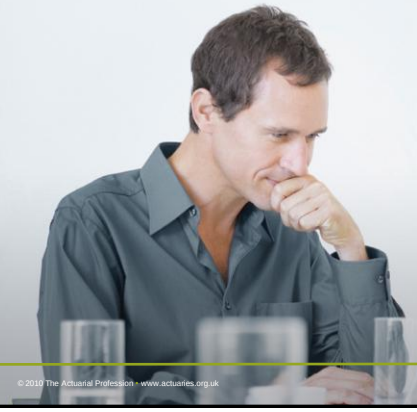
The Actuarial Profession
making financial sense of the future

GIRO conference and exhibition 2011
Oliver Bettis



Limits to Growth

11-14 October 2010

Limits to Growth: Introduction
"Who Killed the Spark?" – GIRO 2008

- Closing speech of the 2008 GIRO in Sorrento.
  - "Who killed the spark?" What was it about?
- Q. Why was Prof. Obeng so opaque? A. To avoid "pushback".
- But it's our job to think about risks.
- Make up your own mind, be curious.
- Presentation covers a lot of ground – so please:

Limits to Growth
GIRO 2010

- The exponential function
- Climate change is one of many problems
- Making sense of it all - the “Limits to Growth”
- Why are we in this situation?
- What are the solutions?

Exponential Growth

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

$$x(t) = x_0 e^{ti}$$

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

Refer: http://www.albartlett.org

Exponential Growth - Doubling Time

- Doubling time
  Approx. doubling time = 70/(Growth Rate in %)
  Reason: 70 ≈ 100*ln(2)

- Every time you hear a growth rate, think doubling time:
  - "Crime Doubled in a Decade!"
  - "Growth in GDP"

Exponential Growth – Resource Use

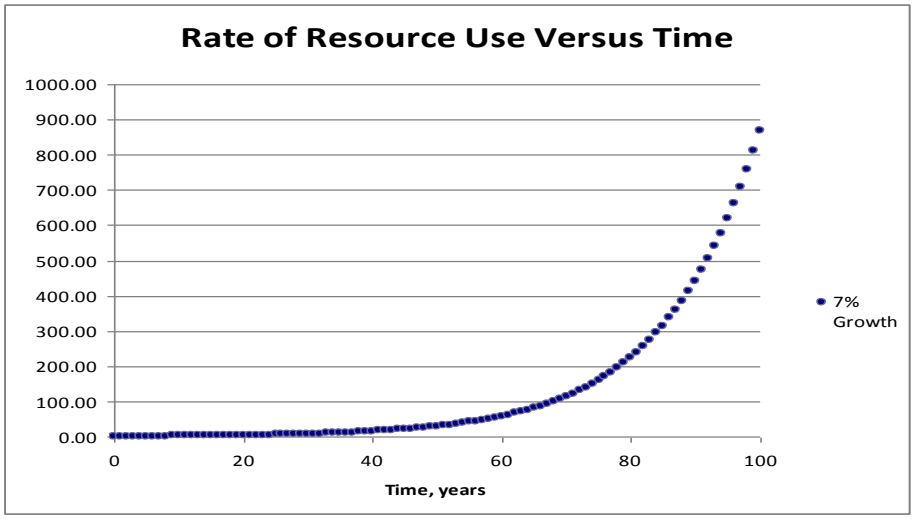
For a resource which is used up at a constantly increasing rate:

- 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.

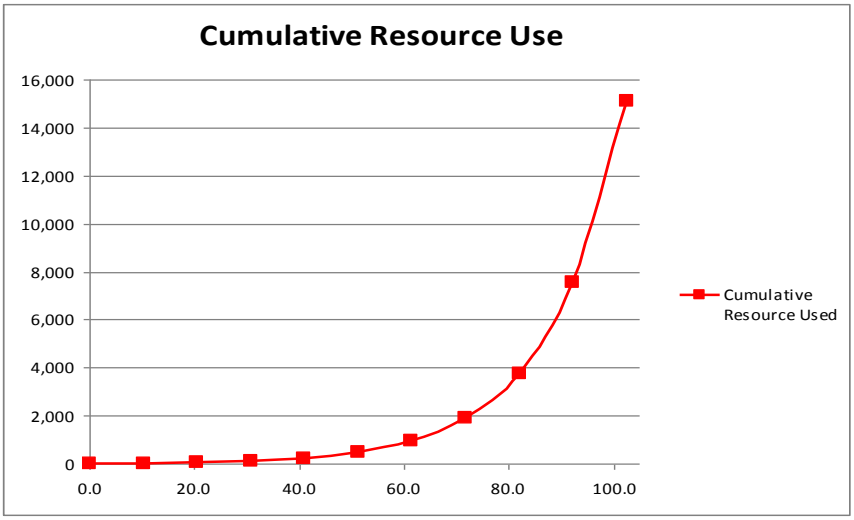
- This is not an intuitive result!

