Institute
and Faculty
of Actuaries

Limits to Growth

Highlights of the Life Conference 2013
London

Matthew Donnery
Resource and Environment Board

11 March 2014

Objective for this session

- Take you through some of the interesting graphs and facts presented in the report from January 2013.
  - Hopefully encourage you to read more about the subject!
- Discuss how (life) actuaries could use this work and get involved.

Agenda

- Exponential Growth
- Opinions on Future Growth
- Resource Limits
- Actuarial Impact
- Resource Limits and (Life) Actuaries

T.S.Eliot warned

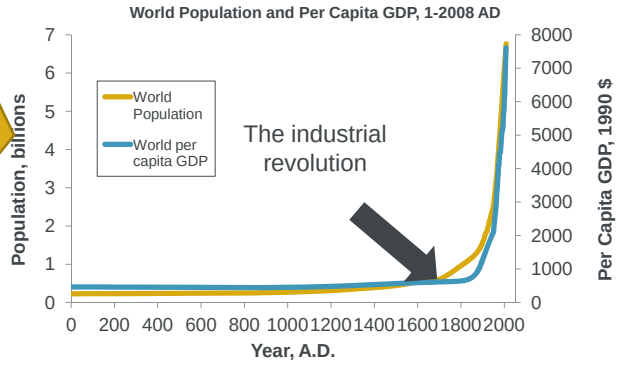
`Growth will be at the expense of future generations, but it makes the GNP numbers look good today'.[53]

Growth

Exponential Growth

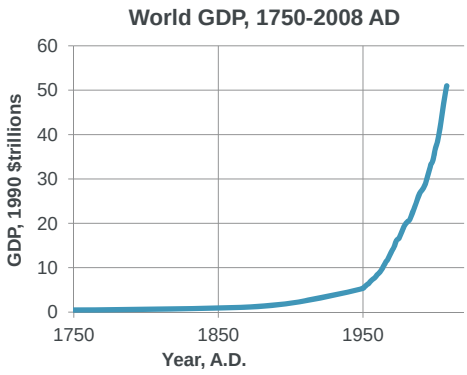
The population has been exhibiting exponential growth.

Likewise the per capital GDP has been growing exponentially.



Source: http://www.albartlett.org
There is a great presentation about exponential growth at this web address.

Growth



Exponential Growth

World GDP growth has been exponentially growing.

- In real terms world GDP has grown at average rate of c.3% per year in recent decades = doubling time 23 years.
- 2014 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.

Growth

Where is the growth happening?

Sustained higher growth in the emerging economies.

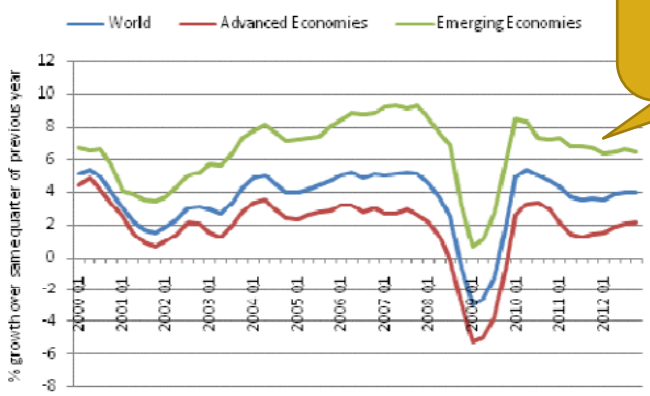
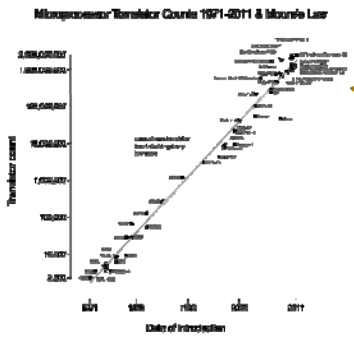


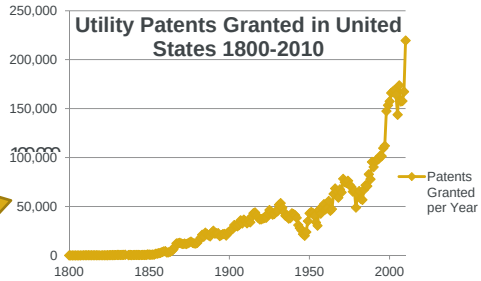
Figure 55: Real GDP growth q1 2000 - q4 2012[668]

Growth



Moore's Law

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



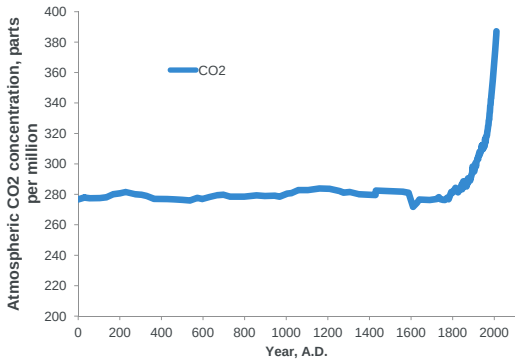
Intellectual Property

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

Growth

Carbon Dioxide

Not everything that grows exponentially is that great.



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

Growth to Service Debt

"Since the 1970's actuaries in the US have warned that given the aging of the baby boomers, a fiscal crunch would occur in America sometime between 2010 and 2020s. From 1993 to 2001 America's Debt:GDP ratio went from 49% to 33%. However by 2012 it reached 119% of GDP."

