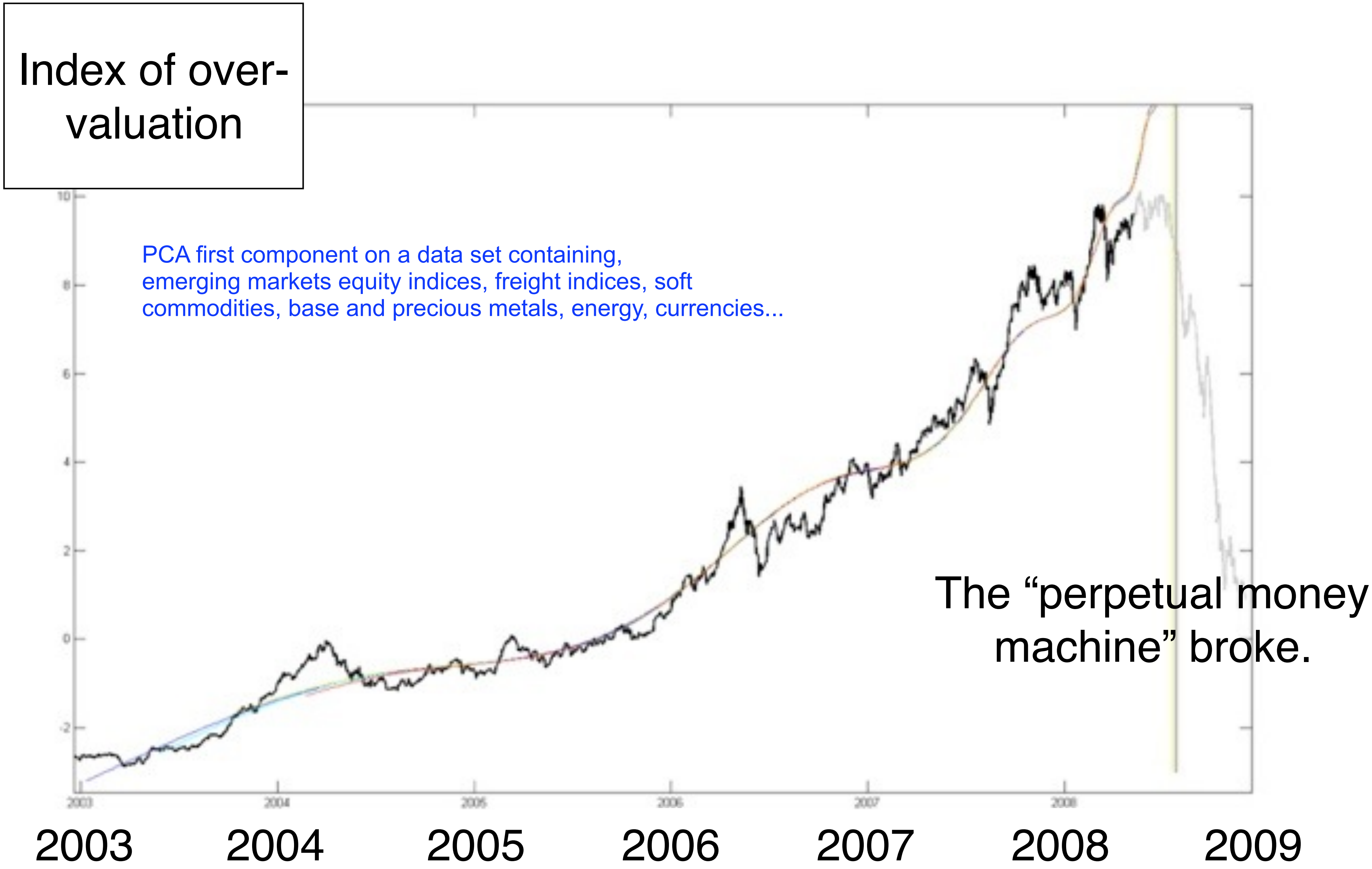


Price-weighted NYSE Index (1/1815-12/1925) with Ibbotson and Sinquefield Index (1/1926-12/1999)

A NEW HISTORICAL DATABASE FOR THE NYSE 1815 TO 1925: PERFORMANCE AND PREDICTABILITY

W.N. Goetzmann, R.G. Ibbotson and L. Peng
Yale School of Management, July 14, 2000

The Global Bubble that burst in 2008



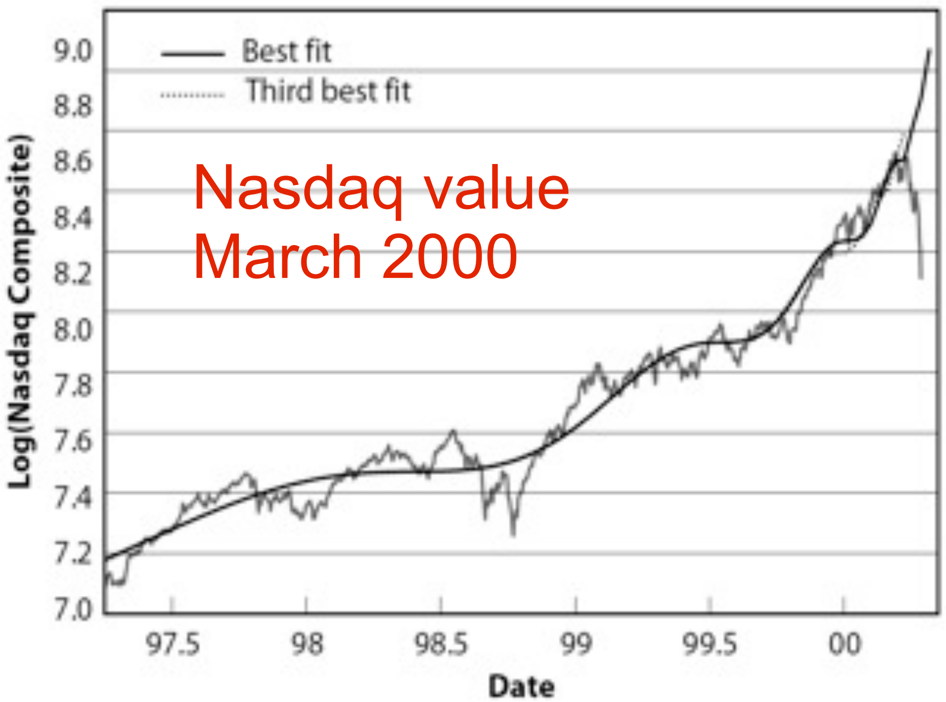
D. Sornette and P. Cauwels, 1980-2008: The Illusion of the Perpetual Money Machine and what it bodes for the future, Risks 2, 103-131 (2014)