Exponential Growth – Resource Use

Example: 7% p.a. growth



Exponential Growth – Resource Use



Limits to Growth
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- Why are we in this situation?
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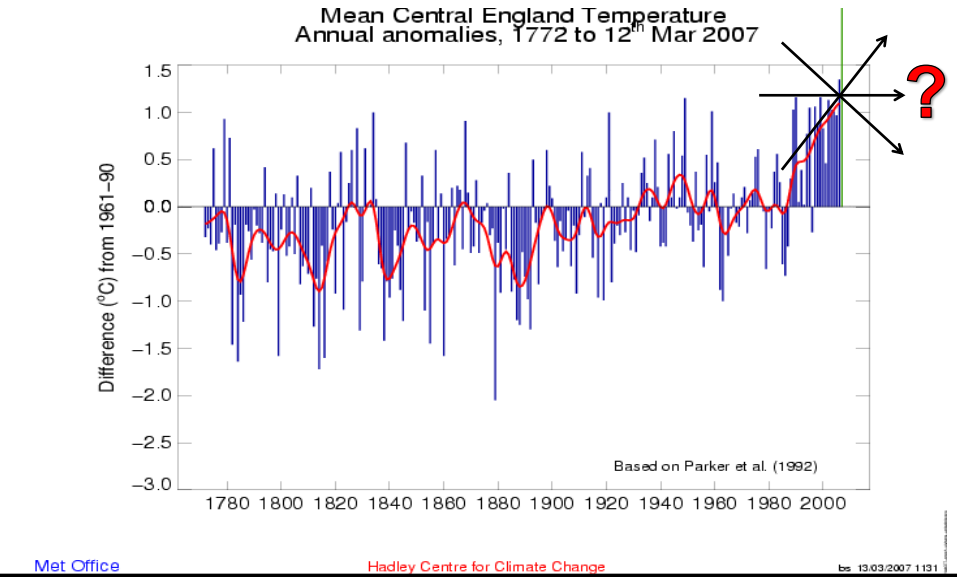
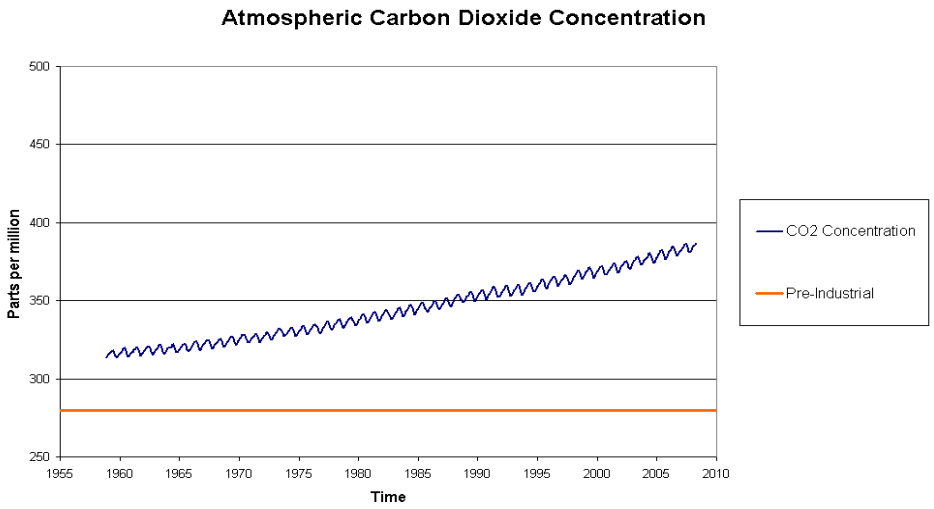
British Summers Getting Warmer?? My Wakeup Call.



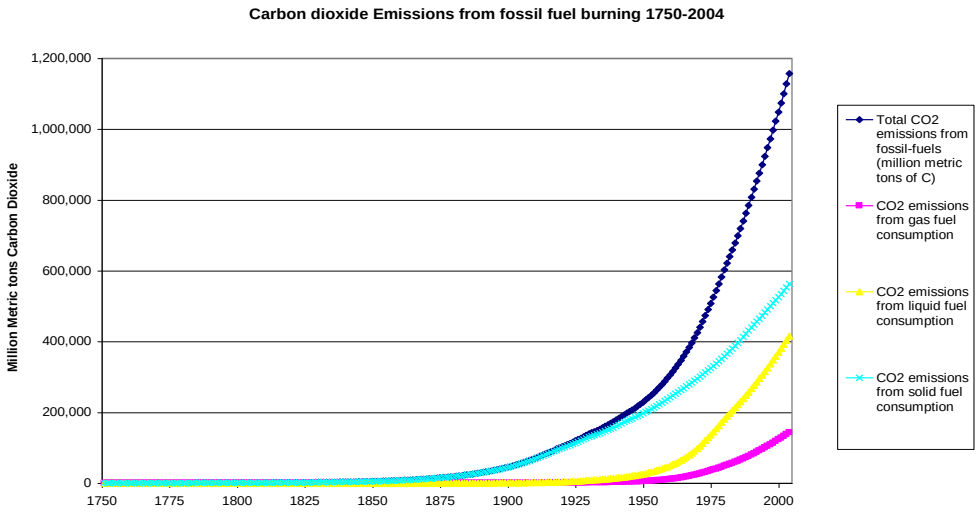
Our climate has already changed

- Anyone pricing business exposed to extreme weather events must allow for climate change now.
- Return periods of storms and floods have already changed.
- Difficult to know how much change has occurred.