Institute of Actuaries Evidence Report, January 2013

Federal debt held by the public

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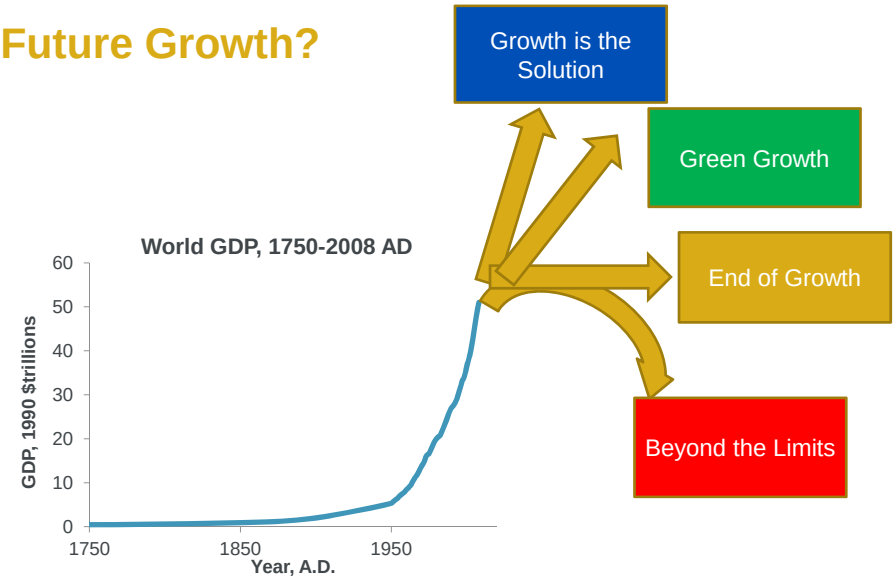
Future Growth?



Opinions: Growth is the Solution

Growth is the Solution

Madison (Contours of the World Economy) predicts 2003-2030 will be the fastest growing period in history – 2.25 fold increase in GDP.

Ridley (The Rational Optimist) speaks of the ability of humankind to adapt to new challenges – i.e. inventiveness and innovation will ensure growth.

Opinions: Green Growth

Green Growth

UNEP International Resource Panel says costs of growth now outweigh benefits. **Global resource usage grew 2x fast as population but not as fast as GDP – so some decoupling of GDP observed**.

OECD Towards Green Growth Framework calls for a move to green growth that will foster economic development and continue to provide natural resources. Follows Green Growth Declaration signed by 34 ministers in June 2009.

Resource Revolution (McKinsey Global Institute). **Price falls over the 20th century wiped out by last 10 years of price rises.** Next 20 years we will have 3bn more middle class consumers . They offer two scenarios. productivity static (supply expansion) and productivity response (most demand met by productivity). Latter scenario needs a good deal more investment but neither avoid 2 degree warming. Third scenario "climate response case" – move to low carbon energy, reforestation, land restoration, carbon capture,

Shell have two scenarios Scramble (energy efficiency left until supplies are tight + greenhouse gas emissions cut when climate change happens) and Blueprint (local actions to ensure growth, deliver energy security and mitigate environment). 2011 updates suggests messages mixed whether we are following Scramble or Blueprint . **Shell actively supports Blueprint**

IEA produced scenarios "Current Policies", "New Policies" and "450" – the former two suggest significant global warming – the latter one **advocates increasing nuclear, gas and renewables**. In 450 scenario - 4/5 of carbon allowed until 2050 is locked in already.

Opinions: End of Growth

End of Growth

Limits to Growth stressed (reiterated) that humanity is on course to overshoot. Profound change needed soon to avoid collapse.

Based on a systems dynamics world view – interconnections, feedback loops, delays, event interactions.

They conclude overshoot caused by…

- Rapid Change
- Limits / barriers to change
- Errors / delays in perceiving limits / controlling change.

Concludes that physical growth will ultimately cease completely whether we like it or not.

Richard Heinberg (The End of Growth) states the **global economy is playing a zero sum game with an ever shrinking pot divided among the winners**. He cites the causes as:

- Depletion of natural resources
- Negative environmental impacts
- Inability of financial systems to service debt accumulated over recent years

Monetary systems are designed to need growth to sustain them because they are based on unsustainable debt (Debt has grown 500% since 1980)

Heinberg tells us that the the debt is a claim on resources that don't exist – and that no growth is likely to become the new-normal.

Tim Jackson (Prosperity without Growth) highlights that **a sub-system of a finite system cannot grow indefinitely.** Discusses the link between consumption and social status – we need to find ways of meeting our psychological needs without money.

Limits to Growth – Predictions

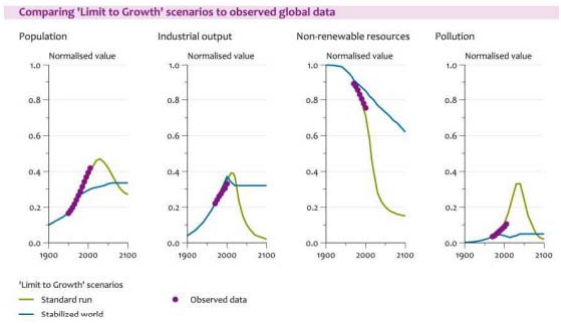


Figure 1: Comparison of World3 Limits to Growth scenarios to observed data. [13]

Limits to Growth (30 Year Update)

The 1972 LtG paper used a systems dynamics model (World 3) to explore the feedback between;

- Population
- Industry
- Food
- Non-renewable resources
- Pollution system.

The green lines represent the "standard scenario" – which is a business as usual (growth agenda).

The purple observations show the realised observations.

Netherlands Environmental Assessment Agency / Turner (2008)

Opinions : Beyond Limits

Beyond the Limits

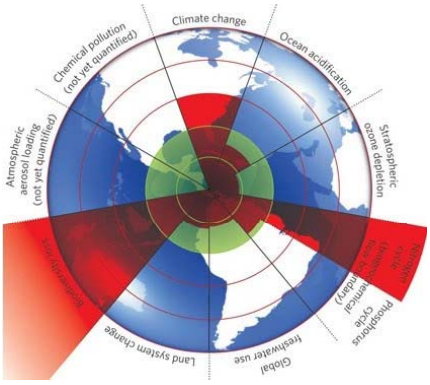
Stockholm University Resilience Centre (Planetary Boundaries) suggests 7 planetary "thresholds and ""boundaries " within which humans can operate.

Thresholds are the tipping points where-after positive feedback loop means it is not possible to go back – non-linear transition points.

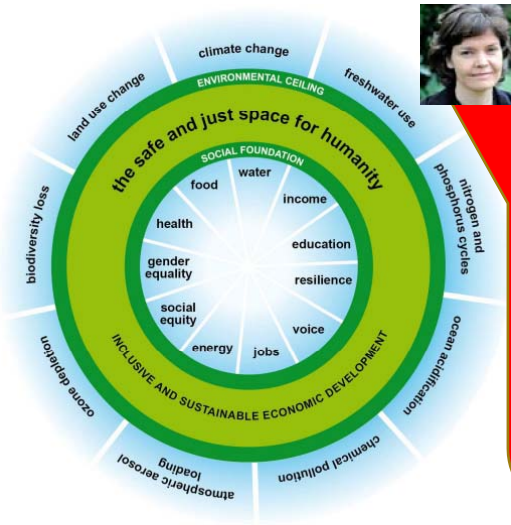
Boundaries are human defined safe distances from the thresholds like a risk appetite.

