

The Actuarial Profession
making financial sense of the future

GIRO conference and exhibition 2011
Oliver Bettis



Resource and Environmental Limits to Economic Growth

13 October 2011

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Resource and Environmental Limits to Economic Growth

1. **Key concepts**
2. We live in an exponential world
3. Resource limits to economic growth: e.g. peak oil
4. Environmental limits to economic growth: e.g. climate change
5. Making sense of the data: The Limits to Growth
6. Prosperity without growth?
7. What are actuaries doing?
8. Red pill or blue pill?

1. Key Concepts

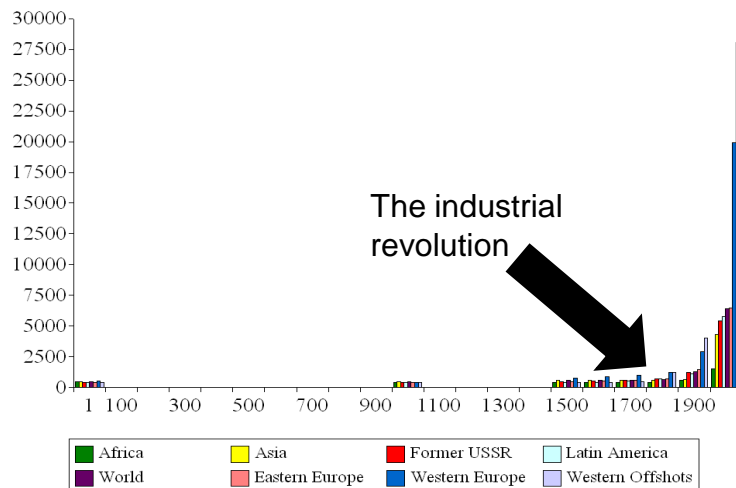
- Slides contain many references.
- Don't take my word for anything!
- Above all, I hope this makes you curious to learn more.

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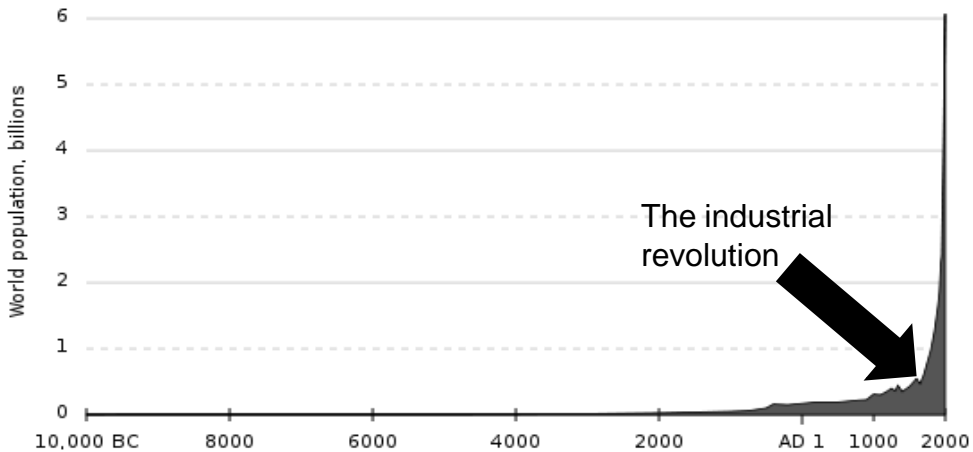
1. Key Concepts Exponential growth of GDP - recently

World GDP/capita 1-2003 A.D.



1. Key Concepts

Massive growth of World Population - recently



1. Key Concepts

Why did the industrial revolution start in England?

“Energy and the English Industrial Revolution”*

By Sir Edward Anthony Wrigley:

- Professor of Economic History at Cambridge University
- President of the British Academy from 1997-2001.
- Answers question, “Why didn’t growth stop?”
- Fossil fuel allowed us to escape the limits of land.
- England had easily accessible coal deposits
- Adam Smith and David Ricardo would have considered as absurd the notion that economy could grow by fixed % per year.

*Wrigley, E. A. (2010), *Energy and the English Industrial Revolution*, Cambridge University Press, Cambridge, UK

1. Key Concepts

The importance of energy to our economy



Road transport



Aviation



Heating and lighting



Construction



Mining

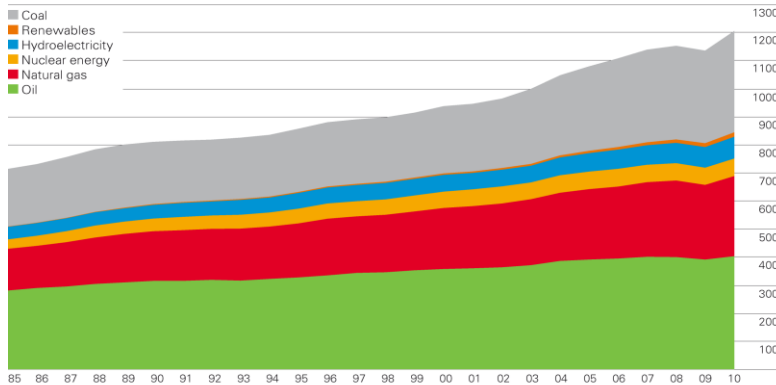


Food production

1. Key Concepts

World primary energy consumption

World consumption
Million tonnes oil equivalent



World primary energy consumption grew by 5.6% in 2010, the strongest growth since 1973. Growth was above average for oil, natural gas, coal, nuclear, hydroelectricity, as well as for renewables in power generation. Oil remains the dominant fuel (33.6% of the global total) but has lost share for 11 consecutive years. The share of coal in total energy consumption continues to rise, and the share of natural gas was the highest on record.

• Our industrial civilization uses about 13 Tera Watts for machinery.

• Estimated net primary productivity of Earth's ecosystems $\approx 70\text{TW}$ on land*².

Source: BP Statistical Review of World Energy 2011

1. Key Concepts

Why are Fossil Fuels so Useful?

- Fossil fuel is very energy dense
- Oil is particularly useful as it is liquid – easy to transport
- Energy content of 1 barrel of oil = manual labour of 30 people for 1 month.

“Energy Slaves”

- UK energy consumption per person = 125kWh per day*1 (= 5.2kW per person)
- 1 person produces ~ 75 Watts sustained power
- UK citizens have ~ 70 “energy slaves”

*1 Refer: www.withouthotair.com - David MacKay, 'Sustainable Energy Without Hot Air'

1. Key Concepts

We are addicted to oil

We are addicted to fossil fuels, especially oil.



"Here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world,"
George W. Bush, 2006 State of the Union address

Source: http://articles.cnn.com/2006-01-31/politics/bush.sotu_1_energy-research-union-speech-advanced-energy-initiative?s=PM:POLITICS

1. Key Concepts Exponential Growth

“The greatest shortcoming of the human race is our inability to understand the exponential function”

– Professor Albert Bartlett, Colorado University

- The exponential function arises whenever a quantity grows or decays at a rate proportional to its current value.
- For example; compound interest.

Source: <http://www.albartlett.org>

There is a great presentation about exponential growth at this web address.

1. Key Concepts Exponential Growth

Doubling Time

- Approx. doubling time = $70/(\text{Growth Rate in \%})$
Reason: $70 \approx 100 \cdot \ln(2)$
- E.g. 7% growth means doubling time of $70/7 = 10$ years

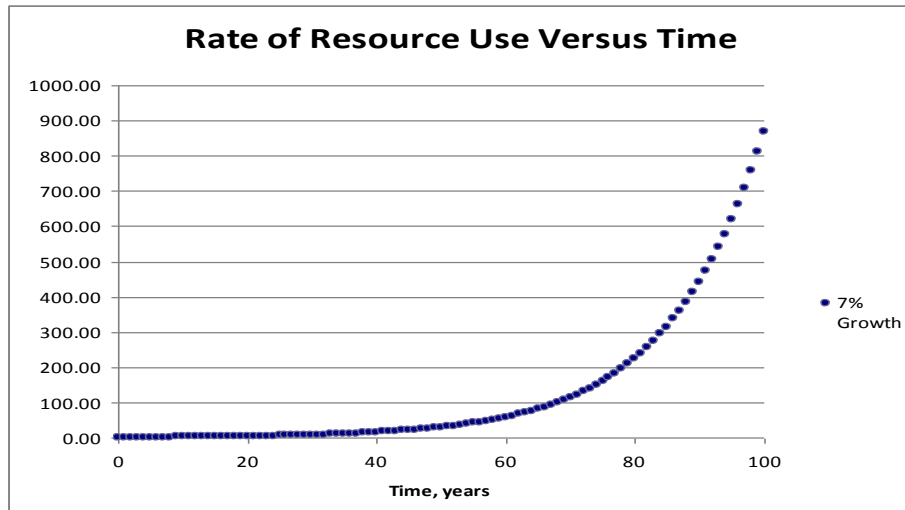
Resource used during doubling period

For a resource which is used up at a constantly increasing rate:

- In the time it takes to double the rate of use, the amount of resource used will be the same as the resource used in all prior doubling periods combined.

