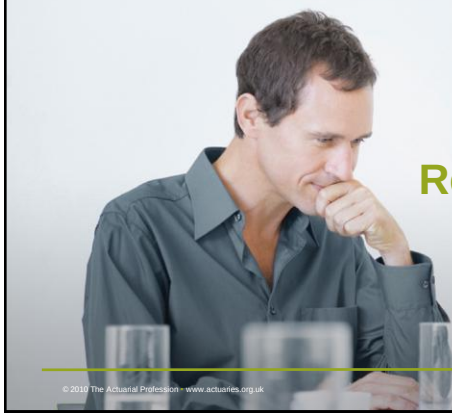
The Actuarial Profession
making financial sense of the future

Risk & Investment Conference 2012
Oliver Bettis & Claire Jones



Resource and Environmental Limits to Economic Growth

29 June 2012

Resource and Environmental Limits to Economic Growth

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- Pricing Actuary, Munich Re
- Chair of Profession's Resource and Environment Group
- Co-Vice-Chair, IAA Environment Working Group

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- 12 years pensions consulting experience
- Studying for MSc Sustainability (Ecological Economics)
- From October 2012, Sustainability and Economics Manager, ICAEW

Resource and Environmental Limits to Economic Growth

1. **Introduction: we live in an exponential world**
2. Resource and environmental limits?
3. A systems view: economic growth in perspective
4. Can economic growth continue?
5. Do we need economic growth?
6. What does it mean for actuaries?

1. We live in an exponential world
The Planet Under Pressure conference

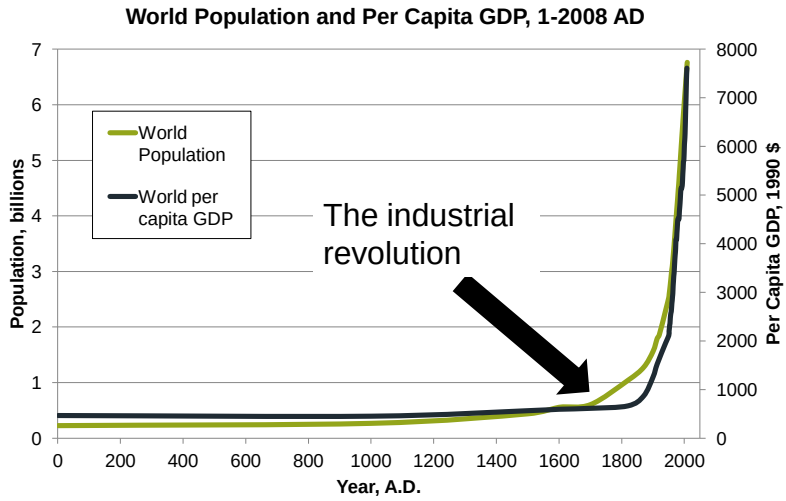
Planet Under Pressure 2012 was the largest scientific conference leading up to the United Nations Conference on Sustainable Development (Rio+20), with over 3000 delegates.

State of the Planet Declaration:

- "1. Research now demonstrates that the continued functioning of the Earth system as it has supported the well-being of human civilization in recent centuries is at risk…"

See: http://www.planetunderpressure2012.net/

1. We live in an exponential world
A long term view of growth

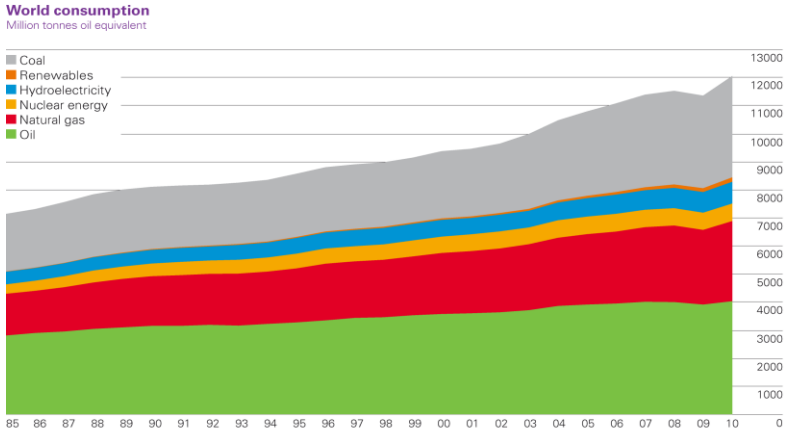


Source: Maddison 2008 http://www.ggdc.net/MADDISON/oriindex.htm

1. We live in an exponential world
Future world GDP growth: the conventional view

- In real terms world GDP has grown at average rate of c.3% per year in recent decades = doubling time 23 years.
- 2012 to 2100 is almost 4 doubling periods.
- If 3% growth continues, world economy would grow 14 times as large in 2100 as it is now.

1. We live in an exponential world
Energy fuelling the economy is mainly fossil fuel



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.

Source: BP Statistical Review of World Energy 2011

- Our industrial civilization uses about 13 Tera Watts for machinery.
- Estimated net primary productivity of Earth's ecosystems ≈70TW on land.

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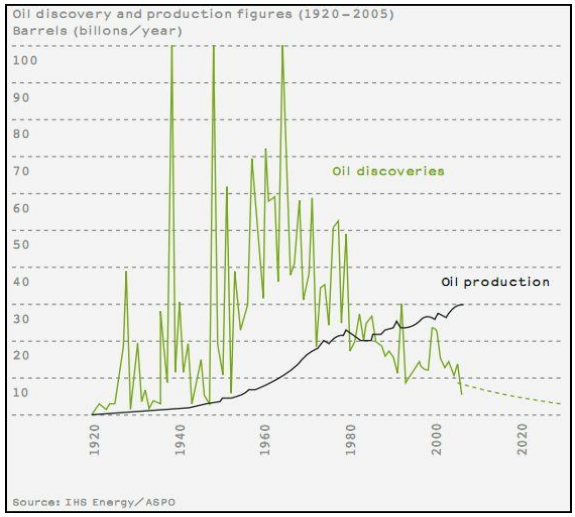
2. Resource limits to growth: Peak oil
Oil discoveries versus oil production