They highlight the uncertainty in these thresholds / boundaries and the adverse interactions between them .

They estimate humanity has crossed three:
- Climate Change
- Rate of Biodiversity Loss
- Changes in Nitrogen Cycle



Doughnut Economics



Kate Raworth
Doughnut Economics

"The social foundation forms an inner boundary, below which are many dimensions of human deprivation. The environmental ceiling forms an outer boundary, beyond which are many dimensions of environmental degradation. Between the two boundaries lies an area – shaped like a doughnut – which represents an environmentally safe and socially just space for humanity to thrive in. It is also the space in which inclusive and sustainable economic development takes place"

Source: Oxfam. The 11 dimensions of the social foundation are illustrative and are based on governments' priorities for Rio+20. The nine dimensions of the environmental ceiling are based on the planetary boundaries set out by Rockström et al (2009b)

Opinions : Beyond Limits

Beyond the Limits

Carbon Tracker Initiative (Unburnable Carbon) tell us we have used one third of our budget for carbon to 2050 in order to remain within 2 degrees of global warming.

It highlights the assets on energy company balance sheets in the form of reserves**. The CO_2 potential of the carbon reserves in the London financial markets account for around 20% of the total carbon budget** – 100 times the carbon footprint of the UK's own carbon reserves.

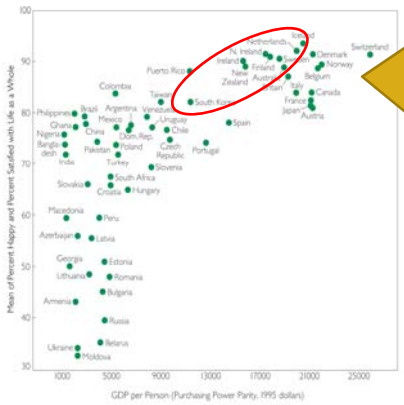
Only 20% of global carbon reserves are burnable to stay within 2 degrees . What we use this budget for is a key question.

WWF 2010 Living Planet Report tells us topical diversity has reduced by 60%. They find 5 threats to biodiversity which underpin human ecosystems (freshwater, carbon storage, agriculture):

1) Habitat loss, fragmentation, alteration
2) Over-exploitation of wild species (food, materials, medicine)
3) Pollution (excessive fertiliser, pesticides)
4) Climate change
5) Invasive species

WWF highlight water is the main link between ecosystems and climate – current demand placed on freshwater ecosystems is already beyond sustainable levels.

Does Growth Make You Happy?



Does growth make you happy?

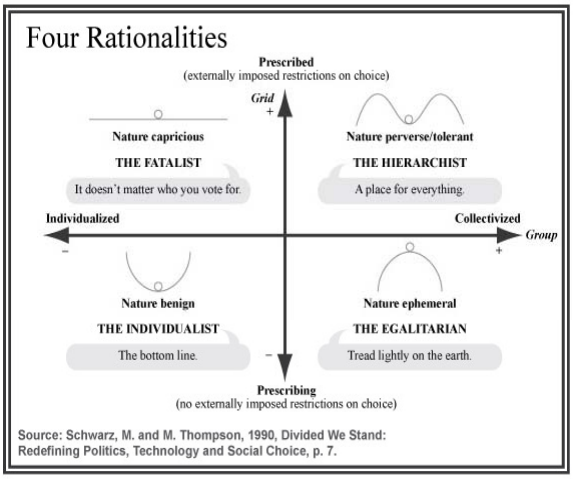
The graph % of people content versus GDP per person at PPP.

Economic growth remains the dominant concern of politics even in rich countries yet beyond the levels achieved by countries like Ireland, South Korea or New Zealand the positive correlation between GDP / person and happiness breaks down.

Evidence that inequality leads to a less contented society too (The Spirit Level - Wilkinson) – and to less innovative economies!

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

Why so many views?



Source: Schwarz, M. and M. Thompson, 1990, Divided We Stand: Redefining Politics, Technology and Social Choice, p. 7.

Cultural Theory of Risk

Anthropology has something to say about this.

That there are 4 *social constructions* of risk that affect the way people perceive risk taking.

These have been applied in environmental negotiations to seek workable solutions between the different viewpoints.

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Oil

This graph from the IEA (International Energy Agency) 2008 World Energy Outlook – shows significant dependence on fields yet to be developed.

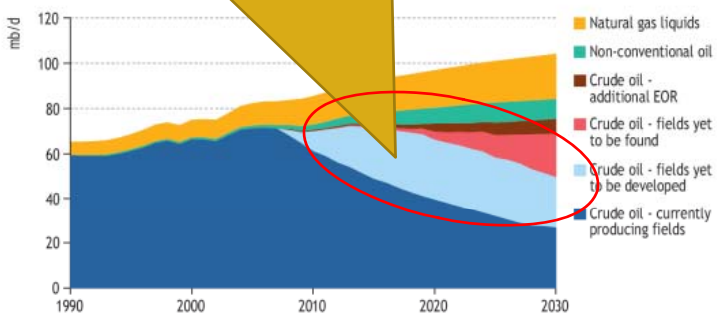

Figure 7: World oil production by source in the 2008 Reference Scenario[224]

Oil

Data on reserves is disputed – this graph from University of Uppsala revised the contributions on non-conventional and yet to be found fields.