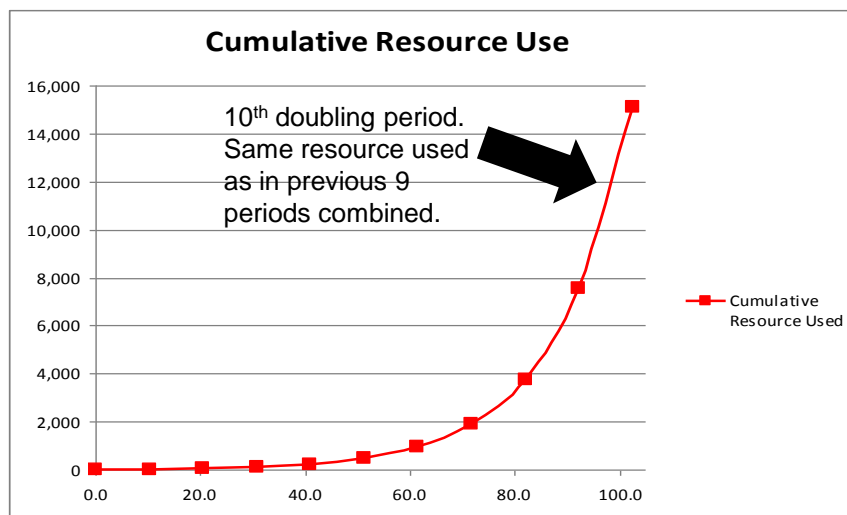
1. Key Concepts

Example: 7% growth



1. Key Concepts

Cumulative Resource Use @7% growth



1. Key Concepts

Is growth always good?

- Imagine an insurance business plan which says:
 - Grow premium income
 - & increase market share
 - & maintain constant loss ratio
- Can you grow market share and profit simultaneously?
- Many things have an optimal size – further growth is bad
 - E.g . People!



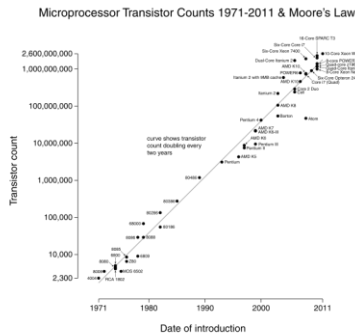
Question: Is economic growth always good?

Resource and Environmental Limits to Economic Growth

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2. We live in an exponential world

Technology and knowledge

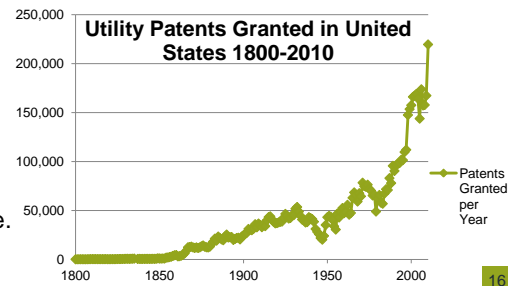


Moore's Law

The number of transistors that can be placed inexpensively on an integrated circuit doubles approximately every two years.

Intellectual Property

No. of patents granted illustrates the explosive growth in human knowledge.

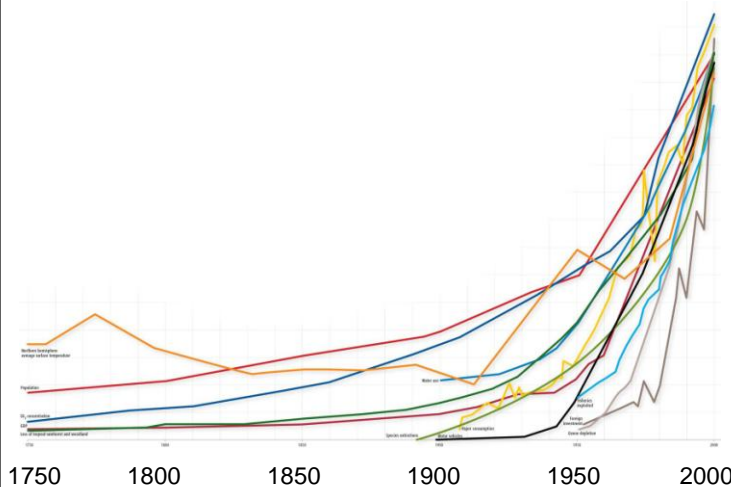


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2. We live in an exponential world

World growth trends 1750-2000



1. GDP
2. Population
3. Paper consumption
4. Motor vehicles
5. Foreign investment
6. CO2 concentration
7. Loss of tropical woodland
8. Water use
9. Species extinction
10. Fisheries exploited

Source: New Scientist 16 October 2008

<http://www.newscientist.com/article/mg20026786.000-special-report-how-our-economy-is-killing-the-earth.html>

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2. We live in an exponential world

World GDP Growth Trends

- World GDP has grown at average rate of c.3% per year in recent decades.
- Doubling time at 3% is just over 23 years.
- From 2011 to 2100 is almost 4 doubling periods.
- World economy would grow 14 times as large in 2100 as it is now.

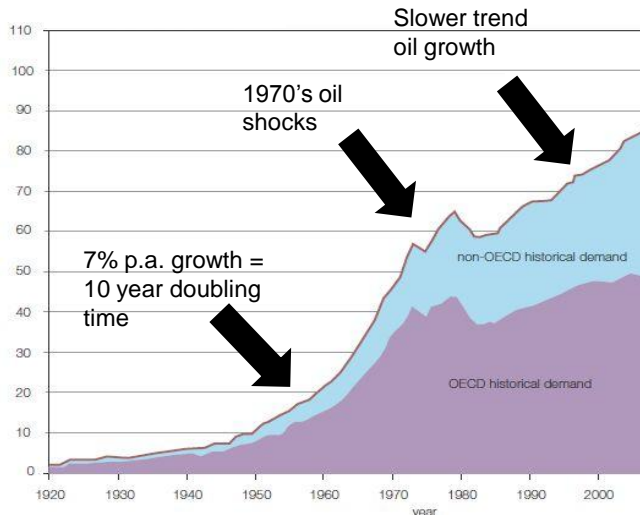
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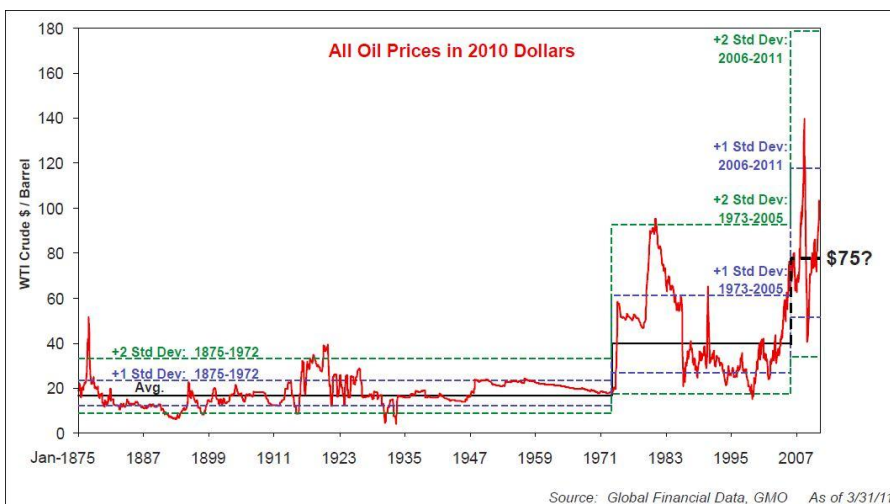
3. Resource limits to growth: Peak oil Global Oil Production Since 1920



Was no accident that the original "Limits to Growth" study was published in 1972.