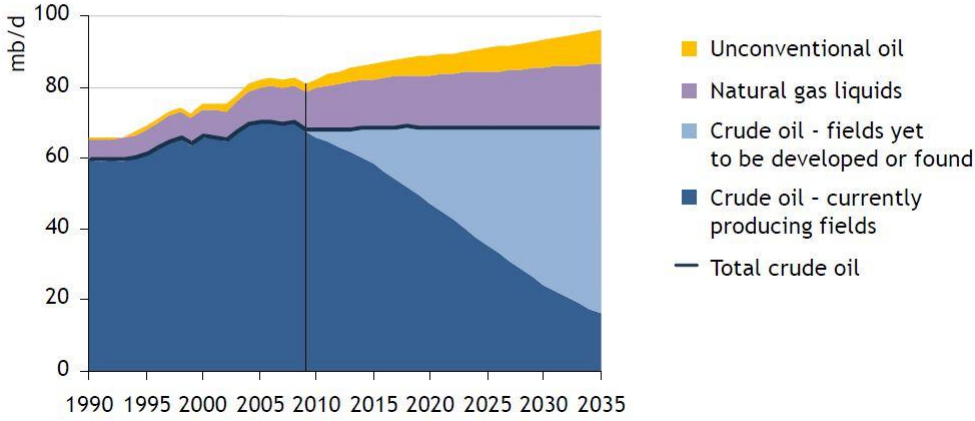


"Discoveries of new deposits peaked as far back as the 1960s and 1970s. Now a number of countries in addition to the UK and the USA, for instance, have reached their production limits. The quantity of oil being pumped out of the earth exceeds new discoveries."

Source: Munich Re Foundation 2009 Report page 28
http://www.munichre-foundation.org/StiftungsWebsite/Publications/2009report_Publication_summary.htm

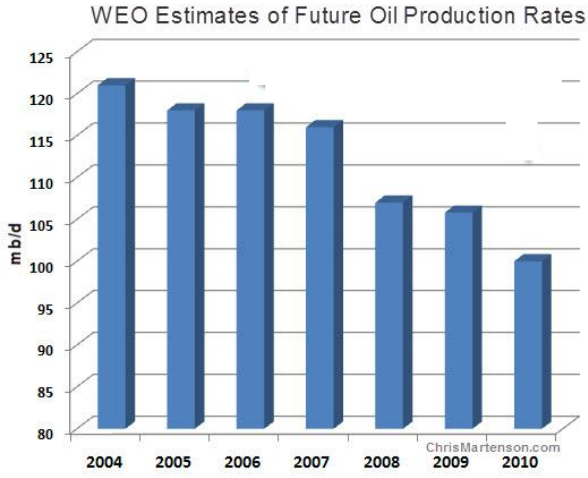
2. Resource limits to growth: Peak oil
International Energy Agency World Energy Outlook

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

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

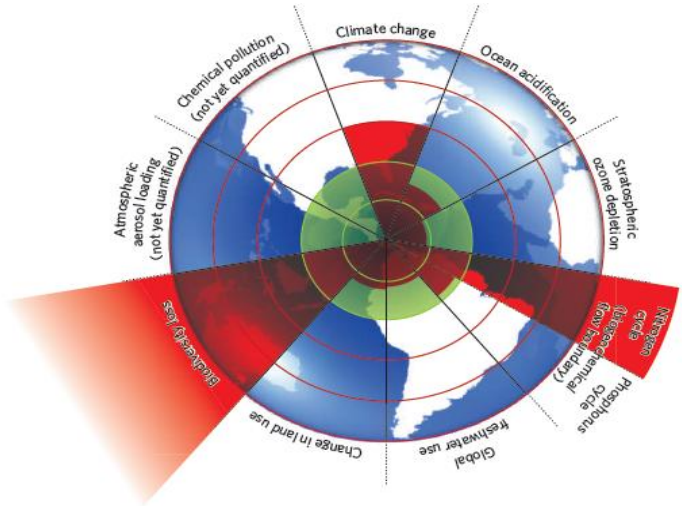


In the 2004 WEO forecast of oil price until 2030:

- Baseline forecast was $25 a barrel.
- "High" scenario was $35 a barrel.

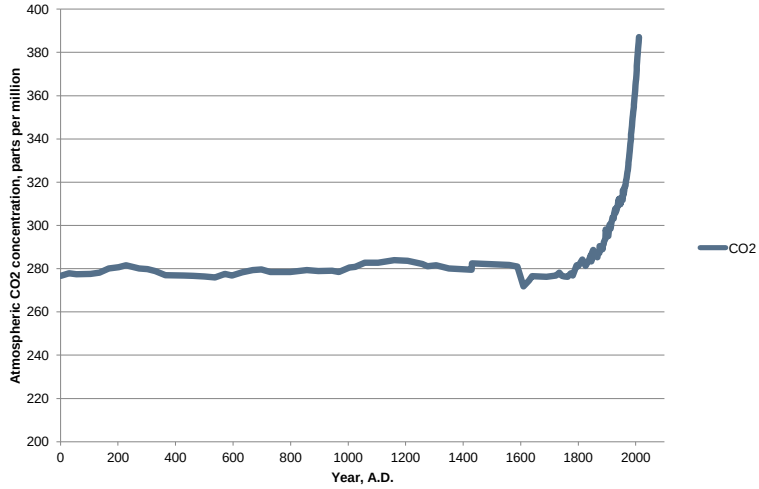
Source: Chris Martenson summary of IEA WEOs http://www.chrismartenson.com/