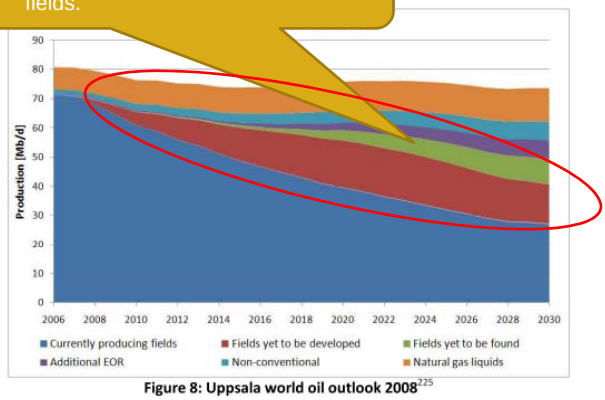

Figure 8: Uppsala world oil outlook 2008[225]

Oil

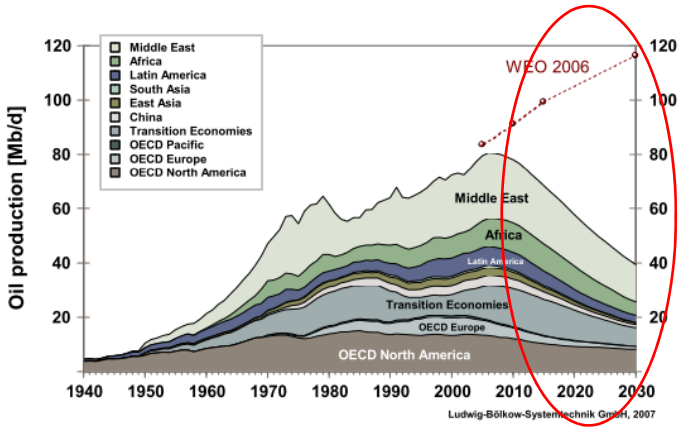

Figure 9: EWG oil production world summary[228]

Energy Watch in Germany produced their own analysis – agreeing with Uppsala that production would fall away.

Oil

Issues

- New fields are smaller – and therefore run off faster.
- Carbon Capture Storage doesn't seem possible for this fuel when used as transportation.
- Reserves concentrated in a few geographic locations.
- EROEI (energy returned on energy invested) is falling.
- Many national oil companies – oil set to become more of a political issue – cheaper to go to war than buy oil?

When will Peak Oil occur?

According to some it has occurred already (e.g. Macquarie Group) – according to others it is a long way of (e.g. Exxon Mobil).

	World Peak Estimate	Source	Date of prediction
Before 2012	2005	Association for the Study of Peak Oil & Gas[186]	2009
	2006	Energy Watch Group[187]	2007
	Conventional crude – 2006	IEA[188]	2010
	2008	Aleklett, Höök, Jakobsson, Lardelli, Snowden, Söderbergh (Uppsala University, University of Adelaide, University of Liverpool)[189]	2010
	2009	Macquarie Group Ltd[190]	2009
	2011	Oil Depletion Analysis Centre[191]	2007
By 2020	2013	French Economics, Industry & Finance Ministry[192]	2005
	2014 or sooner	Skrebowski (Director, Peak Oil Consulting, Founding Member, Association of the Study of Peak Oil)[193]	2011
	by 2015	UK Industry Task Force on Peak Oil & Energy Security (ITPOES)[194]	2010
	2015	Van de Veer (CEO, Shell)[195]	2008
	2017/2018	Maxwell (Industry Analyst)[196]	2010
	Before 2018 (worst-case, 2008)	Robelius (Uppsala University)[197]	2007
	All-liquids peak in 2018	PFC Energy[198]	2005
	Before 2020	UK Energy Research Centre[199]	2009
	By 2020	Shell, Signals & Signposts[200]	2011
	Before 2020	Ricardo Consulting[201]	2011
	Before 2020	Li (University of Utah)[202]	2011
	2020	Birol (Chief Economist, IEA)[203]	2009
By 2030	Next 10 - 20 years	World Energy Council[204]	2007
	before 2030	IEA[205]	2009
	2028	Hirsch (for the US Department of Energy)[206]	2005
	After 2030 - "undulating plateau", peak "highly questionable"	CERA[207]	2006
After 2030	By 2060	HSBC[208]	2011
	Not before 2030	IO EA[209]	2004
	"Nowhere in sight"	Exxon Mobil[210]	2006

Coal (Briefly!)

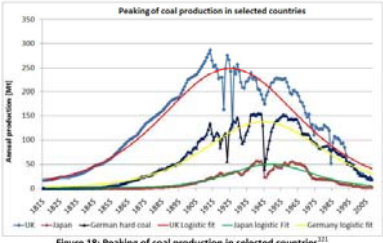

Figure 18: Peaking of coal production in selected countries[321]

Peak production has occurred in UK, Germany and Japan.

90% of reserves are in 6 countries. USA, Russia, India, China, Australia and South Africa,

BP Statistical Review of World Energy 2012

Most production is in China despite only having 14% of global reserves. In 2010 China accounted for 43% of world production. Depletion rate is 1.9% per annum.

Chinese consumption is 47% of global total – some estimate of a Chinese peak by 2020 – Chinese government are considering a cap to preserve reserves.

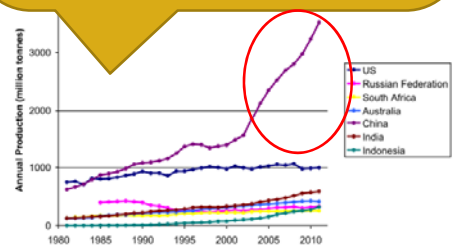

Figure 19: World's largest coal producers (annual production above 250 million tonnes), 1981 - 2011 (based on BP *Statistical Review of World Energy* 2012 data)

Coal (Briefly!)

	World Peak Estimate	Source	Date of prediction
By 2020	By 2011 (energy terms), by 2015 (mass)	Patzek & Croft (University of Texas; University of California, Berkeley)[327]	2010
By 2030	By 2025	Energy Watch Group[328]	2007
	2048 (mass); between 2011 – 2047 (energy)	Mohr & Evans (University of Newcastle, Austalia)[329]	2009
	Between 2020 - 2050	Höök, Zittel, Schindler & Aleklett (Uppsala University, Ludwig Bölkow Systemtechnik GmbH)[330]	2010
	90% exhaustion by 2070. Suggested extrapolated peak well before.[331]	Rutledge (California Institute of Technology)[332]	2011
	Before 2030	Li (University of Utah)[333]	2011
No peak on the horizon	Undefined – production still climbing up to 2100 in many scenarios	IPCC[334]	2007
	Not a grave concern	Summers[335]	2010
	Coal to last another 118 years	World Coal Institute[336]	2011

When is peak coal?

Predications around 2030 with some not concerned. One voice says we are past the energy peak.