From "The Oil Crunch"; Second report of the UK Industry Taskforce on Peak Oil & Energy Security (ITPOES) , February 2010 <http://peakoiltaskforce.net/>

3. Resource limits to growth: Peak oil Oil Prices since 1875



3. Resource limits to growth: Peak oil

IMF World Economic Outlook, April 2011

Baseline scenario 0.8% p.a. oil growth for 20 years.

- Minimal effect on economic growth (reduction of <0.25%)

2 alternative “peak oil” scenarios: Greater decline in oil (-2% p.a. instead of +0.8%) and greater dependence on oil.

- Result was much larger loss of GDP than baseline (3 to 4X in first scenario and double in second scenario).
- Oil price increases 800% over 20 years.
- Additional adverse effects possible from interdependencies.
- Oil exporting nations may keep more oil for themselves.

Source: IMF World Economic Outlook – April 2011

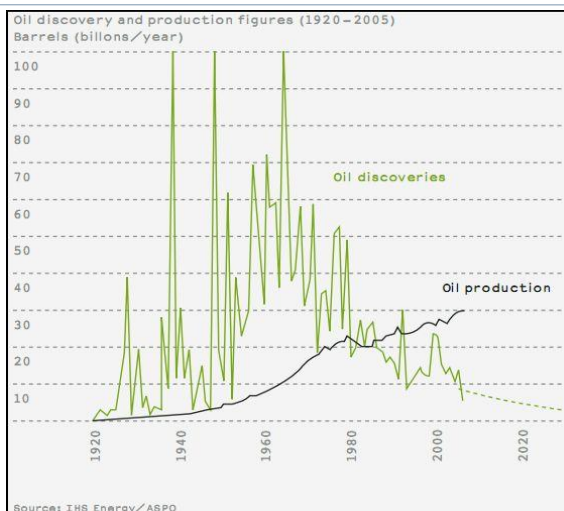
<http://www.imf.org/external/pubs/ft/weo/2011/01/index.htm>

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3. Resource limits to growth: Peak oil

Oil Discoveries versus Oil Production



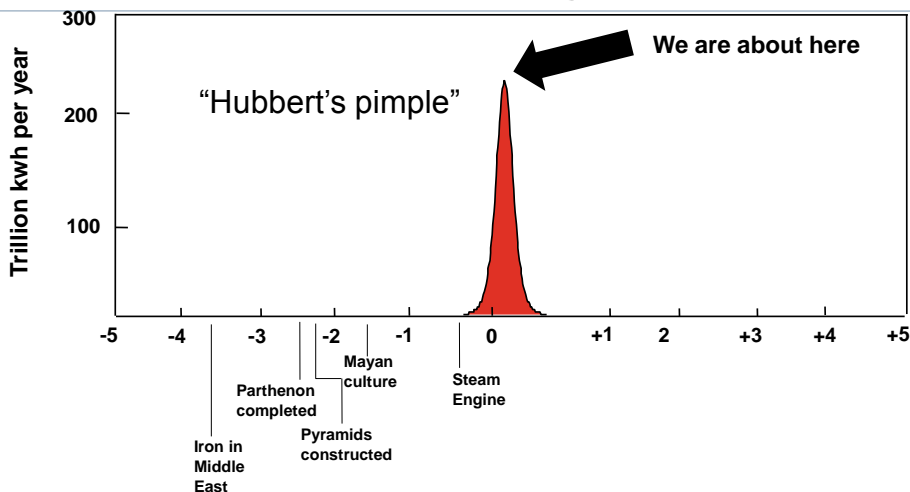
“Discoveries of new deposits peaked as far back as the 1960s and 1970s. Now a number of countries in addition to the UK and the USA, for instance, have reached their production limits. The quantity of oil being pumped out of the earth exceeds new discoveries.”

Source: Munich Re Foundation 2009 Report page 28

http://www.munichre-foundation.org/StiftungsWebsite/Publications/2009report_Publication_summary.htm

3. Resource limits to growth: Peak oil

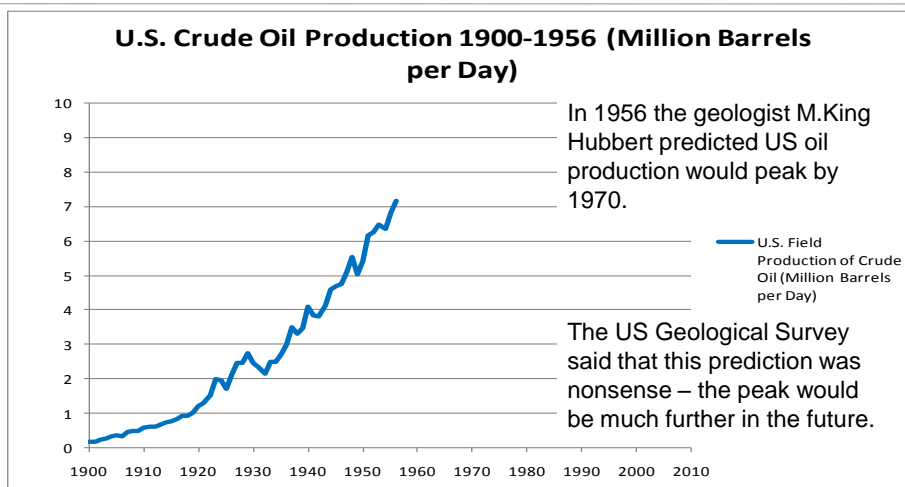
Global Fossil Fuel Use – A Long Term View



Source: Professor Charles A.S. Hall, State University of New York <http://www.esf.edu/efb/hall/>
After Hubbert, 1969

3. Resource limits to growth: Peak oil

United States Oil Production 1900-1956



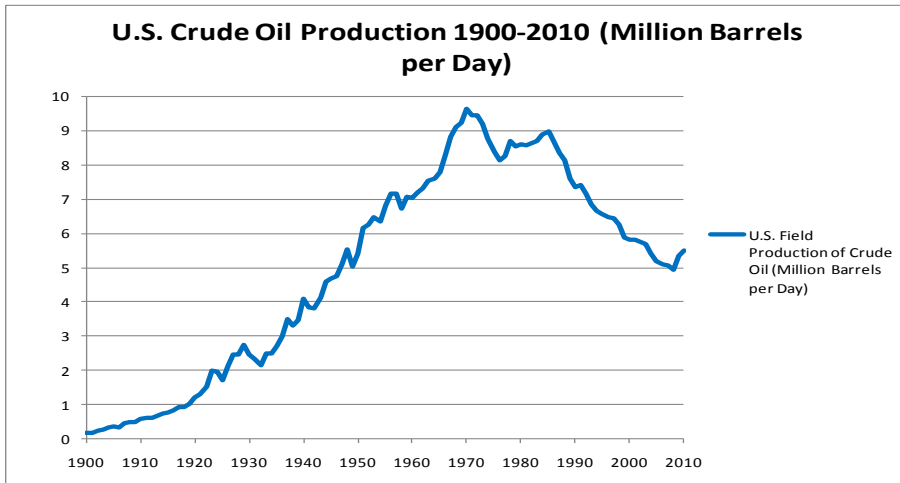
Source: United States Energy Information Administration <http://www.eia.gov/>

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3. Resource limits to growth: Peak oil

United States Oil Production 1900-2010



Source: United States Energy Information Administration <http://www.eia.gov/>

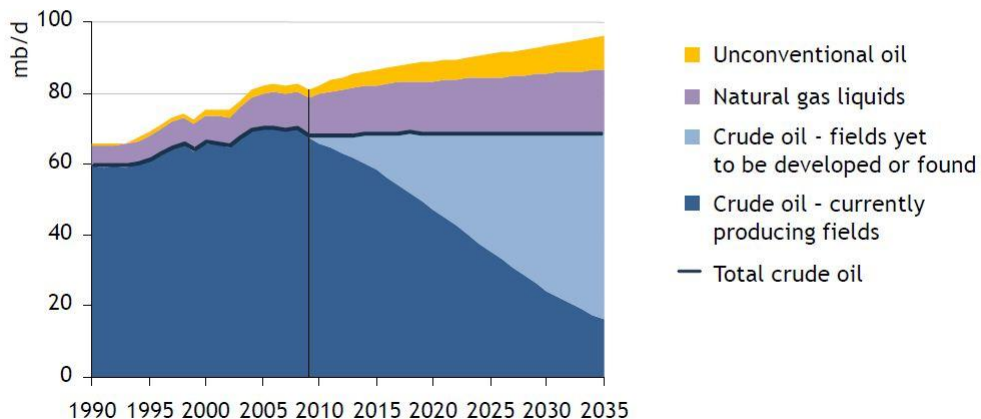
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3. Resource limits to growth: Peak oil