2. Environmental limits to growth
Hard-wired environmental limits?



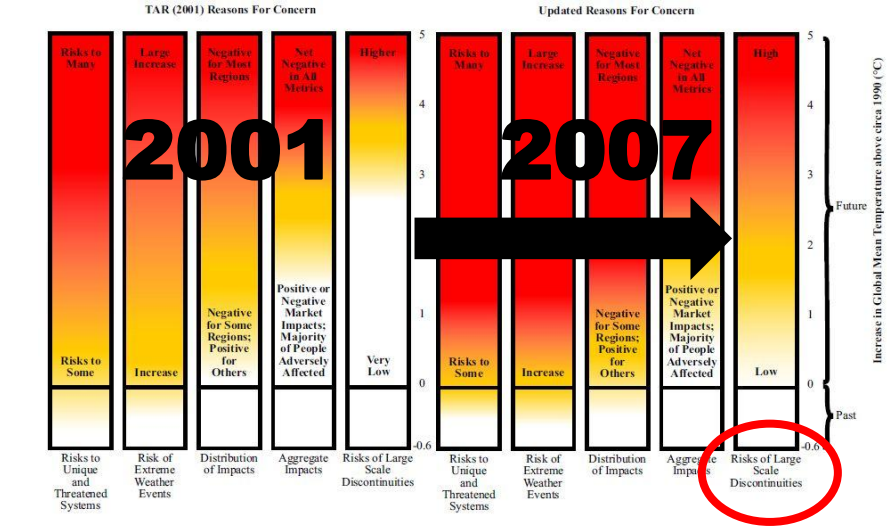
From Rockstrom et al "A safe operating space for humanity", Nature 2009
http://www.nature.com/nature/journal/v461/n7263/full/461472a.html

2. Environmental limits to growth: Climate change
Atmospheric carbon dioxide concentration



Source: Scripps Institution of Oceanography (SIO) CO2 Program http://scrippsco2.ucsd.edu R. F. Keeling, S. C. Piper, A. F. Bollenbacher and S. J. Walker

2. Environmental limits to growth: Climate change
Updated "Reasons for Concern"



From: J.B.Smith et al PNAS 2009

Resource and Environmental Limits to Economic Growth

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3. A systems view: economic growth in perspective
Link between problems

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

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

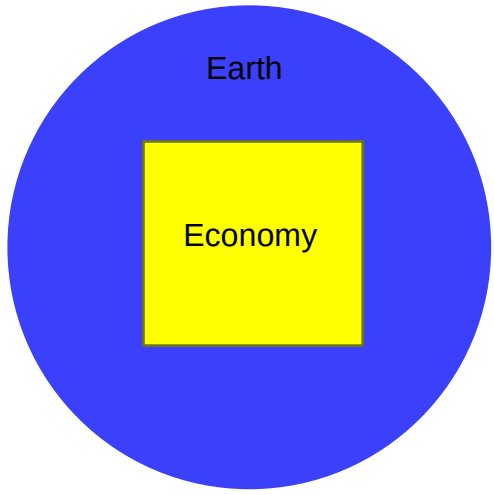
Growth drives our problems!

3. A systems view: economic growth in perspective
Is growth always good?

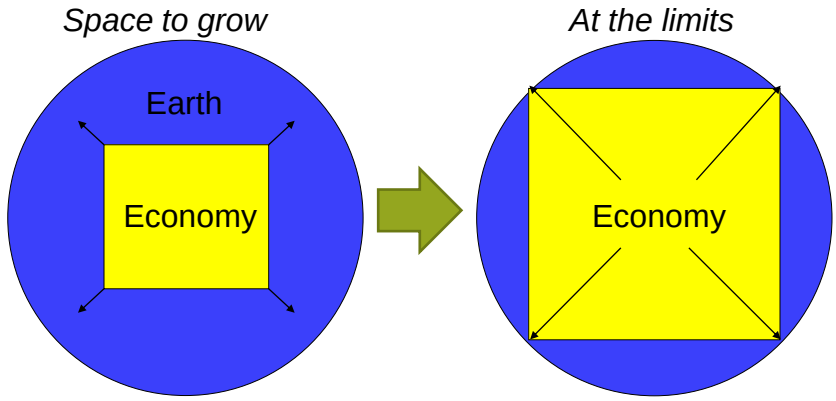
- Many things have an optimal size – further growth is bad
  - E.g. People!

Question: Is <u>economic</u> growth always good?

3. A systems view: economic growth in perspective
The human economy is a subset of the Earth



3. A systems view: economic growth in perspective
The human economy is a subset of the Earth



(adapted from Clapp and Dauvergne 2005: p.101)

3. A systems view: economic growth in perspective
Human impact on the Earth – a simple approach

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

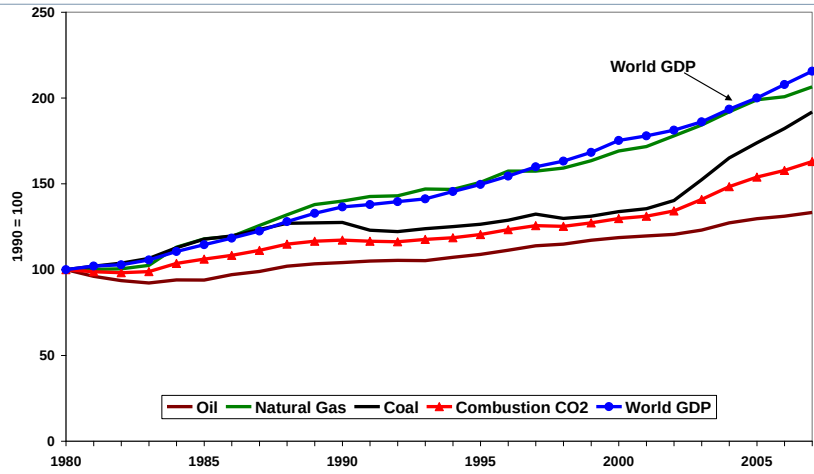
I = Impact

P = Population

A = Affluence (consumption per capita)

T = Technology (environmental impact per unit of consumption)