Issues

EROEI (energy returned on energy invested is a key concept).

US coal in the early 20th century was around 177:1 whereas it is now around 50-85:1 – with estimates of global EROEI being 28:1.

Falling heating values are seen too with falls in the energy value of around 30% since 1955.

Gas (Briefly!)

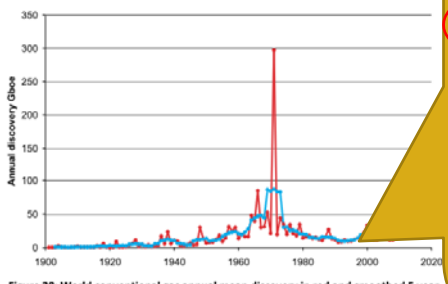

Figure 20: World conventional gas annual mean discovery in red and smoothed 5 year discovery in blue (Giga barrels of oil equivalent).[338]

Since 1980 the gap between discoveries and consumption has been negative and continues to widen.

In 2010 the BP Statistical Review estimated c60 years of global production was left.

IMP World Economic Outlook Special Report on Gas - however projects as much as a 50% increase in gas use as it is the clean fossil fuel.

Year on year increase of 4% in demand reduces the amount left to 33 years worth.

Fracking now accounts for 30% of US production – provides US with additional 4 years of gas at current usage levels. Unproven reserves may add additional years – US EIA estimates 20 years.

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Gas (Briefly!)

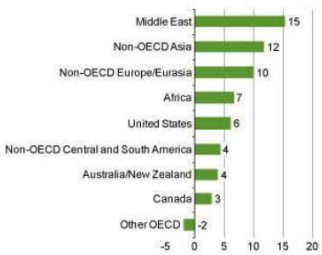

Figure 23: Change in world natural gas production by region (trillion cubic feet), 2008 - 2035[355]

Important to distinguish between reserves and recoverable reserves.

MIT Study explains that around half of the reserves are recoverable at 2011 gas prices.

Geography plays an important role too in gas. c65% of gas is located in:

- Russia
- Qatar
- Iran
- Saudi Arabia

Supply chains will be critical – pipelines needing to cross land – liquefied natural gas needs infrastructure ports to be transportable.

Access restriction and a trend towards state owned oil companies with 60%-80% of reserves in countries with national oil companies or restricted access.

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Gas (Briefly!)

When is peak gas?

Seems some agreement that peak gas will be around 2030-2040.

	World Peak Estimate	Source	Date of prediction
Before 2012	2008/9	Bakhtiari (Retired Senior Advisor for the Iranian National Oil Company)[368]	2006
By 2020	N/A	N/A	N/A
By 2030	2027	Hughes (Canadian hydrocarbon geologist)[369]	2009
	2030	Laherrère (Petroleum engineer and consultant; member of the Association for the Study of Peak Oil & Gas)[370]	2004
After 2030	Around 2040	Li (University of Utah)[371]	2011
No peak on the horizon	N/A		

Uranium (Briefly!)

World was in a uranium deficit in 2010 – 14% of supply came from secondary sources. Seems that uranium was used for military purposes and has been returned to civilian use to make up for the shortfall in mined uranium.

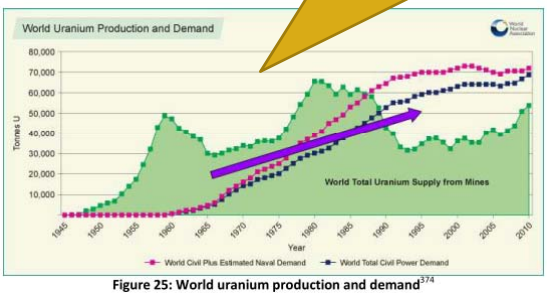

Figure 25: World uranium production and demand[374]

Uranium (Briefly!)

World Nuclear Association reference scenario predicts a 27% increase in nuclear reactor capacity from 2010-2020 – in this case causing a shortfall by c2025 – sooner if nuclear capacity increases faster.

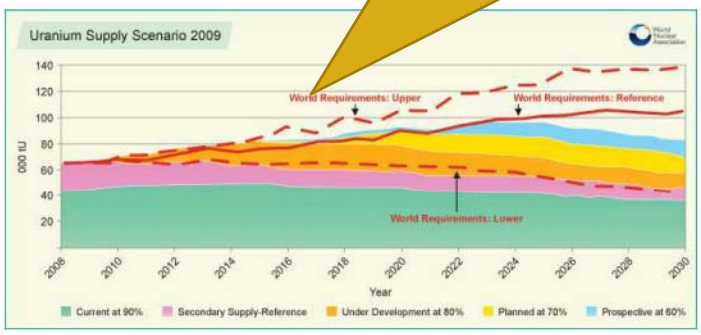

Figure 26: Uranium supply scenario 2009[378]

Uranium (Briefly!)

New discoveries tend to be smaller as the search space is exhausted.

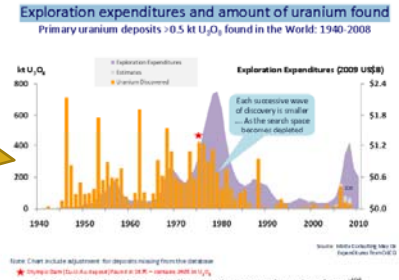

Figure 30: Exploration expenditure and amount of uranium found[408]

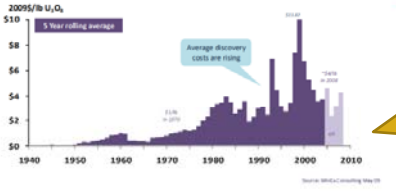

Figure 31: Increase in uranium discovery costs over the last 40 years[409]

Uranium discovery costs have been rising.

Uranium (Briefly!)

When is peak Uranium?

Wide range of answers here from the next 10 years to 100 years.