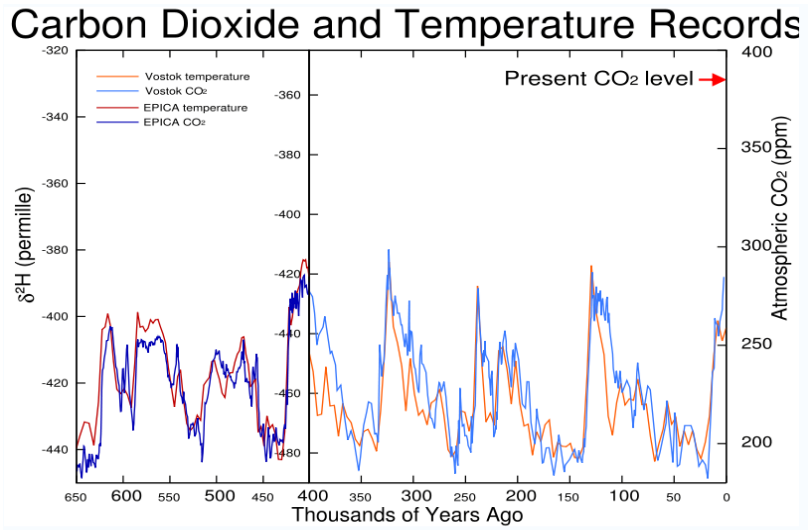
Why is our climate changing?
Atmospheric Carbon Dioxide Versus Time



Cumulative CO_2 emissions from fossil fuels From the beginning of the industrial revolution



The "Smoking Gun" of Climate Change Temperature versus CO_2 concentration



IPCC Estimate vs climate record

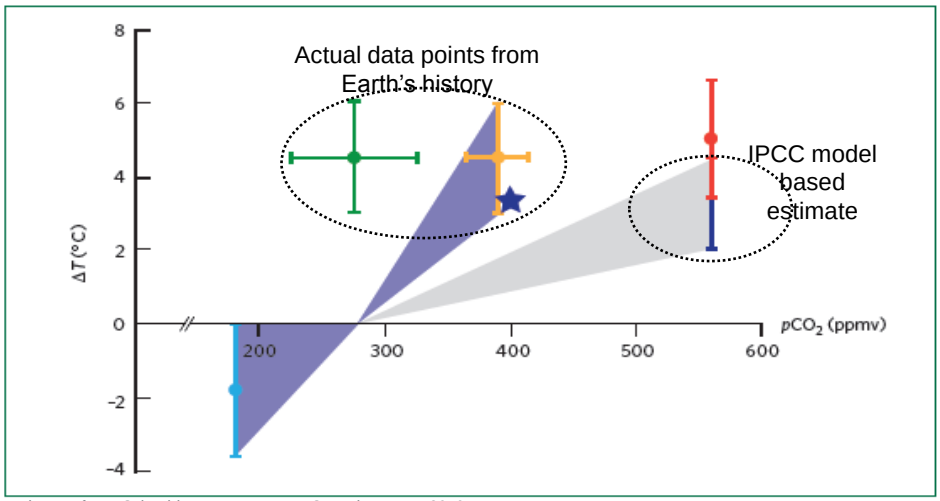


Diagram from: Schneider B. & R., Nature Geoscience Jan 2010

Important: With political will, ways of removing CO_2 from the atmosphere could be developed.

Interpretation of Climate Science

Q. Is it possible that anchoring is occurring with climate sensitivity estimates?

Analogy: GI reserving exercise where emerging experience was different to model forecasts.

Q. How much evidence do you need before you rethink your model?

Paleoclimate data seems to point to the conclusion that maximum safe atmospheric CO2 is <350ppm.

Interpretation of Climate Science

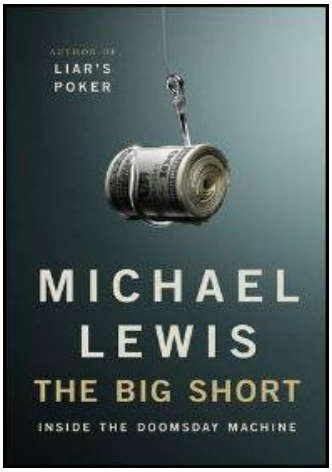
Q. Who has an incentive to recognise that the Earth has a high sensitivity to carbon dioxide?