3. A systems view: economic growth in perspective
Can technology decouple growth from pollution?



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

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3. A systems view: economic growth in perspective
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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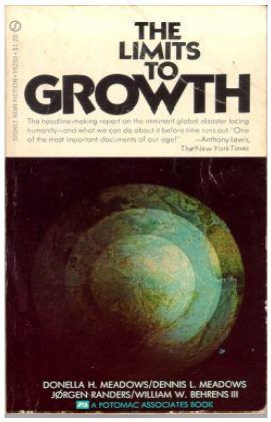
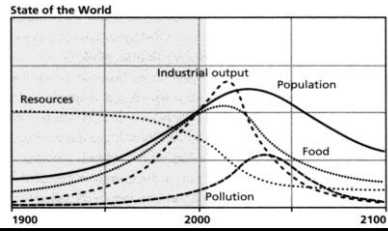
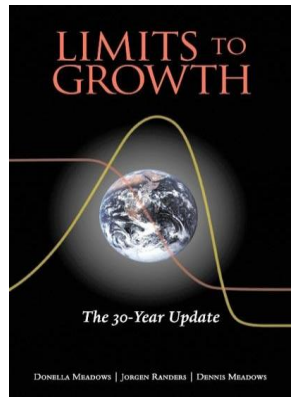
3. A systems view: economic growth in perspective
The "Limits to Growth" study



The original 1972 study was updated in 2004

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

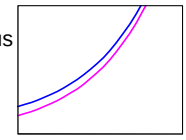




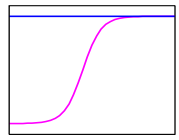
3. A systems view: economic growth in perspective
The "Limits to Growth" argument

- 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.
- Exceeding the carrying capacity of the Earth carries risk.

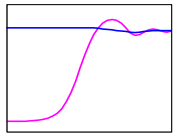
Continuous growth



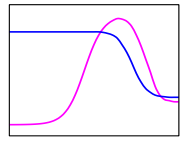
Sinusoidal Growth



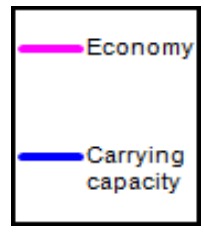
Oscillation



Collapse



The 4 possibilities for exponential growth.



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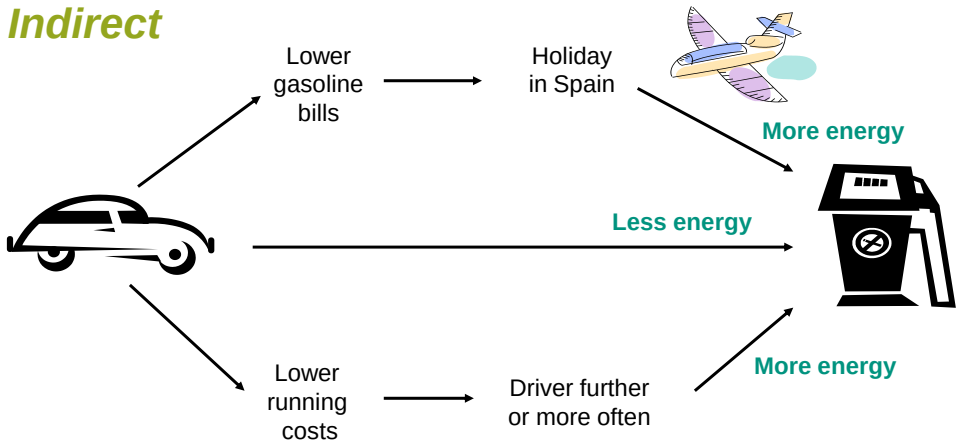
4. Can economic growth continue?
The idea of "green" economic growth

- Need to decouple economic growth from resource use & environmental impacts
  - Absolute not relative decoupling
  - Global not national (take account of trade)
- But is decoupling possible?
  - Rebound effects
  - Role of energy in generating economic growth

4. Can economic growth continue?
Rebound effects – an example



Source: http://www.ukerc.ac.uk/support/tiki-index.php?page=ReboundEffect

4. Can economic growth continue?
The indirect rebound effect in action!

4. Can economic growth continue?
Role of energy in generating economic growth (1)

- Traditional view: labour & capital drives economic growth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- But what about natural resource inputs?
- And what about energy?

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4. Can economic growth continue?
Role of energy in generating economic growth (2)

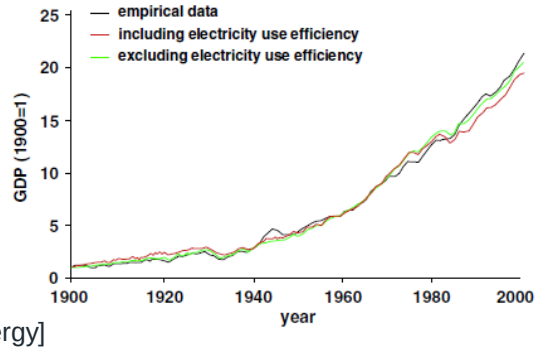
- Neo-classical model:

$$Y = L^{\alpha} \times K^{\beta} \times A$$

- Alternative model:

$$Y = L^{\alpha} \times K^{\beta} \times U^{\gamma}$$

- Where:
  - Y = total output
  - U = useful work [from energy]
  - L = labour
  - K = capital



US economic growth
(α=0.45, β=0.07, γ=0.48)

Source: Ayres et al (2007). Energy efficiency, sustainability and economic growth. *Energy* **(32)** pp.634–648

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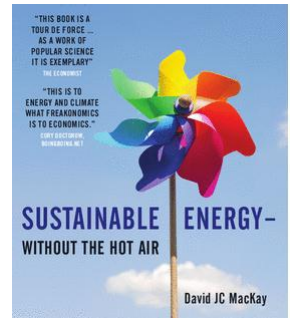
4. Can economic growth continue?
Is low-carbon renewable energy the solution?