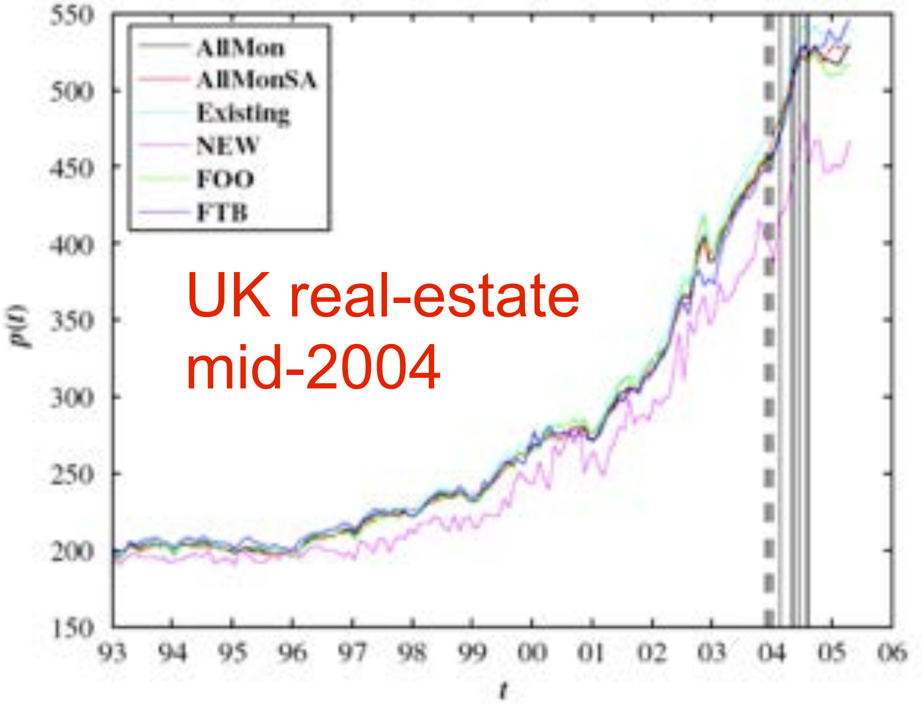
Since 1980, growth is powered by finance and debt

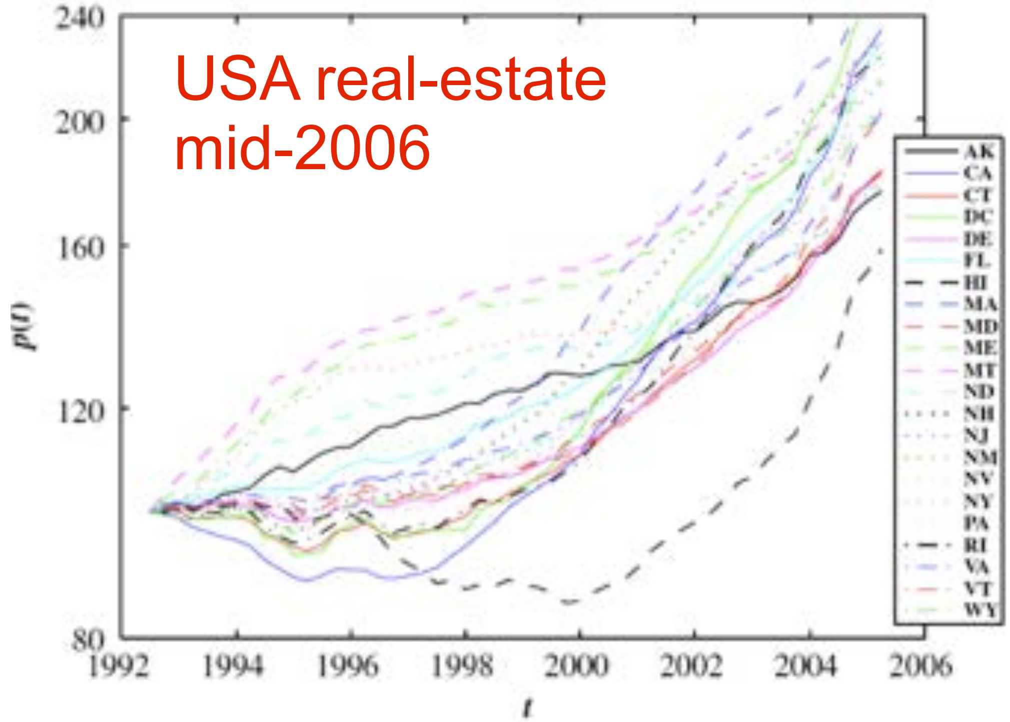
- Worldwide bubble and crash (1980- Oct. 1987)
- The ITC (dotcom) “new economy” bubble (1995-2000)
- Slaving of the Fed monetary policy to the stock market descent (2000-2003)
- Real-estate bubbles (2003-2006)
- MBS, CDOs bubble (2004-2007)
- Stock market bubble (2004-2007)
- Commodities and Oil bubbles (2006-2008)
- Debt and credit bubbles