International Energy Agency WEO 2010

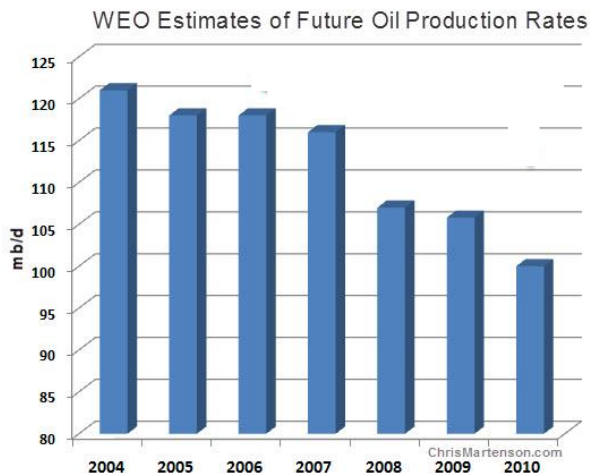
World oil production by type in the New Policies Scenario



Source: Lecture Fatih Birol, Chief Economist of the IEA, at Imperial College, 18 January 2011

http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/naturalsciences/climatechange/newssummary/news_20-1-2011-13-4-51

3. Resource limits to growth: Peak oil IEA: WEO forecasts in years 2004-2010



In the 2004 WEO,
forecast oil price
until 2030:

- Baseline forecast was \$25 a barrel.
- “High” scenario was \$35 a barrel

Source: Chris Martenson summary of IEA WEO's <http://www.chrismartenson.com/>

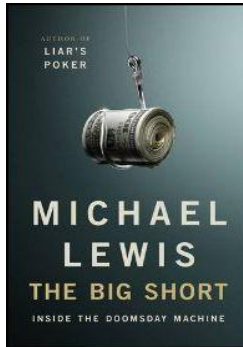
3. Resource limits to growth: Peak oil Some recent reports on resource constraints

- Feb 2010 – UK Industry Task Force on Peak Oil, 2nd Report
“The next five years will see us face ... the oil crunch.”
- June 2010 – Lloyd’s 360 Report, Sustainable Energy Security
“We are in a period akin to a phoney war”, Lloyd’s CEO R. Ward
- June 2010 – Tullett Prebon research “Dangerous Exponentials”
“... impending collision between economic system that must grow and finite resources which cannot grow.”
- April 2011 - GMO letter to investors *“Time to wake up: Days of abundant resources and falling prices are over”*
- April 2011 - IMF World Economic Outlook. Models peak oil scenarios.

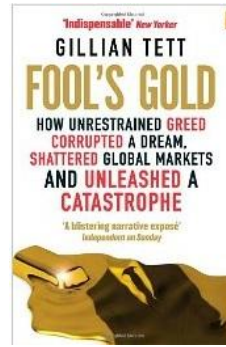
Weblinks to sources in Notes area

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3. Resource limits to growth: Peak oil The Energy Crunch: Another Credit Crunch?



Two excellent books telling stories about people that saw the credit crunch coming.

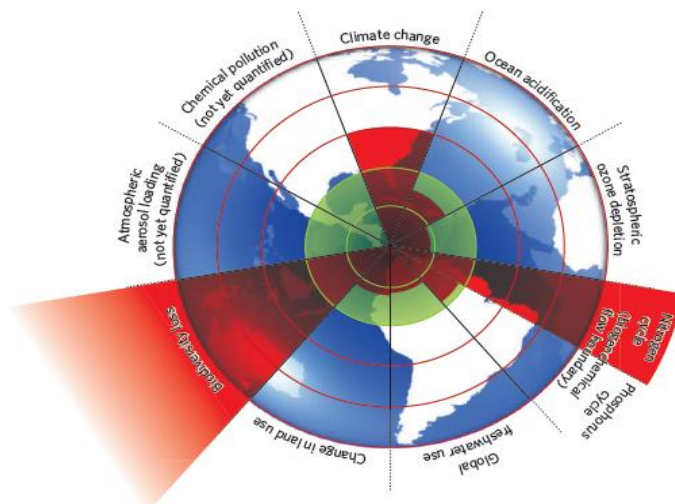


- Not many people predicted the severity of the credit crunch.
- But some people did predict it - it was predictable.
- Why did so few people predict the credit crunch?
- What can we predict today?

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4. Environmental limits to growth: e.g. climate change Hard-wired environmental limits?

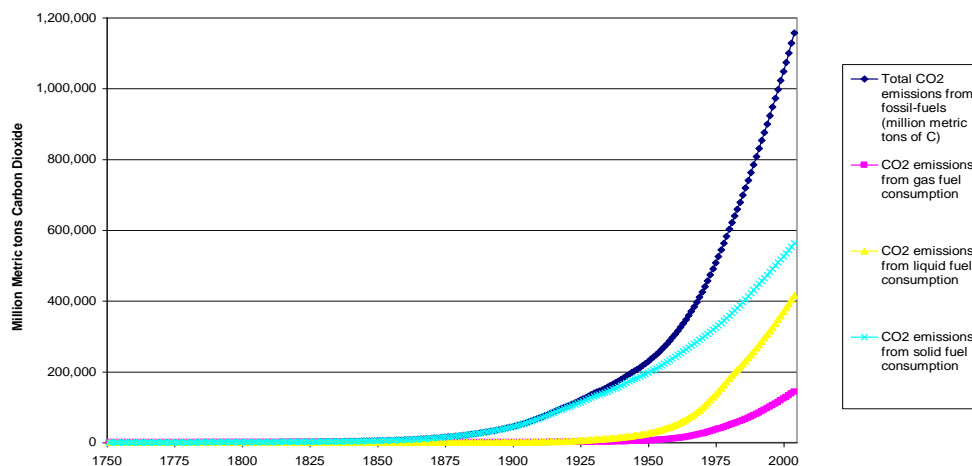


From Rockstrom et al "A safe operating space for humanity", Nature 2009

<http://www.nature.com/nature/journal/v461/n7263/full/461472a.html>

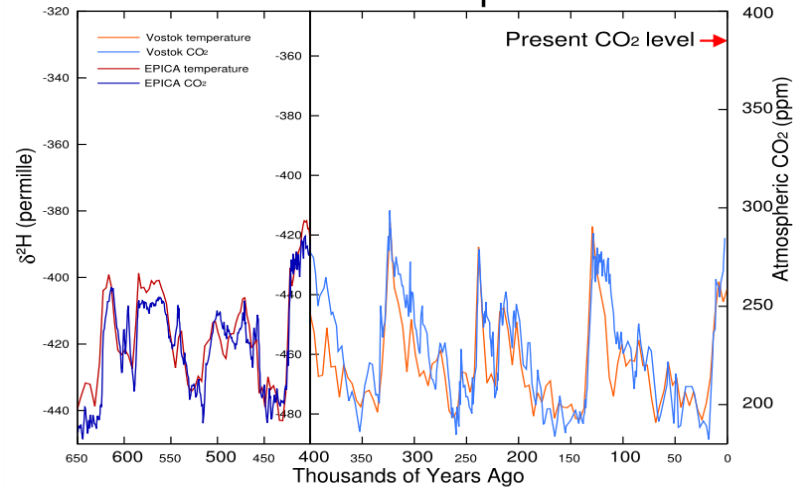
4. Environmental limits to growth: e.g. climate change Cumulative CO₂ emissions from fossil fuels