- Problem is not with climate science.
- Science normally progresses slowly, disagreements can take many years to resolve.
- Problem is with the interpretation of science; the risk management.
- To understand what is going on, **look for the incentives.**

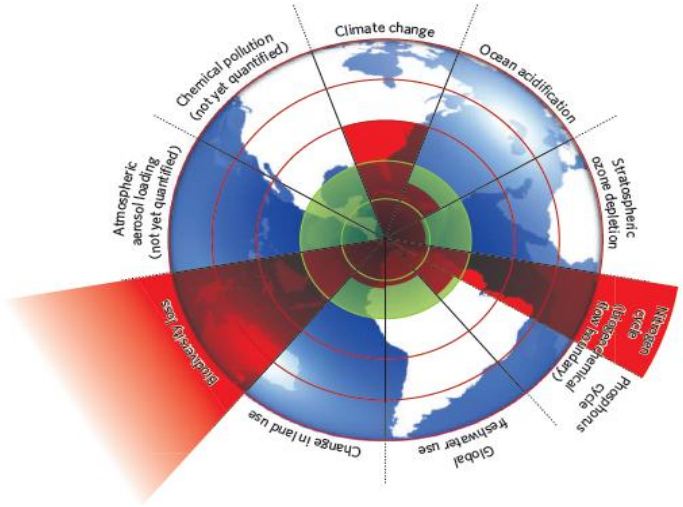
A Parallel with the Subprime mortgage bubble?

• Michael Lewis describes the sub-prime bubble in “The Big Short”.

• Perhaps the we can learn from the failure of risk management in the sub-prime episode?



Climate change is 1 of 9 hard-wired environmental limits



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

The Deepwater Horizon Oil Spill

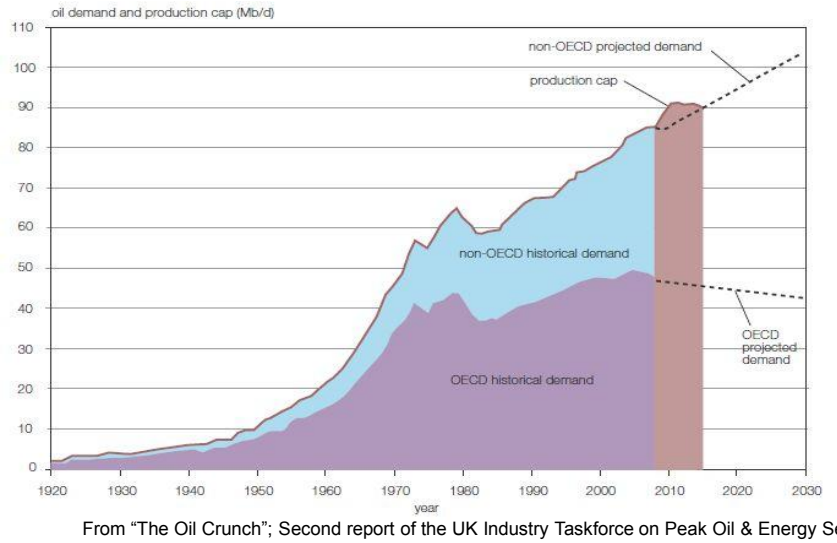
Questions Raised by Deepwater Horizon

- Proximate cause of the oil spill was a blowout.
- Deepwater Horizon rig was drilling through 1 mile of sea and 2 miles of rock.
- Operating at limit of current technical capability.

Questions:

- Why drill in such deep water?
- What is the real cost of fossil fuels?
- Where does our wealth come from?

Global Oil Production Since 1920



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

The Oil Crunch – A wakeup call for the UK Economy

Second report of the UK Industry Task Force on Peak Oil and Energy Security

"The credit crunch of 2008 … stress tested the responses of governments, policy-makers and businesses to the extreme…

The next five years will see us face another crunch - the oil crunch. This time, we do have the chance to prepare. The challenge is to use that time well. As we reach maximum oil extraction rates, the era of cheap oil is behind us."

Our message to government and businesses is clear. ***Act now.****"*

Signed:

Richard Branson, Founder, Virgin Group

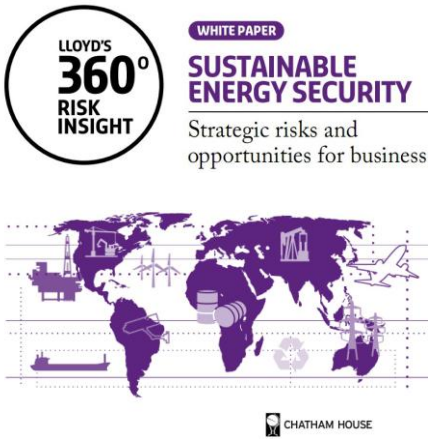
Ian Marchant, CEO, Scottish & Southern Energy

Brian Souter, CEO, Stagecoach Group

Philip Dilley, Chairman, Arup

Jeremy Leggett, Chairman, Solarcentury

Lloyd's 360 Risk Insight – June 2010
Sustainable Energy Security



From the foreword by Lloyd's CEO, Dr Richard Ward

- Deep uncertainty in how we will source energy for power, heat and mobility.
- This is not normal oil and gas market volatility.
- A new energy paradigm is needed.
- We are in a period akin to a phony war.

http://www.lloyds.com/News-and-Insight/360-Risk-Insight/Research-and-Reports/Energy-Security/Energy-Security