D. Sornette and R. Woodard
Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis (2009)(http://arxiv.org/abs/0905.0220)

D. Sornette and P. Cauwels
1980-2008: The Illusion of the Perpetual Money Machine and what it bodes for the future, Risks 2, 103-131 (2014)

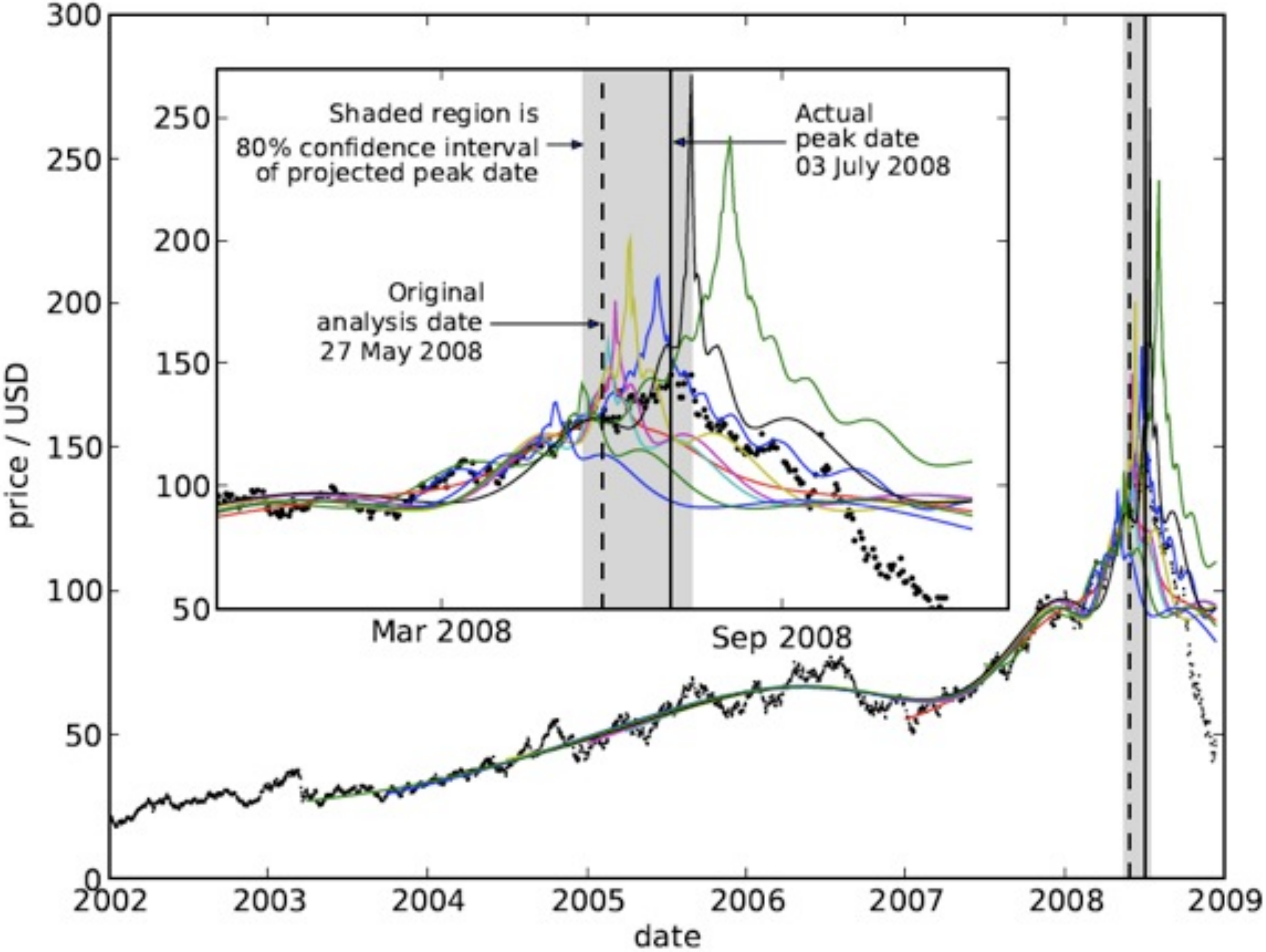

Nasdaq value
March 2000
Best fit
Third best fit
Log(Nasdaq Composite)
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
97.5
98
98.5
99
99.5
00
Date


UK real-estate
mid-2004
AllMon
AllMonSA
Existing
NEW
FOO
FTB
p(t)
550
500
450
400
350
300
250
200
150
93
94
95
96
97
98
99
00
01
02
03
04
05
06
t


USA real-estate
mid-2006
AK
CA
CT
DC
DE
FL
HI
MA
MD
ME
MT
ND
NH
NJ
NM
NV
NY
PA
RI
VA
VT
WY
p(t)
240
200
160
120
80
1992
1994
1996
1998
2000
2002
2004
2006
t