Carbon dioxide Emissions from fossil fuel burning 1750-2004

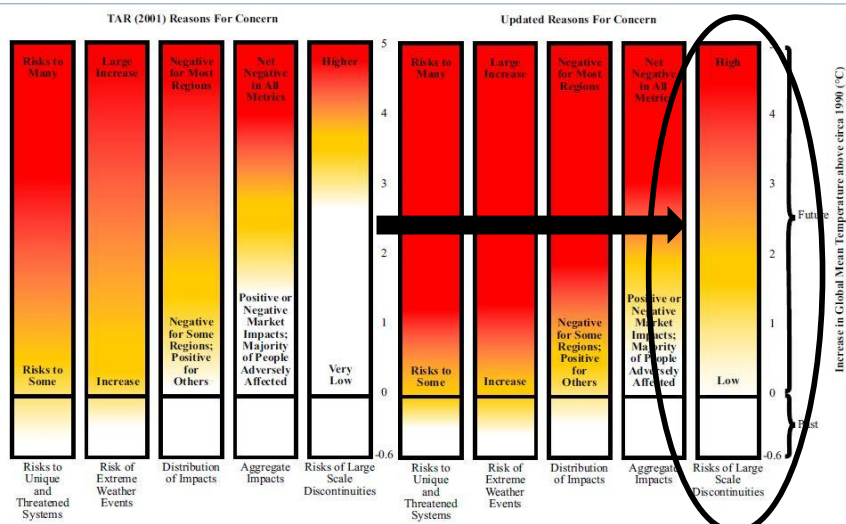


4. Environmental limits to growth: e.g. climate change Temperature versus CO₂ concentration

Carbon Dioxide and Temperature Records



4. Environmental limits to growth: e.g. climate change Updated “Reasons for Concern”



4. Environmental limits to growth: e.g. climate change NAS - Climate Stabilization Targets 2011

- Fossil fuel CO₂ emissions have created new epoch.
- Human activities will largely determine the evolution of Earth's climate.
- Man made CO₂ is long lived in the atmosphere.
- Future generations may be locked into a range of impacts, some of which could become very severe.
- E.g. For 4°C temperature increase, c. 9 out of 10 summers warmer than warmest ever experienced in late 20th century.

Source: "Climate Stabilization Targets: Emissions, Concentrations, and Impacts Over Decades to Millennia" <http://dels.nas.edu/Report/Climate-Stabilization-Targets-Emissions-Concentrations/12877>

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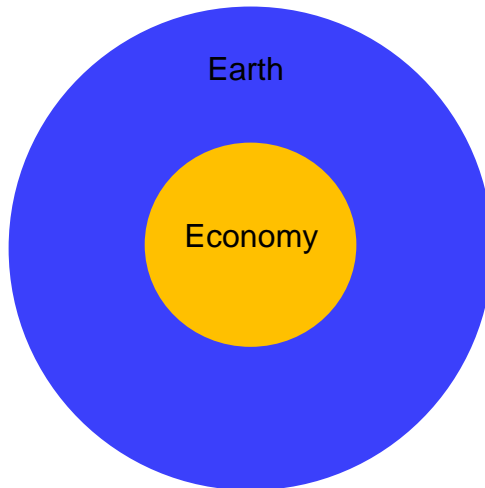
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5. Making sense of the data: The Limits to Growth

The Economy is a Subset of the Earth



“The only people who believe in infinite growth in a finite world are madmen and economists.”
Kenneth Boulding

“If something cannot go on forever, it will stop.”
Herbert Stein

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5. Making sense of the data: The Limits to Growth

Link Between Problems

- Climate change
- Other environmental problems e.g. biodiversity
- Oil depletion
- Other resource depletion

All driven by increasing consumption by humans – caused by exponential growth of population and the global economy.

Growth drives our problems!

5. Making sense of the data: The Limits to Growth Human impact on the Earth – a simple approach

$$I = P \times A \times T$$

I = Impact

P = Population

A = Affluence (consumption per capita)

T = Technology (environmental impact per unit of consumption)

5. Making sense of the data: The Limits to Growth What about technology?

$$I = P \times A \times T$$

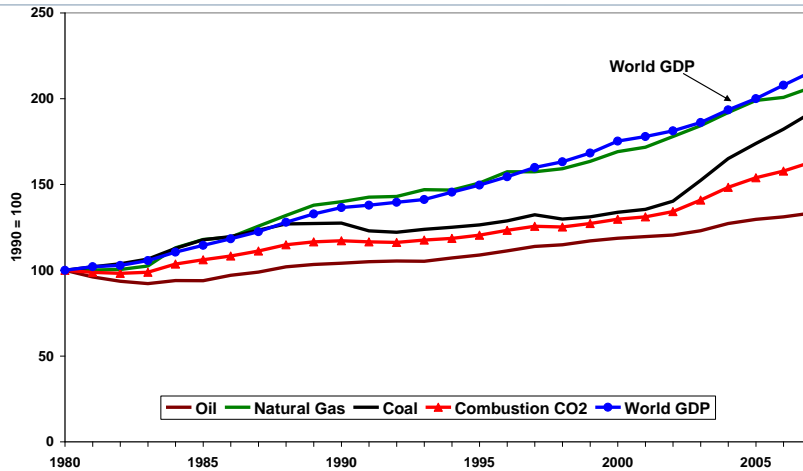
- If affluence and population grow, for impact to stabilize or shrink, technology must improve.
- But, since 2000, carbon intensity of GDP has been increasing. Probably driven by increased coal use*.
- We are betting the house on technology. But it isn't working yet!

*Reference: "Reframing the climate change challenge", Anderson & Bows 2008

<http://rsta.royalsocietypublishing.org/content/366/1882/3863.short>

5. Making sense of the data: The Limits to Growth

The myth of decoupling GDP from pollution



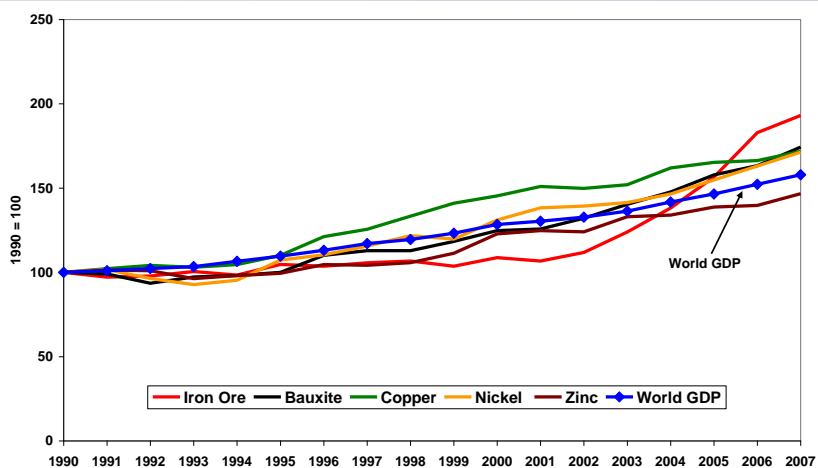
Jackson, T. (2009) *Prosperity Without Growth? Economics for a Finite Planet*, Routledge, London, UK.

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5. Making sense of the data: The Limits to Growth

The myth of decoupling GDP from physical inputs



Jackson, T. (2009) *Prosperity Without Growth? Economics for a Finite Planet*, Routledge, London, UK.

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5. Making sense of the data: The Limits to Growth Scale of human impact: The Anthropocene Age

From The Economist magazine, May 2011

- Humans are reshaping the planet on a geological scale
- e.g. Athabasca tar sands, 30 bn tonnes of Earth moved per year = 2x sediment flowing down all rivers in the world
- Moment of realisation, like Copernicus grasping that the Earth revolves around the sun.
- It would be odd not to be worried.



You maniacs! You blew it up!

Source: The Economist – 26 May 2011 <http://www.economist.com/node/18744401>

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5. Making sense of the data: The Limits to Growth The “End of the World Syndrome”

- Joseph Tainter “The collapse of complex civilizations”
- Every age has its doomsayers. They’ve all been wrong.
- Need a scientific approach not value judgments.
- Is there data which shows that our age is objectively different?
Yes!
 - Wealth
 - Fossil fuel use
 - Atmospheric CO₂ concentration c.390ppm
 - Population c. 7 billion

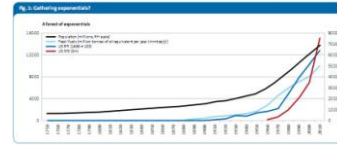
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5. Making sense of the data: The Limits to Growth Just starting to enter the investment world

1. Tullett Prebon (£0.5bn revenue), 2010

- Impending collision between economic system and finite resources.
- “one of the most important changes in the lifetime of anyone reading this report.”



“A forest of exponentials”
Dr. Tim Morgan, head of research

2. GMO Asset Managers (>\$100bn assets under management)

Jeremy Grantham, Quarterly Letter, April 2011: “Time to Wake Up”

- Days of abundant resources and falling prices are over forever.
- The world is using up its natural resources at an alarming rate.
- This has caused a permanent shift in their value.