Decline in Oil – why we need to know about it professionally

- Energy underpins economic activity. It is the "master resource".
- Transport needs liquid fuel – no easy substitutes*.
- Sudden change to asset prices is possible when world becomes "peak oil aware"
- Interest rates and inflation rates greatly affected
- Economic forecasts must allow for peak oil – to make "financial sense of the future"

*Refer: Hirsch Report, 2005 for the US Department of Energy
http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf

Summary: Why actuaries need to know about sustainability issues

Climate Change

- Natural Catastrophe claims cost
- Other weather related and possibly liability claims
- New markets
  - Existing products
  - New products

Oil and Resource Depletion

- Economic impacts:
  - Interest rates
  - Inflation – Raw Materials
  - Asset prices

What the *$#! is going on?

Limits to Growth
GIRO 2010

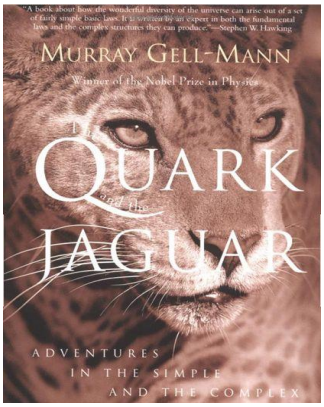
- The exponential function
- Climate change is one of many problems
- Making sense of it all - the “Limits to Growth”
- Why are we in this situation?
- What are the solutions?

The CLAW Approach

The world is highly complex; full of non-linear systems.

Get a more realistic view of the world by taking a Crude Look At the Whole.

From Murray Gell-Mann, “The Quark and the Jaguar”



A CLAW for human impact on the Earth

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

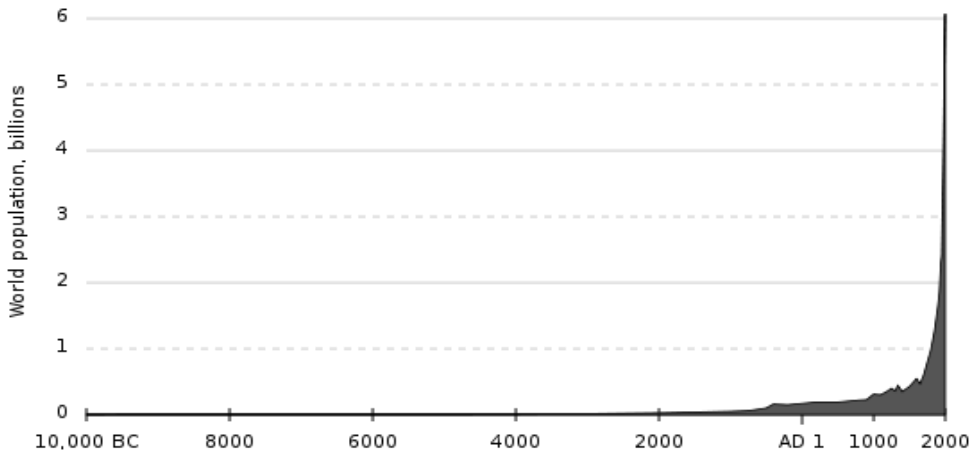
I = Impact

P = Population

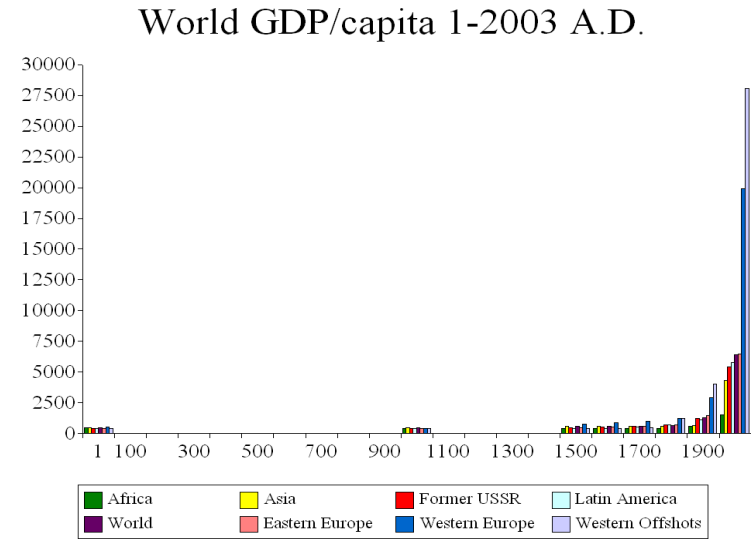
A = Affluence (consumption per capita)

T = Technology (environmental impact per unit of consumption)

World Population



Affluence



Technology

I = P x A x T

- If affluence and population grow, for impact to stabilize or shrink, technology must improve.
- Up to the year 2000, carbon intensity of global GDP was reducing.
- Since 2000, this trend has gone into reverse, probably driven by increased coal use*.
- Technology might deliver radical improvements – but it hasn't happened yet!