	World Peak Estimate	Source	Date of prediction
Before 2012	1980 – but supplies still abundant	Vance (NEA)[410]	2006
	Supply shortages 2010 – 2019	Fleming (The Lean Economy Connection)[411]	2007
By 2020	2015	Dittmar (Institute of Particle Physics)[412]	2011
By 2030	N/A		
After 2030	2034 (high-grade ore)	Storm van Leeuwen (Cedeeta Consulting)[413]	2006
	2035 (at current consumption rates)	Energy Watch Group[414]	2006
No peak on the horizon	At current consumption, enough to last 100 years	OECD[415]	2007
	Up to 1000 years supply available – potentially limitless	Hopf (US Nuclear Engineer)[416]	2004

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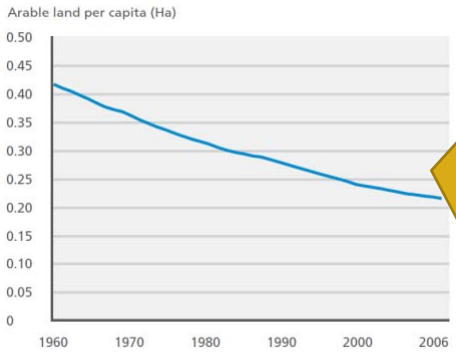
Land, Soil, Food



Arable Land (Where Cereals Can Be Grown)

- Arable land per capita has halved over the last 50 years.
- The area of land growth was much less of a factor in the production increases – productivity increases have kept agriculture apace.
- To increase production just from land use would have resulted in 3x as much land use being required.

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Land, Soil, Food

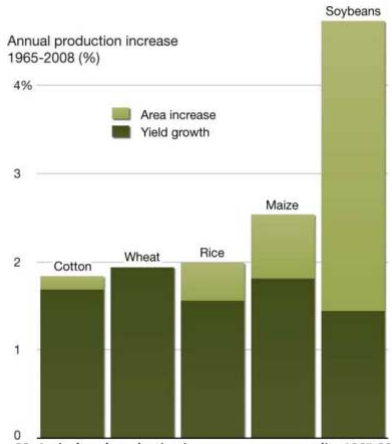

Figure 33: Agricultural production increases, per commodity 1965-2008[422]

Yields Have Increased

Since 1960s the increase in yields has been:

- 270% - Cereals
- 160% - Tubers / Roots
- 400% - Meat

Increased yields can be attributed to:

- 50% from fertiliser
- 20% from irrigation

Fertilisers from phosphorous – demand is expected to grow by 50%-100% by 2050 with peak phosphorous by around 2030.

75% of phosphorous production concentrated in USA, China, Morocco and Russia.

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Land, Soil, Food

- From the Land Commodities Global Agriculture & Farmland Investment Report 2009
- A story of forests and grasslands giving way to agricultural land to support populations.
- In 2005 University of Wisconsin reported that 40% of the worlds surface is being used for agriculture – vs. 7% in 1700.
- 13.4bn ha on earth – 3bn ha suitable for agriculture – 1.5bn used already – the rest is underneath rain forest!

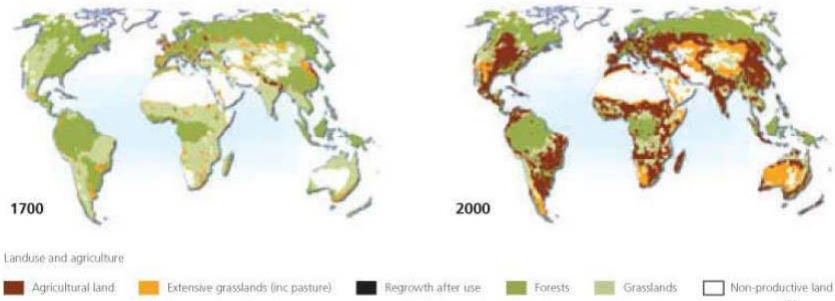

Figure 34: Estimated global agricultural land use 1700 and Actual global agricultural land use in 2000 based on satellite imagery[431]

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Land, Soil, Food

Soil Degradation

- Production time for 6 inches of topsoil is tens of thousands of years.
- Mainly caused by weather (flooding, irrigation, wind).
- 40% of agricultural land is seriously degraded. 80% of global farmland is moderately to seriously degraded.
- Over past 40 years 30% of global arable land has become unproductive.

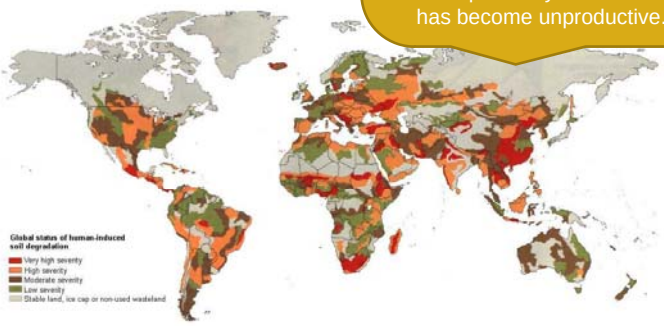

Figure 38: Global status of human induced soil degradation[457]

Land, Soil, Food

What happens when you have too many people for your land to support?

- If you are rich you go and buy up land from someone poorer than yourself – its not just land but water resources being secured.

Source : Guardian

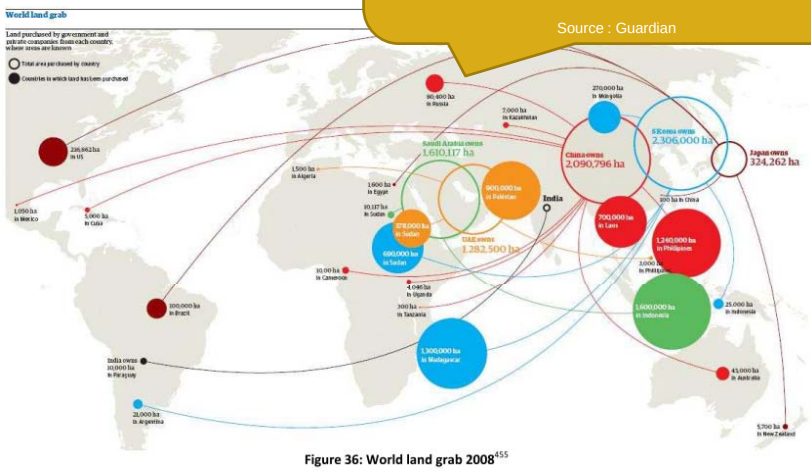

Figure 36: World land grab 2008[455]

Land, Soil, Food

What happens when you run out of water?