*Chart from: Morgan T. “Dangerous exponentials: A radical take on the future”
Tullett Prebon Strategy Insights issue 5, June 2010

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5. Making sense of the data: The Limits to Growth Why didn't anyone see this coming?

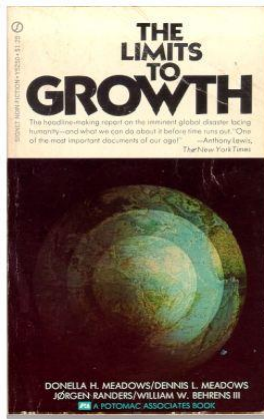
- Exponential growth has a simple mathematical formula.
- Why didn't anyone predict these problems decades ago?
- Answer: Someone did, but the message was forgotten.

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5. Making sense of the data: The Limits to Growth

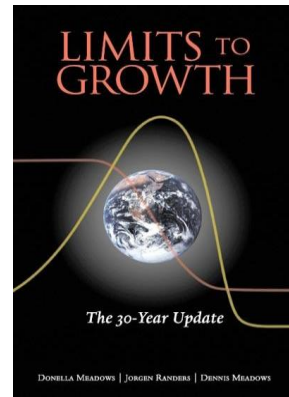
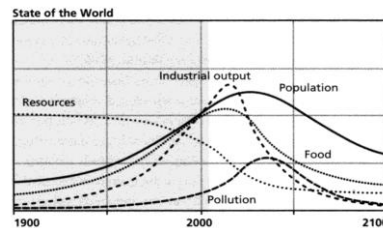
The “Limits to Growth” Study



The original 1972 study was updated in 2004



Example below of one of the indicative modelled scenarios (not a prediction)



5. Making sense of the data: The Limits to Growth

The story of the “Limits to Growth”

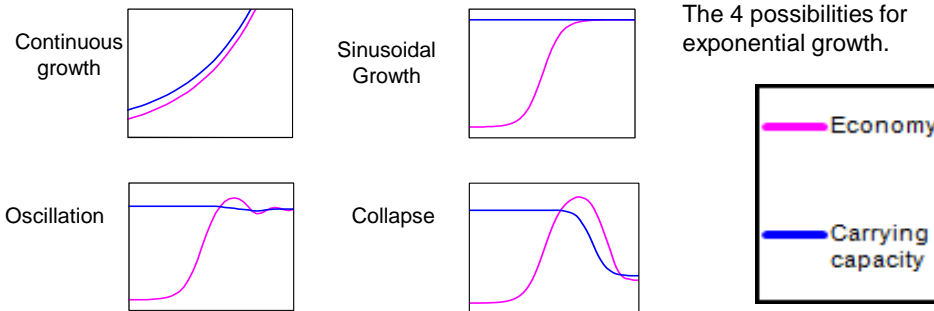
- A group of systems scientists in MIT* were commissioned by the Club of Rome.
- The book “Limits to Growth” was published in 1972. Sold over 20 million copies.
- Was controversial, attacked by “cornucopians”.
- 1970s oil shocks and “stagflation” appeared to confirm predictions.
- But, in 1980’s cheaper oil let economies grow again. The “Limits to Growth” was forgotten.

Time to rediscover the Limits to Growth?

*Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens

5. Making sense of the data: The Limits to Growth The “Limits to Growth” Argument

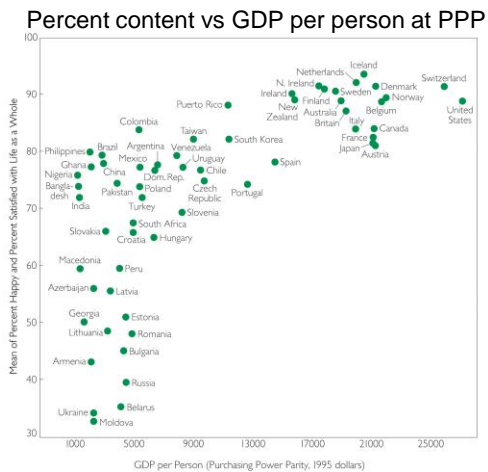
- Endless physical growth in a finite world is not possible.
- If growth in consumption is not contained, humanity will exceed the carrying capacity of the Earth.
- By exceeding the carrying capacity of the Earth, humanity risks sudden and uncontrollable collapse.



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6. Prosperity Without Growth Happiness versus GDP per capita



- When material needs are met, further wealth doesn't have much effect on happiness.

Source: Jackson, T. (2009) *Prosperity Without Growth? Economics for a Finite Planet*, Routledge, London, UK.

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6. Prosperity Without Growth Economist and Nobel Laureat Robert Solow

"It is possible," says Solow, "that the United States and Europe will find that, as the decades go by, either continued growth will be too destructive to the environment and they are too dependent on scarce natural resources, or that they would rather use increasing productivity in the form of leisure. . . . There is nothing intrinsic in the system that says it cannot exist happily in a stationary state."

From Harper's Magazine, March 2008

6. Prosperity Without Growth?

JS Mill on the stationary state

John Stuart Mill, Principles of Political Economy, 1848

“I cannot, therefore, regard the stationary state of capital and wealth with the unaffected aversion so generally manifested towards it by political economists of the old school. ... **I confess I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on;** that the trampling, crushing, elbowing, and treading on each other's heels, which form the existing type of social life, are the most desirable lot of human kind, or anything but the disagreeable symptoms of one of the phases of industrial progress.” [my emphasis]

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6. Prosperity Without Growth?

JM Keynes

John Maynard Keynes, 1945

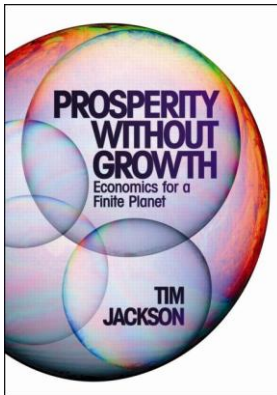
“The day is not far off when the economic problem will take the back seat where it belongs, and the arena of the heart and the head will be occupied or reoccupied, by our real problems — the problems of life and of human relations, of creation and behaviour and religion.”

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6. Prosperity Without Growth

Summary of the argument



- Poor nations need growth for basic needs.
- For rich nations, much consumption is competitive. Competition induces anxiety.
- Trying to grow carries great risks and might not be possible much longer.
- For rich nations, it's in our self-interest not to grow any more.
- Trade wealth for leisure.
- Alternative steady state economics exists, we can change if we want to.

Source: Jackson, T. (2009) *Prosperity Without Growth? Economics for a Finite Planet*, Routledge, London, UK.

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6. Prosperity Without Growth

Why are politicians so afraid of growth stopping?

Our economic system depends on growth because:

- Improving technology drives increasing productivity.
- Productivity growth means the same number of people can generate more goods and services.
- People need to consume those additional goods & services or unemployment rises.
- Therefore the economic system we have needs rising consumption to function.
- Fractional reserve banking system adds to instability.

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6. Prosperity Without Growth

We have a Culture of Exponential Growth

- Some things we “know” without learning. We “know” that economic growth is always good at all times, for everyone.
- These things that we “know” are cultural rules, not absolutes.



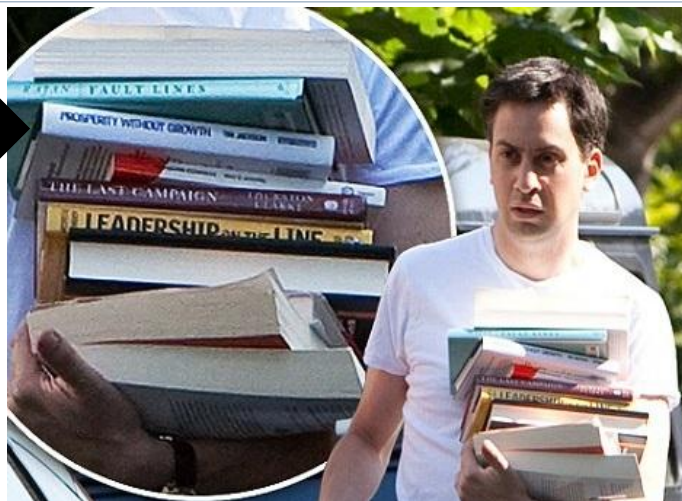
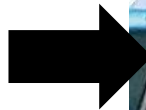
- The ancient Egyptians knew they should build pyramids.
- They were not built by slaves but by workers.