*Reference: "Reframing the climate change challenge", Anderson & Bows 2008
http://rsta.royalsocietypublishing.org/content/366/1882/3863.short

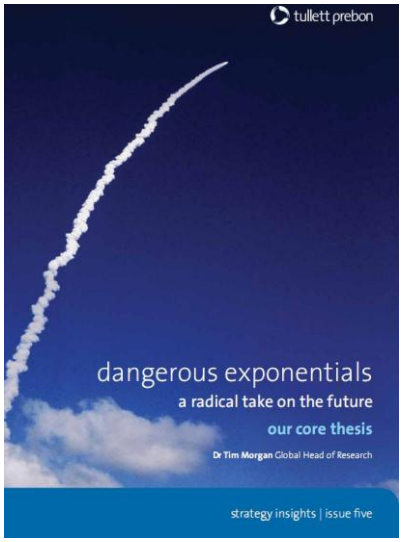
Link Between Problems

- 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!

A closer look at growth
Tullett Prebon research "Dangerous Exponentials"



- Tullett Prebon is a wholesale broker with revenue ≈£0.5bn
- Report says there is impending collision between economic system that must grow and finite resources which cannot grow.
- This collision is likely to be "one of the most important changes in the lifetime of anyone reading this report."

Dr Tim Morgan

June 2010

Tullett Prebon report
"A forest of exponentials"

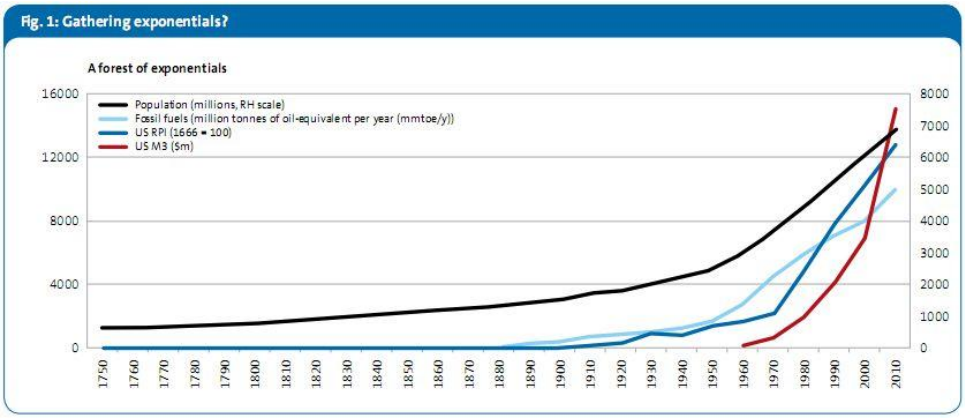


Chart from: Morgan T. "Dangerous exponentials: A radical take on the future" Tullett Prebon Strategy Insights issue 5, June 2010

Energy Return On Energy Invested (EROEI)

- "An assessment of the future outlook for energy inputs needs to be calibrated in terms of an energy rather than a monetary equation."

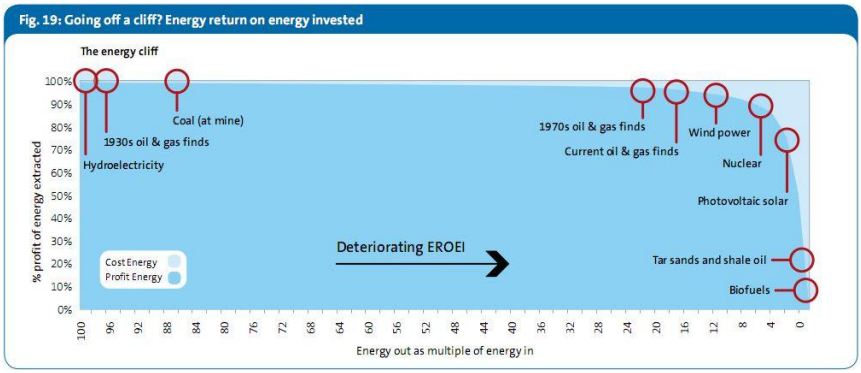
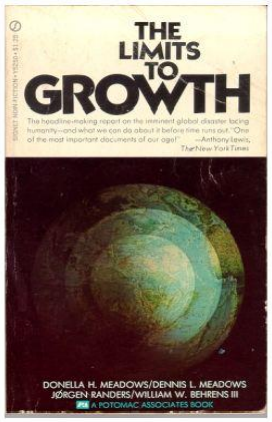


Chart from: Morgan T. "Dangerous exponentials: A radical take on the future" Tullett Prebon Strategy Insights issue 5, June 2010

The Limits to Growth

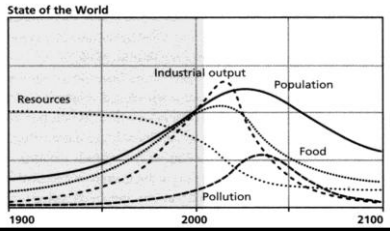
- Exponential growth has a simple mathematical formula.
- Why didn't anyone predict these problems decades ago?
- Answer: Someone did, but the message was forgotten.