- Huge renewable potential, but hard to realise it
  - Diffuse, intermittent sources
  - Capture, storage & transmission
- Too little, too late?
  - Massive investment needed
  - Lock-in to existing infrastructure
  - Long lead-time for new technologies
- Use energy to generate energy



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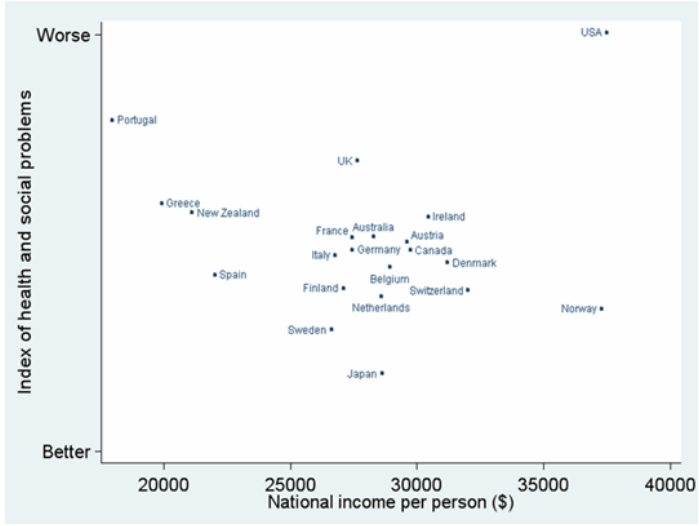
5. Do we need economic growth?
GDP as an indicator of well-being (1)

Index of:

- Life expectancy
- Maths & literacy
- Infant mortality
- Homicides
- Imprisonment
- Teenage births
- Trust
- Obesity
- Mental illness – incl. drug & alcohol addiction
- Social mobility



Source: Wilkinson & Pickett (2009). The Spirit Level, p.21

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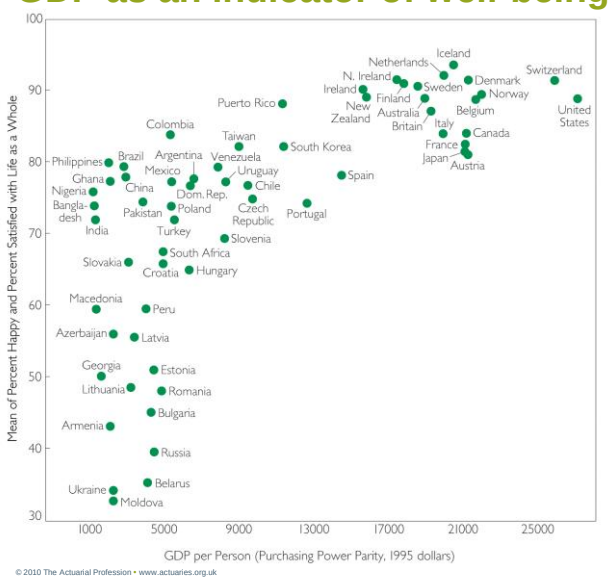
5. Do we need economic growth?
GDP as an indicator of well-being (2)



% of people content
versus
GDP per person at PPP

Source: Jackson, T. (2009) Prosperity without growth? Economics for a finite planet, .

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5. Do we need economic growth?
Income equality rather than absolute income

Index of:

- Life expectancy
- Maths & literacy
- Infant mortality
- Homicides
- Imprisonment
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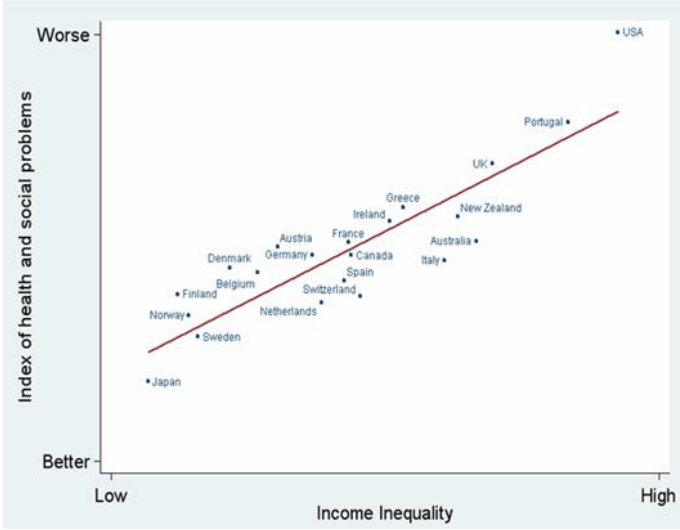
- Social mobility



Source: Wilkinson & Pickett (2009). The Spirit Level, p.20

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5. Do we need economic growth?
The role of economic growth in society

- Economic growth is the dominant concern of politics
  - e.g. austerity versus growth debate
- Society is structurally dependent on economic growth:
  - Fractional reserve banking: grow income to repay debts
- Technological progress increases productivity
  - Produce more rather than reduce workforce
- Social, psychological and cultural dependence on growth
  - Firms create demand for their products

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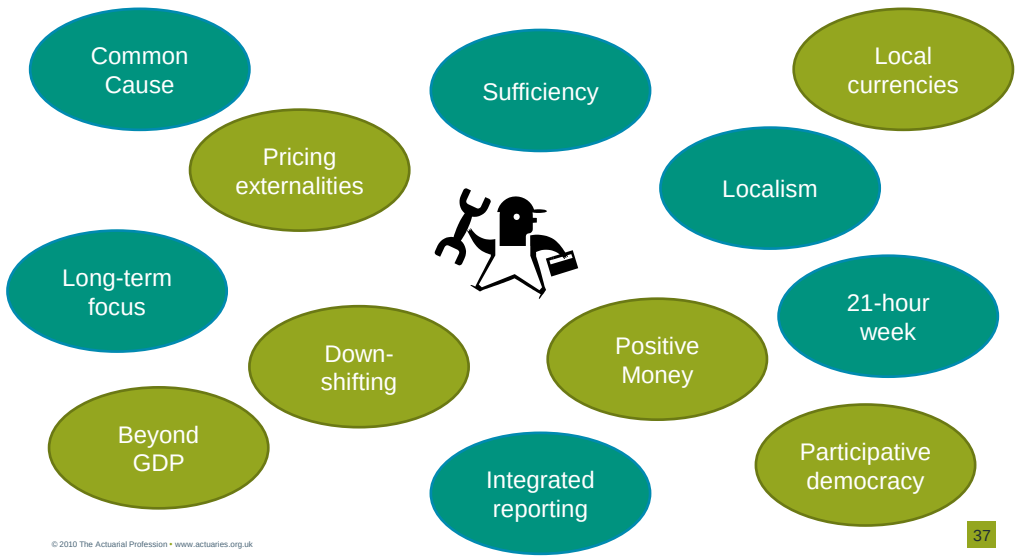
5. Do we need economic growth?
Alternatives to the current economic system