Source: <http://www.nationalgeographic.com/pyramids/pyramids.html>
and <http://news.bbc.co.uk/1/hi/8451538.stm>

6. Prosperity Without Growth

Maybe the time has come?

In Ed
Miliband's
holiday
reading –
August
2011



“Prosperity Without
Growth” by Prof.
Tim Jackson

Resource and Environmental Limits to Economic Growth

1. Key concepts
2. We live in an exponential world
3. Resource limits to economic growth: e.g. peak oil
4. Environmental limits to economic growth: e.g. climate change
5. Making sense of the data: The Limits to Growth
6. Prosperity without growth?
7. **What are actuaries doing?**
8. Red pill or blue pill?

7. What are actuaries doing?

- Resource & Environment MIG has >400 members
- Steering committee set up on resource & environment issues.
- Networking event held on 13th September
- IAA have an Environment Working Group. First conference call on 30th September 2011.
- 2nd Edition Literature Review on Resource & Environment, launch date 17th October 2011
- Research into the limits to growth has been commissioned. Led by Dr Aled Jones at Anglia Ruskin University. Results in 2012.
- Society of Actuaries will be looking into resource issues also.

7. What are actuaries doing?

Tick the REG box if you want to keep up to date

Home » My account » My account

My Account

- Our profile of you**
- Edit website account
- Website activity
- CPD summary
- Exams
- Newsletter preferences
- Course booking
- Receipts
- Pay your subscription
- Actuarial directory

This is the profile you have provided. If you need to amend it, please do so here.

Person Classifications

- Work-based skills information received ☒
- Practice Area Communities
 - Enterprise Risk Management practice ☐
 - Finance & Investment practice ☐
 - General Insurance practice ☒
 - Health & Care practice ☐
 - Life practice ☐
 - Pensions practice ☐
- Member Interest Groups
 - Birmingham Actuarial Society ☐
 - Bournemouth Actuarial Society ☐
 - Bristol Actuarial Society ☐
 - Chinese Regional Society ☐
 - Gibraltar Regional Society ☐
 - Norwich Actuarial Society ☐
 - Welsh Actuarial Society ☐
 - Yorkshire Actuarial Society ☐
 - Ageing Population ☐
 - Banking ☐
 - Damages ☐
 - Equity Release ☐
 - Financial Consumer Interest ☐
 - Global Financial Crisis ☐
 - Medical Advances ☐
 - Mergers and Acquisitions ☐
 - Property Research ☐
 - Pensions Buy-out ☐
 - Resource and Environment ☒
 - Risk Management ☐
 - T&A & P & W ☐
 - TANC - The Actuarial Network at CASS ☐
 - Variable Annuities ☐
- Other
 - I agree to transfer my data to ASSA ☐

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7. What are actuaries doing?

Literature Review 2011

- 17 actuaries contributed
- 21 papers and reports reviewed to give a broad overview of resource and environmental issues. Particular focus on energy.

- Concepts
- Current status of resources
- Current Status of Climate Science
- Economic Responses
- Institutional Investment Issues
- Risk Management & Uncertainty

- Please get in touch if you'd like to contribute to the next one.

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Resource and Environmental Limits to Economic Growth

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8. Red pill or blue pill?

8. Red Pill or Blue Pill?



8. Red Pill or Blue Pill? Why take the red pill?

- We actuaries have the skill-set to understand what's going on.
- We are insurance actuaries – we look at data and try to strip away bias every day of the week.
- Solvency II
- Personal financial security.

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8. Red Pill or Blue Pill? Shift from financial assets to real assets



Source: www.bullionvault.com

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3. Resource limits to growth: Peak oil Shift from financial to real assets: Iron Ore

Iron Ore Prices (2011 \$/dry metric ton)



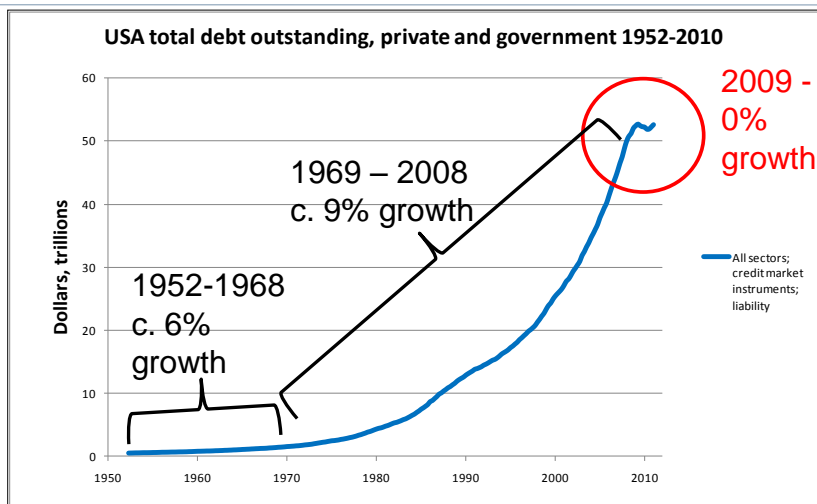
100 year low – then 110 year high within 8 years

Source: GMO Quarterly Letter, April 2011

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8. Red Pill or Blue Pill? The next 20 years will be unlike the last 20 years



Source: United States Federal Reserve data download program

<http://www.federalreserve.gov/datadownload/>

8. Red Pill or Blue Pill? Opportunities for Actuaries

- The world needs unbiased forecasting – not optimistic or pessimistic. Actuaries are ideally suited for this role:
 - Long term thinking
 - Base decisions on data; scientific approach
 - Experts in risk and modelling
 - Exponential growth is bread and butter
 - Experts in the financial system
- This is potentially a huge area of work for actuaries; we can be leaders in this field.

*We care about removing bias “Making actuaries less human: Lessons from behavioural finance” by Nigel Taylor http://www.sias.org.uk/siaspapers/listofpapers/view_paper?id=BehaviouralFinance.

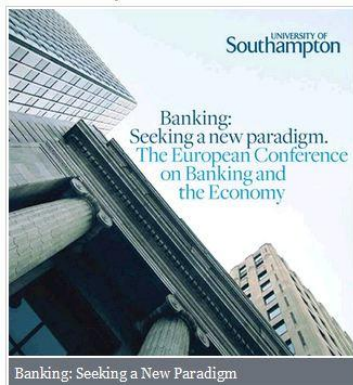
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8. Red Pill or Blue Pill? One possible area – Reform of financial system?

Centre for Banking, Finance and Sustainable Development

European Conference on Banking and the Economy



This was a conference on 29th September 2011 organised by Prof. Richard Werner

Keynote speakers:
Lord Adair Turner and
Professor Charles Goodhart

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Final Thought and Further Reading

Every time you see growth mentioned, question the assumptions that lie behind.

Further reading:

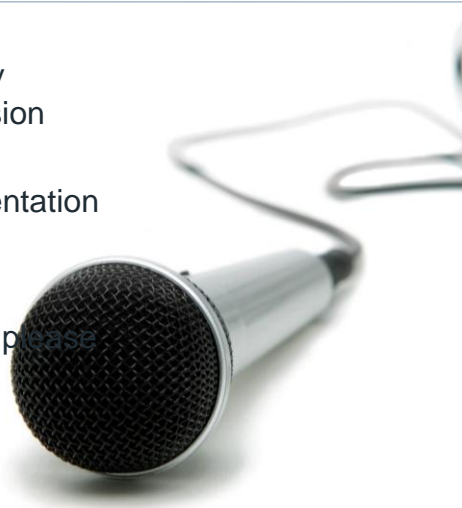
- <http://www.withouthotair.com/> (energy)
- <http://www.neweconomics.org/> (economics for sustainability)
- <http://www.chrismartenson.com/> (energy and economics)
- www.theoildrum.com (energy)
- <http://www.energybulletin.net/> (energy)
- <http://www.positivemoney.org.uk/> (financial reform)
- <http://steadystate.org/> (CASSE – steady state economics)

Questions or comments?