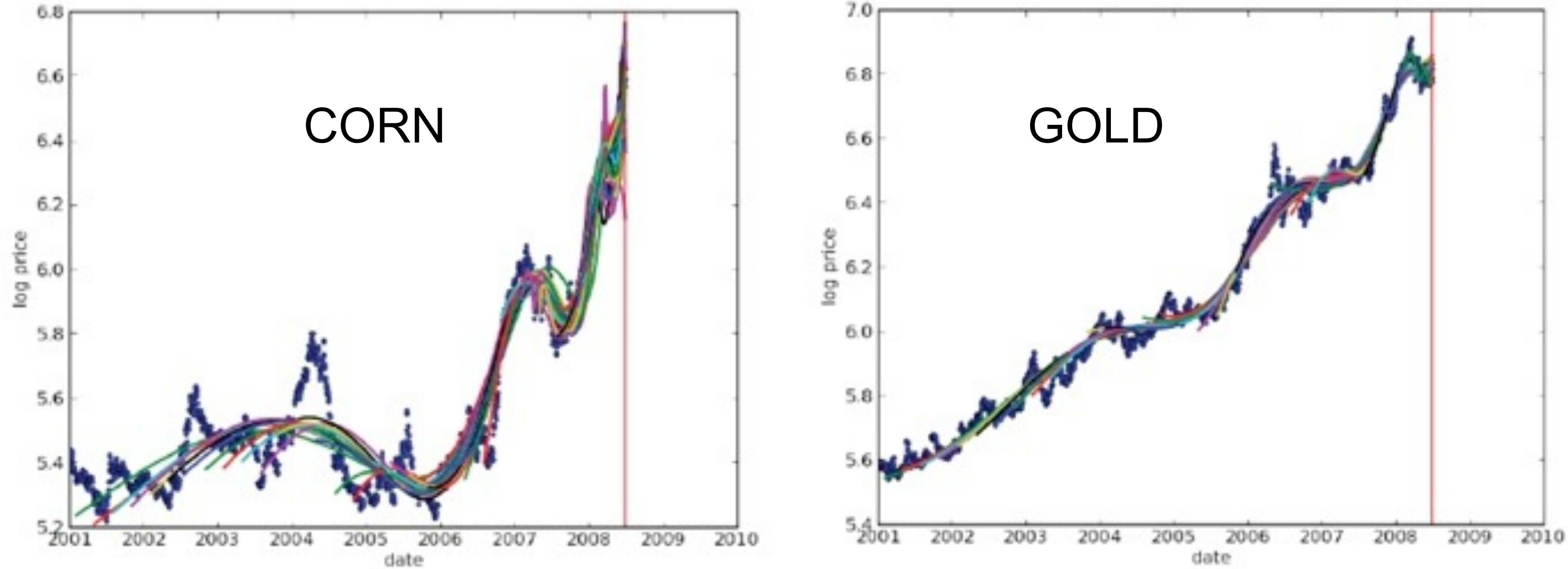

Index price vs. time, S&P 500
S&P500
Oct-2007
S&P 500 index price / USD
1700
1600
1500
1400
1300
1200
1100
1000
2003/12
2004/12
2005/12
2006/12
2007/12
2008/12
date

2006-2008 Oil bubble
Speculation vs supply-demand

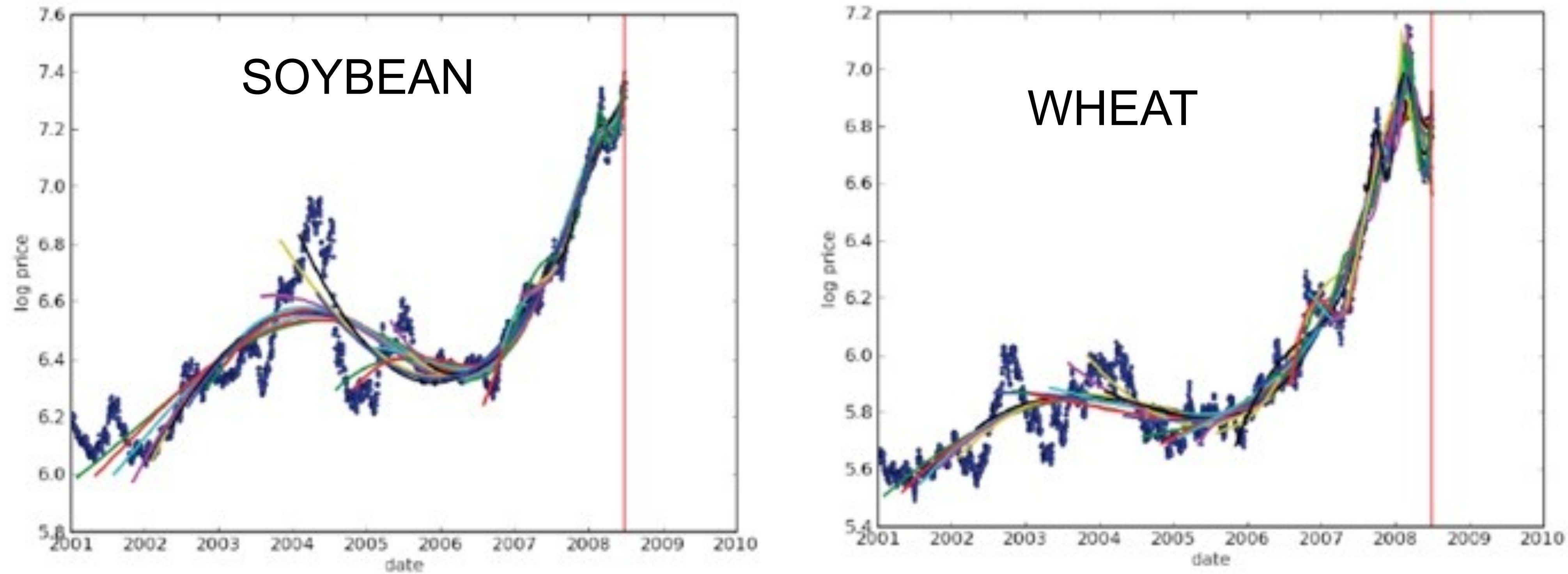


D. Sornette, R. Woodard and W.-X. Zhou, The 2006-2008 Oil Bubble and Beyond,
Physica A 388, 1571-1576 (2009)
(arXiv.org/abs/0806.1170)