- Saudi Arabia reports that it has exhausted its principal aquifer through over irrigation of its wheat and will now stop producing wheat by 2016.
- In 2008 Saudi government earmarked $5bn for private firms wishing to invest in countries with strong agricultural productivity potential.

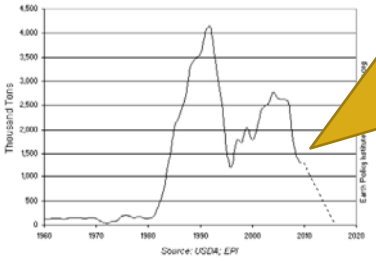

Figure 37: Wheat Production in Saudi Arabia, 1960 - 2009, with Projection to 2016[452]

Land, Soil, Food

Private Investment in Land

- In 2011 there was $14bn invested in farmland – this figure is expected to grow 10 fold according to one source.
- US Pension Funds are among the biggest investors – $5-15bn are reported to be invested with expected return rates of 10% - 20% cited.
- Increasing common area for pension fund investment here in the UK too.

Fund	Total assets under management (AUM)	Global farmland investment portion...(% of AUM)	...and its status
AP2 (Second Swedish National Pension Fund)	SEK220 billion [US$34.6 billion]	US$500 million in grain farmlands in US, Australia and Brazil (1.4%)	**Planned** joint venture with TIAA–CREF. **First forays** into farmland investing were in 2010
APG (administering the National Civil Pension Fund), Netherlands	€220 billion [US$314 billion]	**€1 billion** (0.5%) [US$1.4 billion]	A planned increase
Ascension Health, USA	US$15 billion	Up to US$1.1 billion (7.5% target)	**Looking** to invest in farmland for the first time, to help meet a real assets target of 7.5% that is currently underachieved
CalPERS (California Public Employees' Retirement System), USA	US$231.4 billion	About US$50 million (0.2%): majority invested in agribusiness firms with huge int'l farmland holdings	**Current**
Dow Chemical, USA		not revealed	**Farmland added recently**, Aimed annual returns on US holdings: 8–12%
New Zealand Superannuation Fund	NZ$17.43 billion [US$14.2 billion]	NZ$500 million (3%) [US$407 million]	The 3% allocation **has been made** at the Fund's strategy level. First purchases into domestic farmland have started
PGGM (Pension Fund for Care and Well-Being), Netherlands	€90 billion [US$128 billion]	not revealed	**May raise** farmland allocation in 2011
PKA (Pensionskasernes Administration), Denmark	US$25 billion	US$370 million (1.5%)	In June 2011, made a **first placement** of US$50 million in Silver Street Capital's Silverland Fund.
Sonoma County Employees' Retirement System Association, USA			Expected to allocate **3% to UBS Agrivest Farmland Fund**
TIAA–CREF (Teachers Insurance & Annuity Association – College Retirement Equities Fund), USA	US$426 billion	US$2 billion in **400 farms** in North and South America, Australia and Eastern Europe (0.5%)	**Current**. They claim annual returns of 10%

[452] In ibid (Reproduced with permission.)

Land, Soil, Food

Soil	World Peak Estimate	Source	Date of Prediction
Before 2012	10 millennia ago	David Pimentel, Agricultural Ecologist, Cornell University[487]	?
By 2030	No topsoil left by 2070 (within 60 years)	John Crawford, University of Sydney[488]	2011
	No topsoil left between 40 – 80 years time	John Jeavons, Founder Ecology Action (non-profit)[489]	2010
After 2030	Run out of fertile topsoil or one or two more centuries	David Montgomery, Author 'Dirt: The Erosion of Civilizations'[490]	2008
No peak on horizon			

	World Peak Estimate	Date of Prediction
Palm Oil	Supply of land for palm oil to run out by 2020/2022 in Indonesia and Malaysia	Ken Arieff-Wong, Analyst, KL[491]
Phosphorus	Could peak by 2033	Soil Association[492]
	Enough to last several hundred years	International Fertilizer Development Centre[493]
	2030	Cordell, Drangert, White, Linköping University and University of Technology Sydney, *Global Environmental Change*[494]
	Readily available supplies may start running out at the end of this century	*Scientific American*[495]
	1989	Patrick Déry, The Oil Drum[496]

Issues

- Phosphorous peak
- Energy needed to create fertilizers / irrigation systems / mechanised farming.
- Reliance on fresh water irrigation to provide crops.

When is Peak Soil?

- Predictions of top soil running out between 40-200 years.

When is Peak Phosphorous?

- Peak phosphorous predictions around 2030 – with outliers suggesting 1989 and several hundred years.

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Water (Briefly!)

Issues With Water

- Very localised – very expensive to move around.
- Water Resources Group cite a 40% increase in fresh water use by 2030 if no efficiency gains.
- Third of global population live in areas where demand exceeds supply by 10% now – expected to rise to 50% by 2030.

Rivers Running Dry

- This table gives evidence of the dry running of some major rivers.
- Examples from China, USA, India, Africa, Aral Sea.

Table: Major Rivers Running Dry[208]

Major Rivers Running Dry	
River	Condition
Amu Darya	The Amu Darya, which originates in the mountains of Afghanistan, is one of the two rivers that feed into the Aral Sea. Soaring demands on this river, largely to support irrigated agriculture in Uzbekistan, sometimes drain it dry before it reaches the sea. This, along with a reduced flow of the Syr Darya—the other river feeding into the sea—helps explain why the Aral Sea has shrunk by more than half over the last 40 years.
Colorado	All the water in the Colorado, the major river in the southwestern United States, is allocated. As a result, this river, fed by the rainfall and snowmelt from the mountains of Colorado, now rarely makes it to the Gulf of California.
Fen	This river, which flowed from the northern part of China's Shaanxi province and empties into the Yellow River at the province's southern end, has literally disappeared as water withdrawals upstream in the watershed have dropped the water table, drying up springs that once fed the river.
Ganges	Some 300 million people of India live in the Ganges basin. Flowing through Bangladesh en route to the Bay of Bengal, the Ganges has little water left when it reaches the bay.
Indus	The Indus, originating in the Himalayas and flowing west to the Indian Ocean, feeds Pakistan's irrigated agriculture. It now barely reaches the ocean during much of the year. Pakistan, with a population of 157 million projected to reach 349 million by 2050, is facing trouble.
Nile	In Egypt, a country where it rarely ever rains, the Nile is vitally important. Already reduced to a trickle when it reaches the Mediterranean, it may go dry further upstream in the decades ahead if, as projected, the populations of Sudan and Ethiopia double by 2050.
Yellow	The cradle of Chinese civilization, the Yellow River frequently runs dry before it reaches the sea.