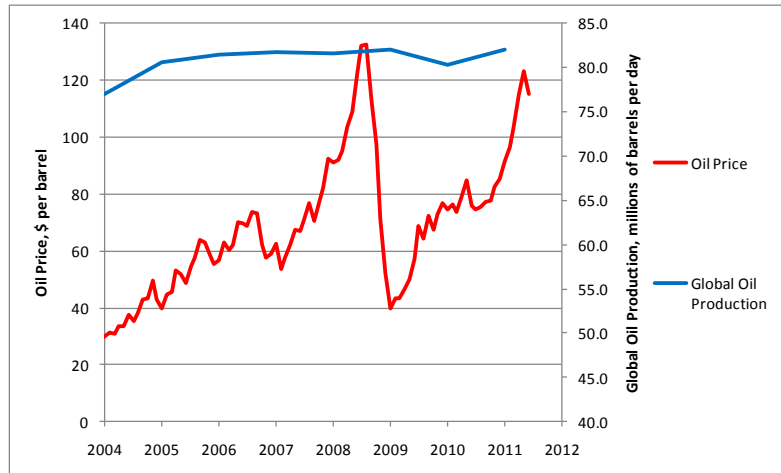
Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

If you want any more information, please can be contacted at
oliver@oliverbettis.com



Oil Price and Global Oil Production 2004- Supply has not yet responded to price signal

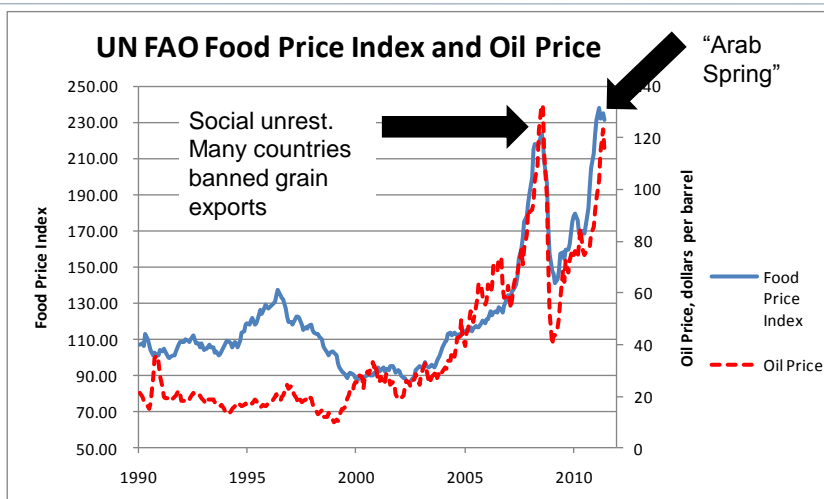


Sources: Oil Price – United States EIA <http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pets&s=rbrte&i=m>
Oil Production: BP Statistical Review of World Energy 2011
<http://www.bp.com/sectionbodycopy.do?categoryId=7500&contentId=7068481>

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Oil and Food Prices



Sources: <http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/>
<http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pets&s=rbrte&i=m>

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What about alternative energy sources?

There are plenty of alternative hydrocarbons:

- Tar sands
- Oil shale
- Shale gas
- Coal (can convert to synthetic oil – “coal to liquid”)

However:

- Transport needs liquid fuel. There are no easy substitutes*
- The alternatives emit more carbon – this is highly dangerous

*Refer: Hirsch Report, 2005 for the US Department of Energy

http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf

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Renewable Energy Sources

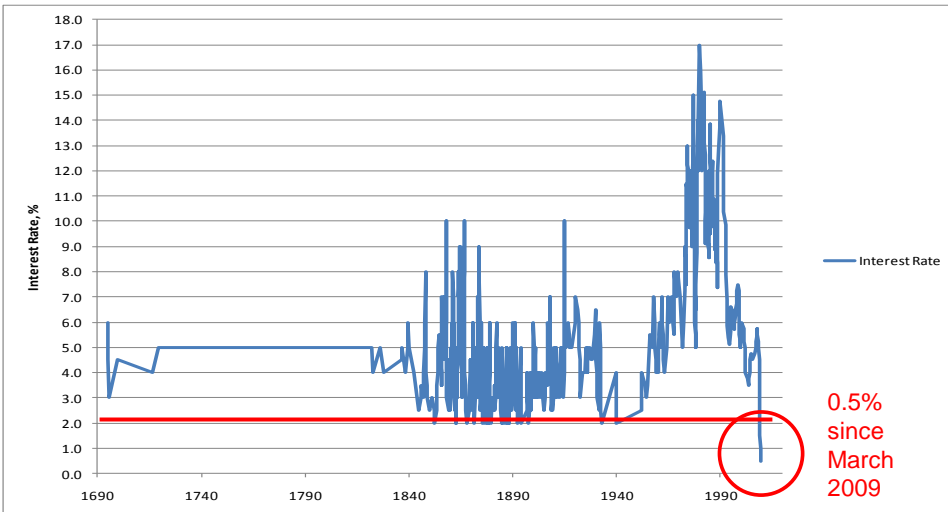
- There is a huge amount of renewable energy available: wind, wave, tidal and solar
- However, these energy sources are diffuse
- Problem is in capturing, concentrating and storing the energy
- This requires huge investment
- Can the investment be ramped up quickly enough to avoid “energy descent”? (i.e. decrease in per capita energy availability)

Refer: David Mackay “Renewable Energy Without the Hot Air”

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Bank of England Base Rates since 1694

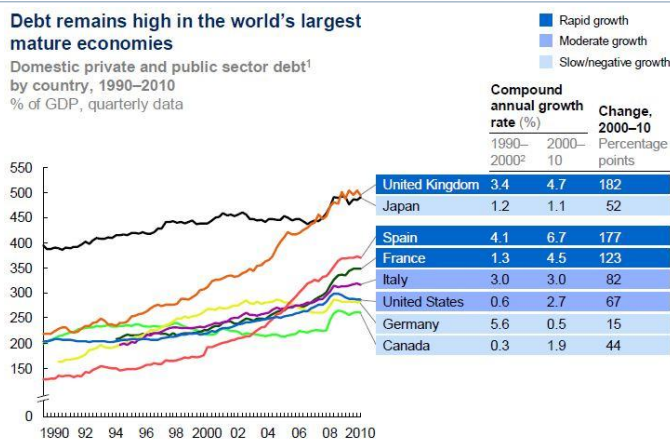


Source: Bank of England <http://www.bankofengland.co.uk/monetarypolicy/decisions/decisions11.htm>
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McKinsey Global Institute Debt to GDP Ratios in Western economies

Debt remains high in the world's largest mature economies

Domestic private and public sector debt¹
 by country, 1990–2010
 % of GDP, quarterly data



1 "Debt" defined as all credit market borrowing, including loans and fixed-income securities.
 2 Or longest time period available.

SOURCE: McKinsey Global Institute analysis

Source: McKinsey Global Institute 2010 "Debt and Deleveraging: The Global Credit Bubble and its Economic Consequences"

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“... deleveraging has followed nearly every major financial crisis in the post-World War II period.”

The four archetypes of deleveraging:

- 1) Austerity (or “belt-tightening”) in which credit growth lags behind GDP growth for many years
- 2) Massive defaults
- 3) High inflation
- 4) Growing out of debt through very rapid GDP growth ?

My guess: High inflation is most likely. Inflation will be >10% within the next few years – although deflation is also possible.

Source for the four archetypes of deleveraging: McKinsey Global Institute 2010 “Debt and Deleveraging: The Global Credit Bubble and its Economic Consequences”

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The credit crunch A risk management failure

- “Yes, I found a flaw,” Greenspan said in response to grilling from the House Committee on Oversight and Government Reform.



Ex Chairman of the Federal Reserve Alan Greenspan, testifying to US Congress about the financial crisis, October 2008.

“We cannot expect perfection in any area where forecasting is required,” he said. “We have to do our best but not expect infallibility or omniscience.”

Worldview

- “Worldview” = beliefs, attitudes and values that make up our mental model of the world.
- Our worldview is our window on the world.
- It is also a filter. We tend to see only information that confirms our existing worldview.
- Psychologists call this assimilation bias.



Refer to: “Making Actuaries Less Human – lessons from behavioural finance”

Cognitive Dissonance

Inconsistent cognitions produce dissonance (a state of unpleasant arousal) when:

- You have freedom to decide
- You are committed to your behaviour
- The behaviour leads to foreseeable adverse consequences

The easiest way to reduce dissonance is to **change beliefs**.

Refer: “Mistakes were made (but not by me)” by C.Tavris and E.Aronson