- Alternative schools of thought include:
  - Steady state economy
  - (Planned) degrowth
- Ideas rooted in thermodynamics
- Society operating within planet's natural carrying capacity
- More equal distribution of planet's resources
- Positive visions of a society focused on human well-being

More info: http://steadystate.org/ and http://degrowth.org/

5. Do we need economic growth?
Toolkit for an alternative economic system



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6. **What does it mean for actuaries?**

6. What does it mean for actuaries?
Use your skills and influence

- Important issues for Actuarial Profession and society as a whole
- Debate the role of economic growth in society
  - Need more discussion and awareness, particularly among finance community
- Help to identify, articulate and test alternatives
  - How might resource & environmental limits affect economic variables?
  - What might a steady-state economy look like?
  - How could we achieve an orderly transition?

6. What does it mean for actuaries?
Implications for your day-job

- Increase awareness and understanding of the issues
  - You, your colleagues, your clients
- Understand and manage portfolio exposure
  - Implications for sector and stock selection
  - Engage with management
- Identify, monitor and reduce risk exposure
  - Reduce the unknown unknowns
- Influence policy, individually or collectively

6. What does it mean for actuaries?
What are actuaries doing? Some examples

- Resource & Environment MIG (REG) has >400 members. 2 literature reviews published, 3rd due in March 2013.
- Resource & Environment Panel set up to guide profession. Peter Tompkins chairs, Philip Scott is a member.
- Research into the limits to growth commissioned; results in 2012.
- Internationally:
  - IAA Environment Working Group
  - CAS Climate Change Committee
  - SOA have started a group looking into resource issues
- Actuaries have the perfect skill-set for these issues. We can be leaders in this field.

Final thought and further reading

Question the assumptions about economic growth that surround you.

Further reading:

- http://www.planetunderpressure2012.net/ (science)
- http://www.withouthotair.com/ (energy)
- http://www.neweconomics.org/ (economics for sustainability)
- www.theoildrum.com (energy)
- http://www.energybulletin.net/ (energy)
- http://www.positivemoney.org.uk/ (financial reform)
- http://steadystate.org/ (CASSE – steady state economics)

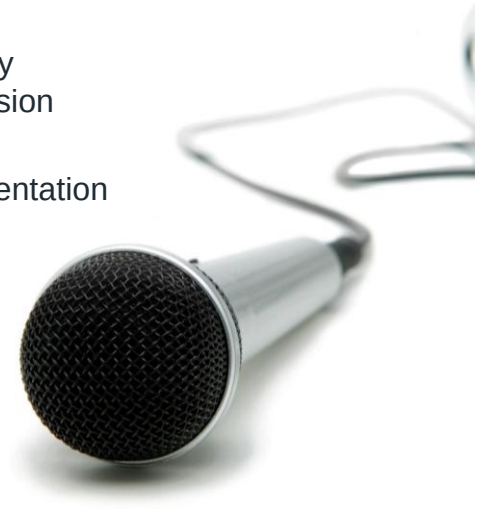
Some specific references

- Jackson (2009). Prosperity without Growth http://www.sd-commission.org.uk/data/files/publications/prosperity_without_growth_report.pdf
- Sorrell (2010). Energy, Economic Growth and Environmental Sustainability: Five Propositions http://www.mdpi.com/2071-1050/2/6/1784/pdf
- MacKay (2008). Sustainable Energy – Without the Hot Air http://www.withouthotair.com/
- Wuppertal Institute (2010). Towards Sustainable Development: Alternatives to GDP for Measuring Progress http://www.wupperinst.org/uploads/tx_wibeitrag/ws42.pdf
- Robertson & Huber (2000). Creating New Money http://www.jamesrobertson.com/book/creatingnewmoney.pdf
- Fair Pensions (2011). Protecting our best interests: rediscovering fiduciary obligation http://www.fairpensions.org.uk/sites/default/files/uploaded_files/fidduty/FPProtectingOurBestInterests.pdf

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 presenters.



Feel free to contact us at:

oliver@oliverbettis.com and mert0311@gmail.com.

Also Twitter at @OliverBettis

Additional Slides

Beyond here are some additional slides with more information about resource and environmental limits.

1. We live in an exponential world
Exponential growth

Well known rule of thumb for doubling time

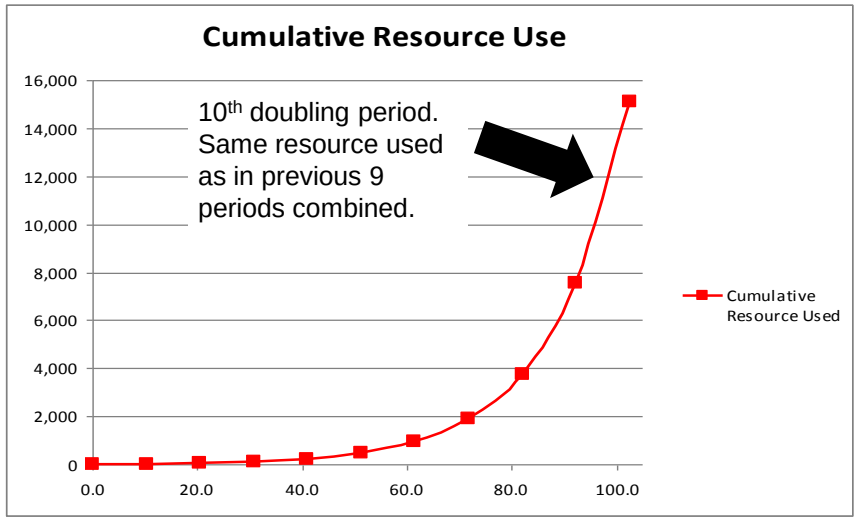
- Approx. doubling time = 70/(Growth Rate in %)
  Reason: 70 ≈ 100*ln(2)
- E.g. 7% p.a. growth means doubling time of 70/7 = 10 years