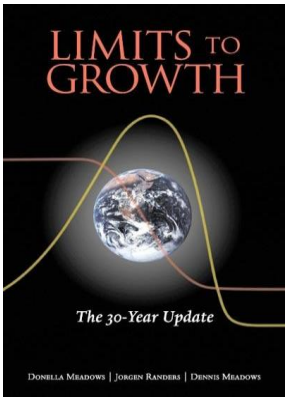
The "Limits to Growth" Study



The original 1972 study was updated in 2004

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





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.

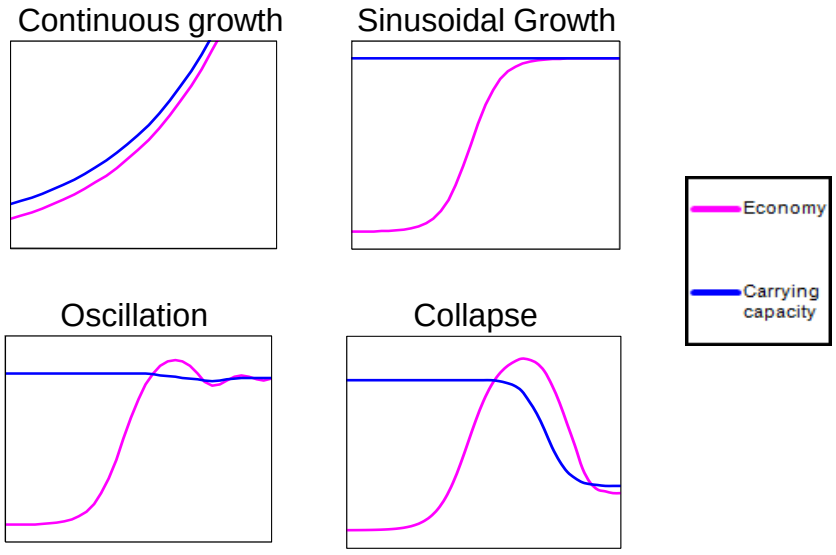
Time to rediscover the Limits to Growth?

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

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.

The 4 possibilities for exponential growth



Conclusion from the "Limits to Growth"

- The Limits to Growth study used systems science to develop models which indicate general behaviour.
- The models do not generate predictions.
- They are "what if" scenarios illustrating general systems behaviour.
- Humanity can avoid the collapse scenario if physical limits of the Earth are recognised.

Limits to Growth
GIRO 2010

- The exponential function
- Climate change is one of many problems
- Making sense of it all - the "Limits to Growth"
- Why are we in this situation?
- What are the solutions?

Fossil Fuels Are Just Too Good!

- Fossil fuels contain energy from sunlight, stored for millions of years.
- Since the industrial revolution, this energy has subsidized our economies.
- Energy content of 1 barrel of oil = manual labour of 30 people for 1 month.
- The world currently uses about 30 billion barrels of oil per year (= 1 cubic mile!)

We are addicted to oil*!

* As admitted by George W. Bush in his State of the Union speech, 31st January 2006

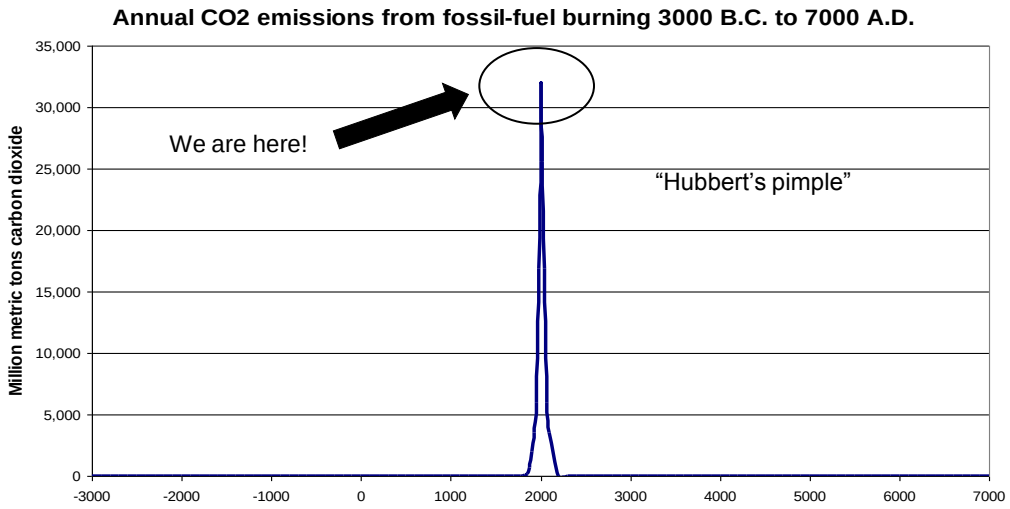
Fossil Fuel Gives Us Energy Slaves

- 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”
- US citizens have double energy consumption*2 ~140 energy slaves each

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

*2 Refer http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html - US Energy Information Administration

A Long Term View of Fossil Fuel Use



Refer: M.King Hubbert

A Culture of Exponential Growth

- Some things we "know" without learning. E.g. We shake hands with our right hand.
- We "know" that economic growth is always good, for every nation, rich and poor.
- These things that we "know" are cultural rules, not absolutes.