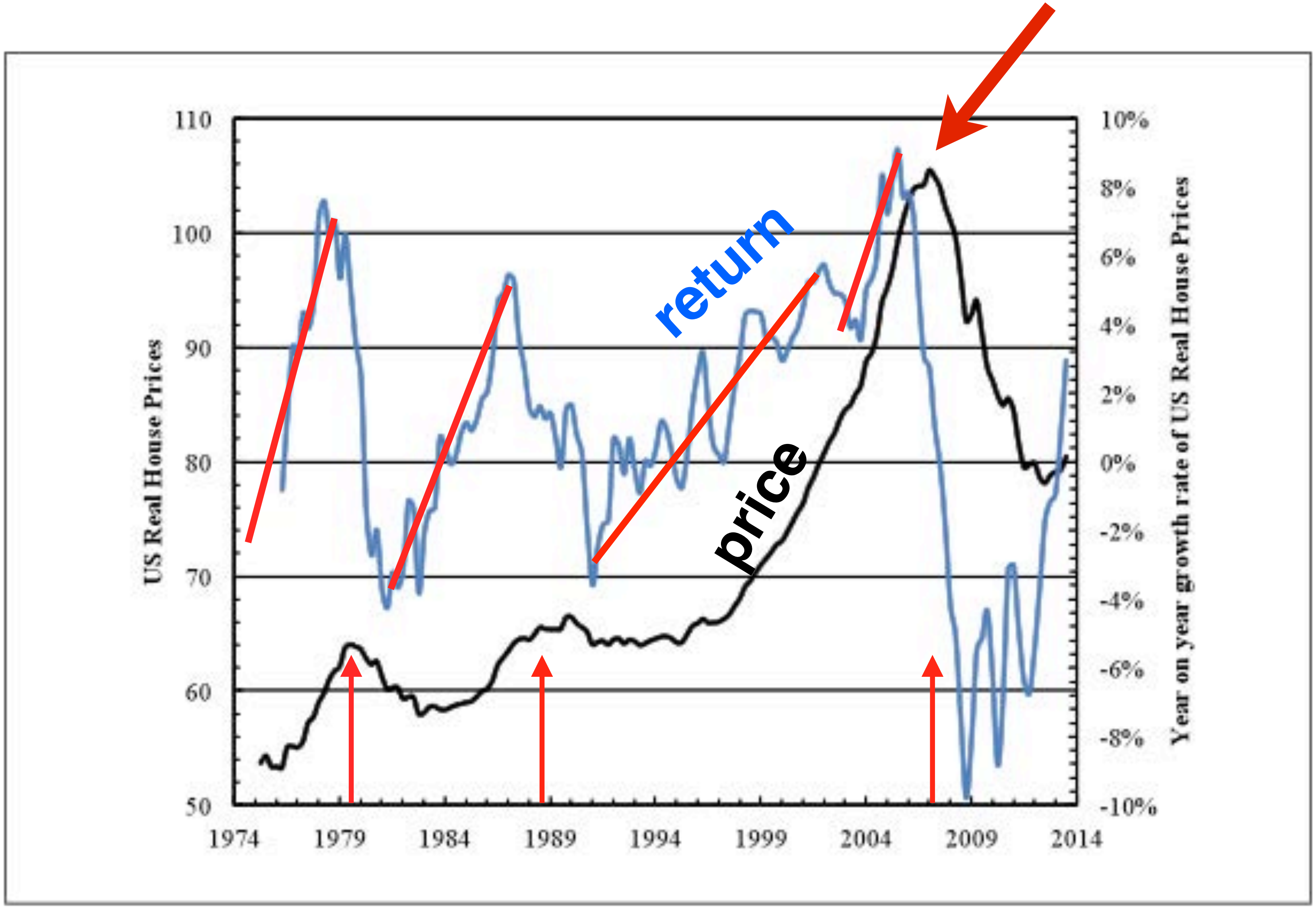
Typical result of the calibration of the simple LPPL model to the oil price in US$ in shrinking windows with starting dates t_{start} moving up towards the common last date t_{last} = May 27, 2008.



R.Woodard and D.Sornette (2008)