Not so well known rule of thumb for cumulative resource used during doubling period

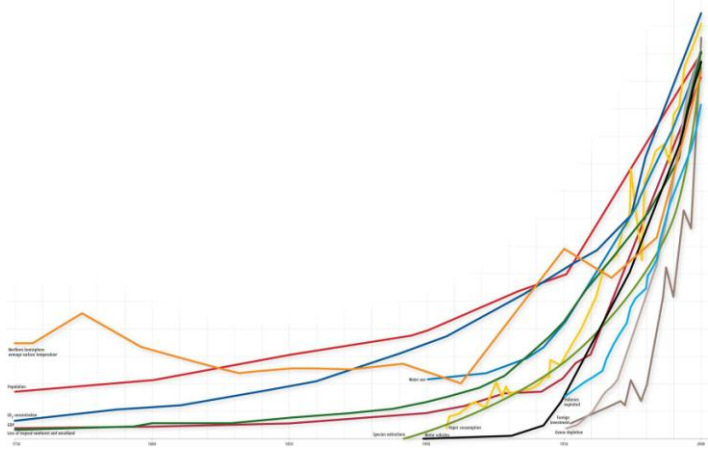
For a resource which is used up at a constantly increasing rate:

- 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. We live in an exponential world
Cumulative Resource Use @7% p.a. growth



1. We live in an exponential world
World growth trends 1750-2000



1750 1800 1850 1900 1950 2000

1. GDP
2. Population
3. Paper consumption
4. Motor vehicles
5. Foreign investment
6. CO_2 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

1. We live in an exponential world
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 1997-2001.

- Fossil fuel allowed us to escape the limits of land.
- 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. We live in an exponential world
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* (= 5.2kW per person)
- 1 person produces ~ 75 Watts sustained power
- UK citizens use ~ 70 "energy slaves"

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

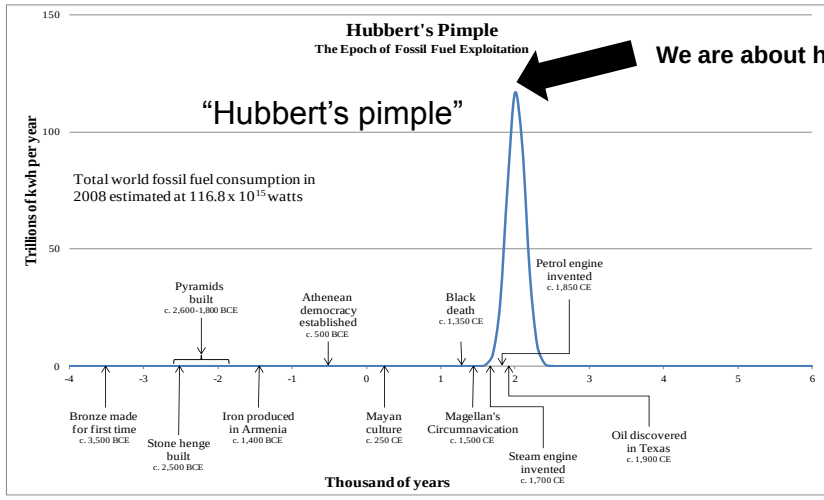
1. We live in an exponential world
We are addicted to oil

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

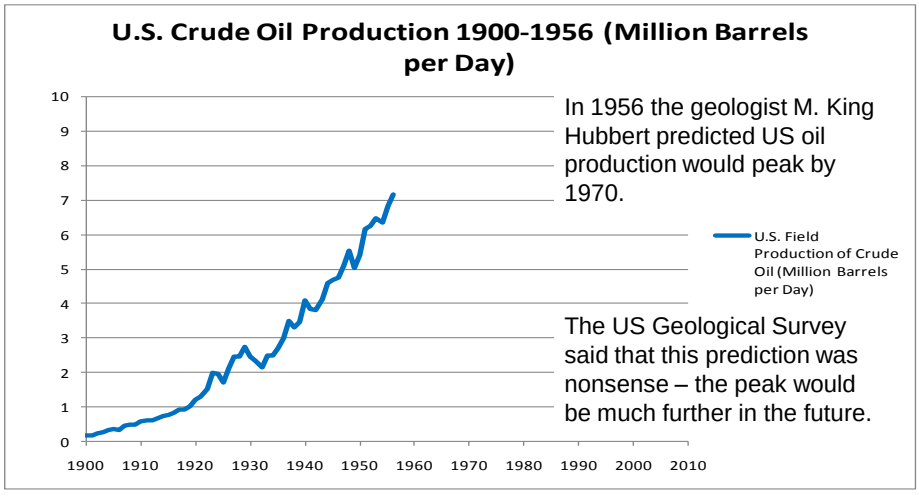
Source: http://articles.cnn.com/2006-01-31/politics/bush.sotu_1_energy-research-union-speech-advanced-energy-initiative?_s=PM:POLITICS

2. Resource limits to growth: Peak oil
Global fossil fuel use – a long term view



Source: http://www.actuaries.org.uk/research-and-resources/documents/climate-change-and-resource-depletion-challenges-actuaries-review-I adapted from Professor Charles A.S. Hall, State University of New York http://www.esf.edu/efb/hall/ After Hubbert, 1969