A Culture of Exponential Growth

Analogy:

- Insurance company with a company culture of endless premium growth in all conditions, through hard and soft markets.
- Would this make sense?
- What would you do professionally if working for this company?

Limits to Growth GIRO 2010

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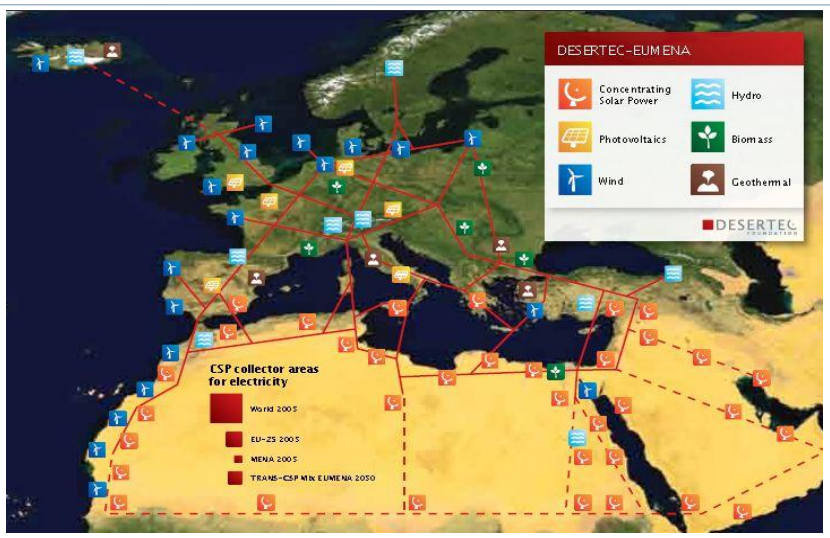
Solutions

- First – face up to the real world, be curious.
- Don't be optimistic – or fatalistic.
- Get the right answers (based on data) not the popular ones. A familiar task to all actuaries.

Technology is important e.g. Desertec



Refer: www.desertec.org

Technology is not sufficient

- Deep questions must be asked about society
- Some great thinkers knew this a long time ago

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.**"

GDP is not a good measure of welfare for rich countries

"Our gross national product … measures everything in short, except that which makes life worthwhile."

Robert Kennedy, 1968

ICAEW THE INSTITUTE OF CHARTERED ACCOUNTANTS IN ENGLAND AND WALES

Nobel Laureat Robert Solow
From Harper's Magazine, March 2008

"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."

Solutions:

Possible examples:

- Reform of the money system – move away from debt based money.
- Focus on non-monetary measures of well-being.
- Switch from consumption into investment in clean energy.

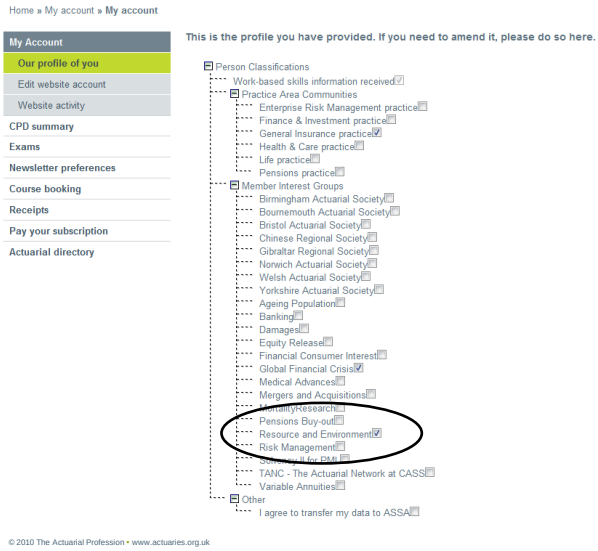
Solutions: Steady State Economy

http://steadystate.org/

What can actuaries do?

- Understand that climate change and peak oil will affect our professional lives. Be curious and learn more.
- Become aware of the invisible rules of our culture. Make up your own mind.
- Join the Resource and Environment Group MIG
- Join the REG wiki at www.resourceandenvironment.pbworks.com

Tick the Resource and Environment Group box



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Further Reading

- Chris Martenson's "Crash Course" is a good introduction http://www.chrismartenson.com/
- Learn more about energy issues at the website www.theoildrum.com – (edited by Gail Tverberg FCAS)
- Many more fascinating information sources on the REG wiki www.resourceandenvironment.pbworks.com

Some final thoughts

- Q. “So many problems, it’s too late to act isn’t it?”
- A. No it isn’t. (Beware, fatalism is another form of denial.)
- What is the risk-free rate of interest?
- Role for the actuarial profession in developing economic systems that don’t need growth?
- There are massive opportunities for those that wise-up early.

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.