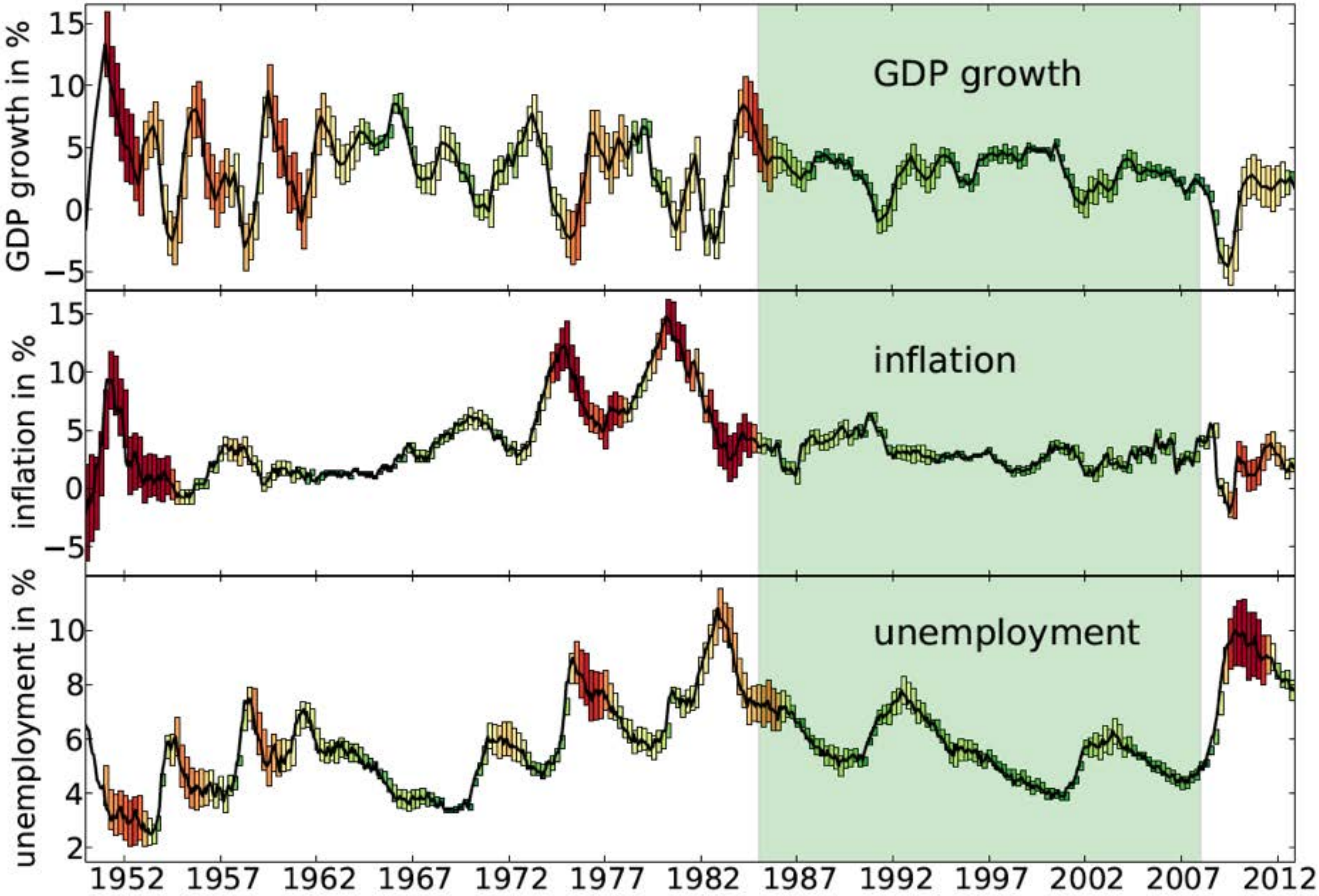


U.S. real-estate bubble



Real U.S. House Prices between 1974 and 2014. Levels are shown in black and should be read on the left axis. Yearly growth rates are shown in blue and should be read on the right axis. Three peaks in the growth rate coincide with a correction in the levels. When the growth itself grows, the process becomes unstable and a correction follows (Source: Federal Reserve Bank of Dallas international house price dataset, http://www.dallasfed.org/institute/houseprice/)

25 YEARS OF "GREAT MODERATION" BEFORE THE GREAT CRISIS



source: U.S. Bureau of Labor Statistics and Zalan Forro (ETH Zurich).

COMPARING QUANTITATIVE EASING PROGRAMS

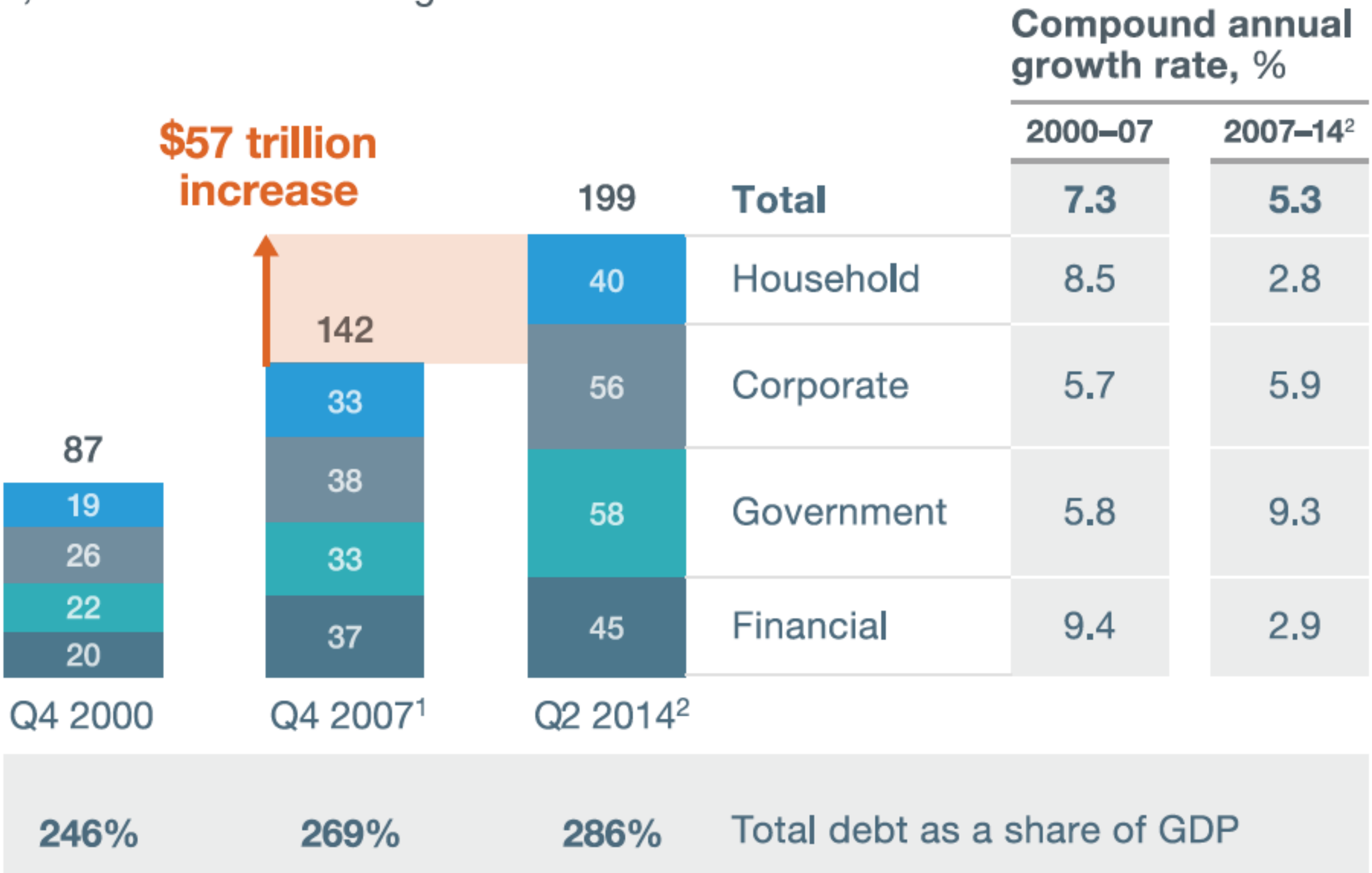
Europe and Japan are the two remaining major central banks that are actively pursuing a program of quantitative easing.