2. 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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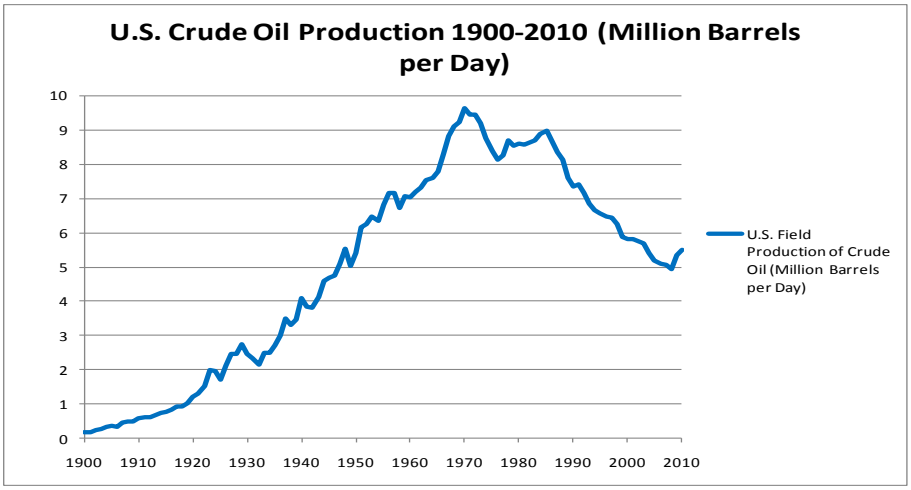
2. Resource limits to growth: Peak oil
United States Oil Production 1900-2010



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

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2. Resource limits to growth: Peak oil
Some 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

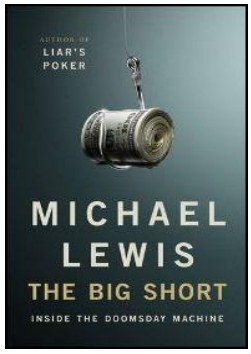
- June 2010 – Tullett Prebon research "Dangerous Exponentials"

"… impending collision between economic system that must grow and finite resources which cannot grow."

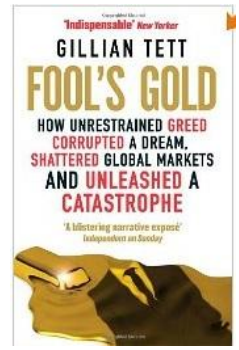
- April 2011 - GMO letter to investors *"Time to wake up: Days of abundant resources and falling prices are over"*
- April 2011 - IMF World Economic Outlook. Models oil scenarios.
- May 2012 – IMF Working paper "The Future of Oil"

Weblinks to sources in Notes area

2. 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?

2. Environmental limits to growth: Climate change
NAS - Climate stabilization targets 2011

- Fossil fuel CO_2 emissions have created new epoch.
- Human activities will largely determine the evolution of Earth's climate.
- Man-made CO_2 stays in the atmosphere a long time.
- 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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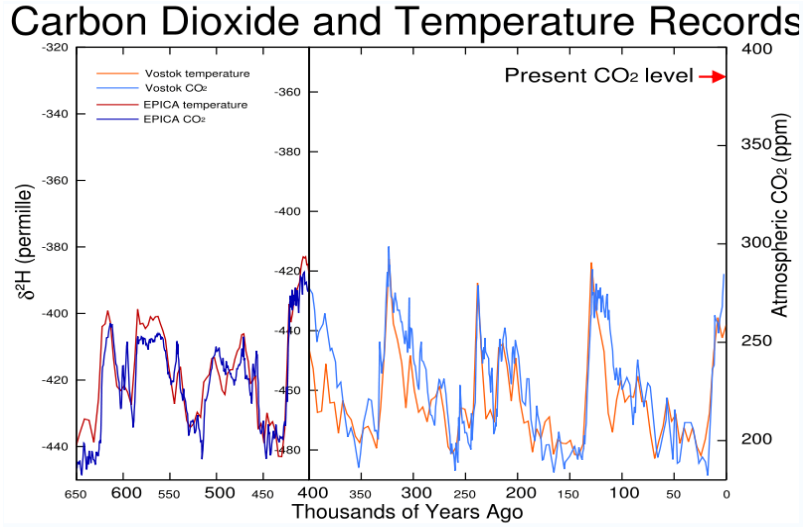
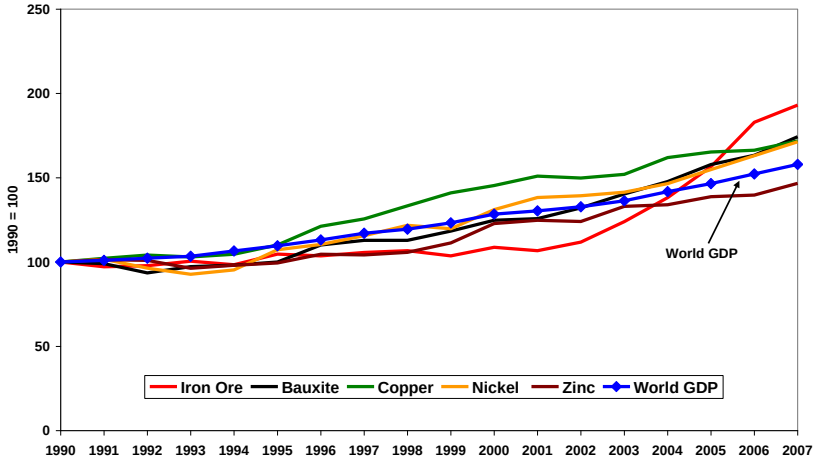
2. Environmental limits to growth: Climate change
Temperature versus CO_2 concentration



3. A systems view: economic growth in perspective
The myth of decoupling GDP from physical inputs

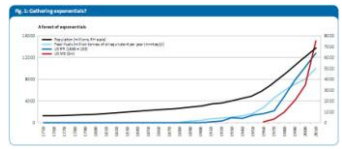


Jackson, T. (2009) *Prosperity Without Growth? Economics for a Finite Planet*, Routledge, London, UK.

3. A systems view: economic growth in perspective
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

3. A systems view: economic growth in perspective
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 1980s, 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