	U.K.*	JAPAN	U.S.	EUROZONE
Amount	**£375 billion**	**¥125 trillion**	**$2 trillion ($4 trillion)****	**€836 billion (€1140 billion)*****
Percent of GDP	21%	26%	12% (25%)	9% (12%)
Percent of bond market	27%	16%	18%	14%
Percent of annual Gross issuance	91%	69%	26%	54%
Percent of annual net issuance	107%	347%	85%	262%

** Amount refers to cash amount/market value rather than the nominal value of bonds bought*
*** Including mortgage-backed securities purchases*
**** Including Covered Bonds, asset-backed securities, and European Institution Debt. Amount refers to cash amount/market value rather than the nominal value of bonds bought*

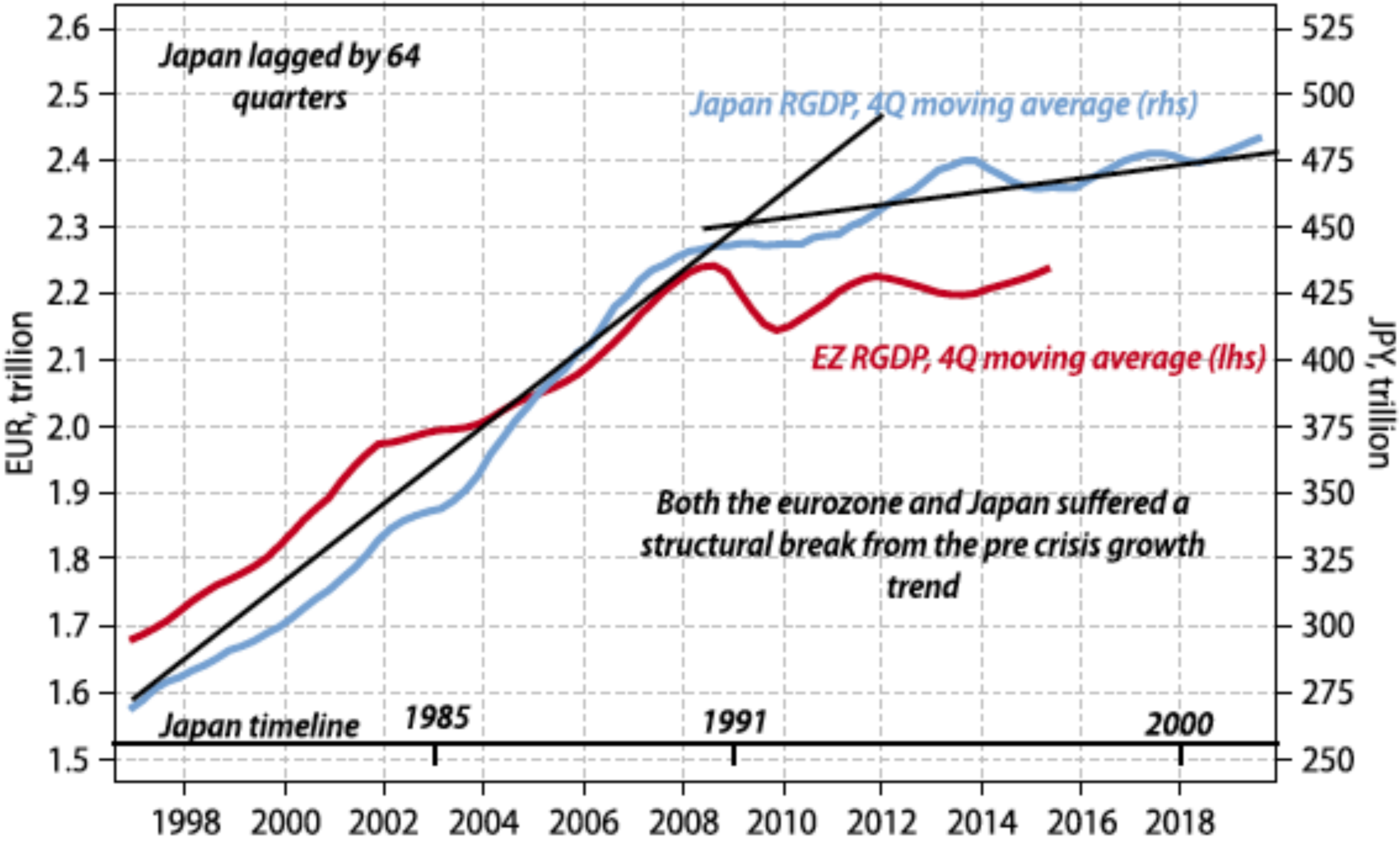
Source: Bloomberg, BoE, BoJ, Federal Reserve, ECB, Morgan Stanley Research

Global stock of debt outstanding,
$ trillion, constant 2013 exchange rates

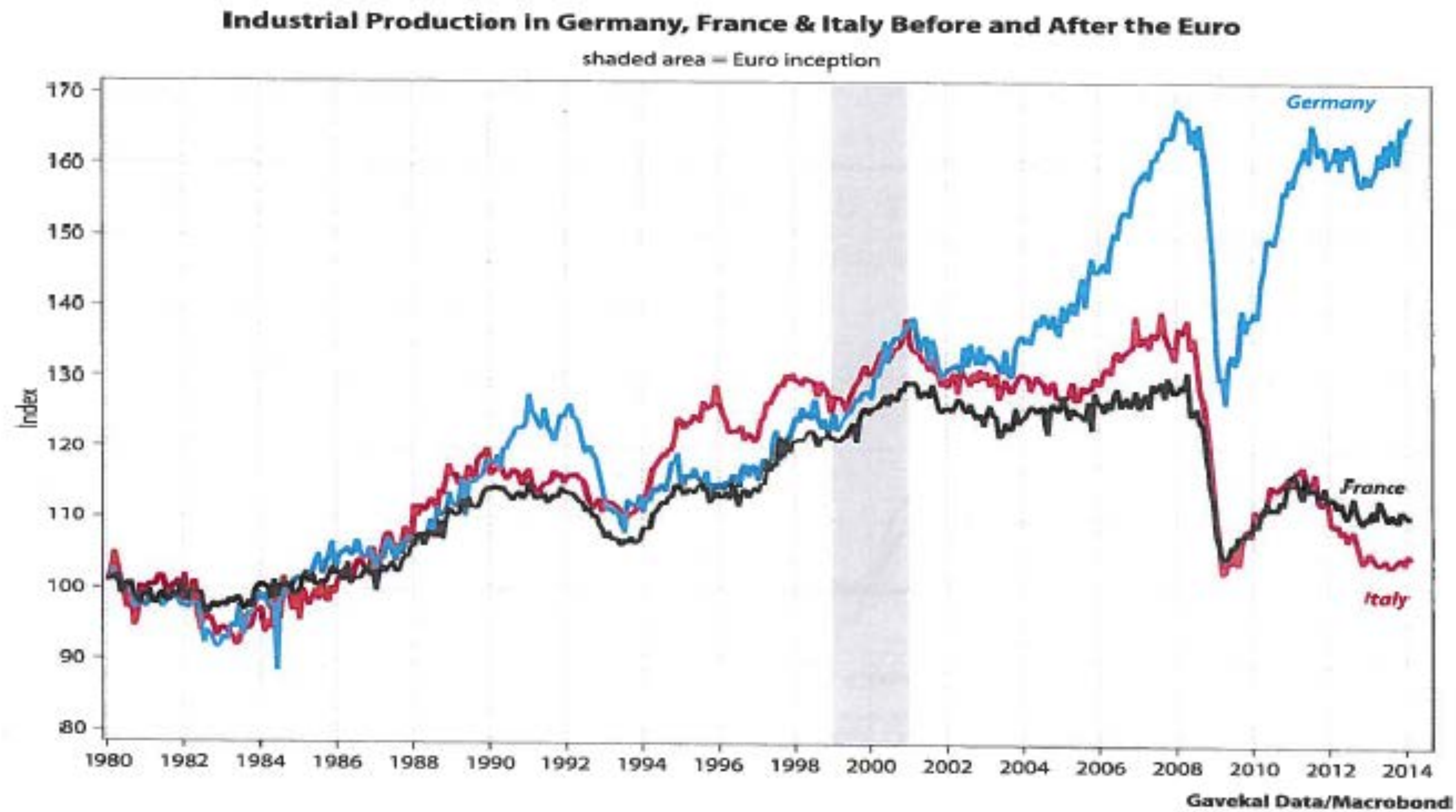


Source: Bank for International Settlements; Haver Analytics; International Monetary Fund *World Economic Outlook*; national sources; McKinsey Global Institute analysis

Will Europe Turn Japanese?



Gavekal Data/Macrobond



The creation of the euro led to the **exact opposite (divergence)** of what the euro was supposed to achieve (convergence).

- Economic development exhibits **transitions** between phases of growth, exuberance and crises, which are the “norm” rather than the exception.

- Since 1990 in Japan and 2008 in the West, consequences of crises resulting from previous excesses are addressed by **monetary policy** and **fiscal policy**.

- need for extreme initiatives and risk taking in **INNOVATION policies**

The Great Depression ended only as a result of the extraordinary “programme de relance” known as WWII.

We need an Innovation and R&D effort on par with that of WWII … without the war. Is this possible? Pb of risk taking, complacency, lack of political courage, rents…

Massive fostering of innovations (not just capital and credit, requires education and risk-sharing processes to encourage entrepreneurship and risk taking)

Super-Apollo-type projects (nuclear, batteries, water, de-desertification, health…)

Danger of social instabilities due to impoverishment of the bottom 90%
=> Fight inequality while conserving equity incentives for creativity and innovations.

productivity —> wage growth AND wage growth —> productivity
(if wages are too low, investments in labour-replacing capital will not pay off, see Robert C. Allen’s narrative of the British industrial revolution)

Present and future useful Social Bubbles

•biotech and nanotech, genomics, proteomics, personalised medicine

•Apps revolution

•open and big data revolution (+3-5 Trillion$ annually, McKinsey Oct. 2013)

•Blockchain v1.0 and v2.0 (“Internet of value”)

•Green tech revolution

•Gas and oil Fracking

•Space frontier (SpaceX, Orbital Science Corp., Virgin Galactic…)

•Ocean frontier

•Nuclear energy technology revolution