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Water (Briefly!)

Since 1900 half of the worlds wetlands have disappeared. Freshwater species down by 50% since 1970 (faster than species disappearance in sea or on land). Global threats to river biodiversity have been mapped as illustrated in Nature.

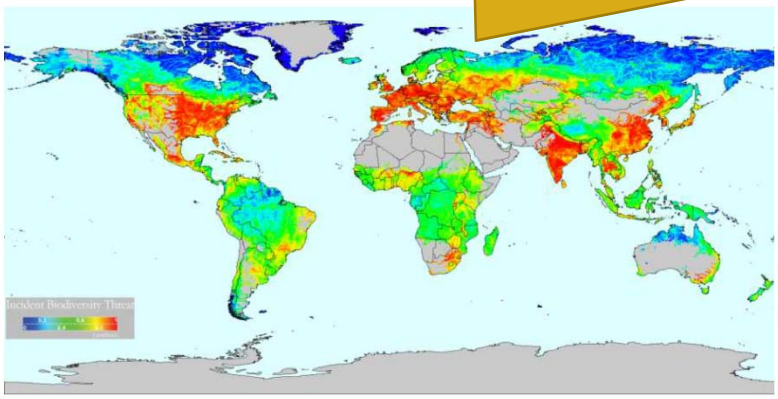


Figure 40: Global geography of incident threat to human water security and biodiversity[518]

Water (Briefly!)

	World Peak Estimate	Source	Date of Prediction
Before 2012	Saudi Arabia hit peak water 10 years ago	The Oil Drum[528]	2008
	Cyprus has hit peak water; Yemen to run out by 2015; Pakistan under pressure	Alexander Bell, author of 'Peak Water', in *The New Statesman*[529]	2010
	Peak water "come and gone"	*Guardian* news[530]	2011
	In many parts of the world already hit peak water, including USA – which hit peak water in the 1970s	Peter Gleick, Pacific Institute, California[531] [532]	2011
	Peruvian watershed likely passed peak water due to melting glaciers	Michel Baraër, McGill University, Montreal[533]	2011
By 2020	"Dawning era of peak water"	Matthew Power, *Wired* magazine[534]	2008
By 2030	By 2030 the global water demand will be 40% greater than today's "accessible, reliable, environmentally sustainable supply"	McKinsey & Company[535]	2009
After 2030	N/A		
No peak on horizon	N/A		

Peak Water?

It seems to be hard to estimate peak water but localised studies suggest some places have hit peak water already.

Commodities (Briefly!)

Copper
Estimate for peak copper around 20-30 years.

Indium
Predictions of running out in 10-20 years – which is an issue given that it is a key resource for photovoltaic coatings.

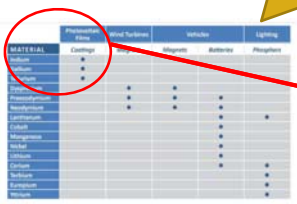


Figure 48: Materials in Clean Energy Technologies and Components[587]

		Peak Estimate	Source	Date of Prediction
		bability" of permanent global rtfalls by 2030	Chris Clugston, The Oil Drum[598]	2010
		n in US – 1998; Chile production eru – 2025; China – 2020; – 2001; Australia – 2030); Canada – 1974; Russia – ow. World – 2020	Jean Laherrère, The Oil Drum[599]	2010
		approach of peak copper	Dr. Les Coleman, University of Melbourne[600]	2009
		e copper mines to be exhausted 2010 – 2015	Andrew Leonard, *Salon*[601]	2006
		within 25 years	Lester Brown, Earth Policy Institute[602]	2006
		tocks of several metals [incl. ppear inadequate to sustain the Developed world" quality of life H's peoples under contemporary y	R. B. Gordon et al, Yale University[603]	2006
		pplies already "at their limit"	BHP Billiton CEO, Marius Kloppers[604]	2011
		o worry about peak iron ore	Gavin Mudd, Monash University, Australia[605]	2011
		bability" of permanent global shortfalls by 2030	Chris Clugston, The Oil Drum[606]	2010
		Peak iron ore / peak metals "not on horizon"	Rio Tinto[607]	2010
		Iron ore could run out in 64 years	Lester Brown, Earth Policy Institute[608]	2006
	Zinc	"Very high probability" of permanent global supply shortfalls by 2030	Chris Clugston, The Oil Drum[609]	2010
		2012	Credit Suisse[610]	2010
		Severe supply shortages by 2010	Dr. Harlan Meade, President & CEO of Pacifica Resources Ltd and Yukon Zinc Corp.[611]	2006
Rare Earth Metals	Gallium	2007 according to USGS data; 2000 according to logistic fit of data	Ugo Bardi and Marco Pagani, The Oil Drum[612]	2007
	Indium	"High probability" of permanent global supply shortfalls by 2030	Chris Clugston, The Oil Drum[613]	2010
		Will run out in 10 years	Achim Reller, University of Augsburg, Germany[614]	2007
		Lack of indium will mean that its "substantial contribution" to future production of solar cell technology will be very limited	René Kleijn, Leiden University, Netherlands[615]	2007
	General	Concern for general supply gaps of "critical materials" by 2015	US Department of Energy[616]	2010
		EU concerned over shortages Of 14 "critical raw materials"	European Commission[617]	2010

Agenda

- Exponential Growth
- Opinions on Future Growth
- Resource Limits
- Actuarial Impact
- Resource Limits and (Life) Actuaries

Actuarial Assumptions – Real Rates

The paper provides historical evidence for the correlation / co-integration of real interest rates and GDP.

Population / wealth change impacts need consideration too.

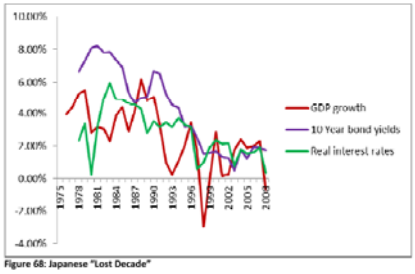


Figure 68: Japanese "Lost Decade"

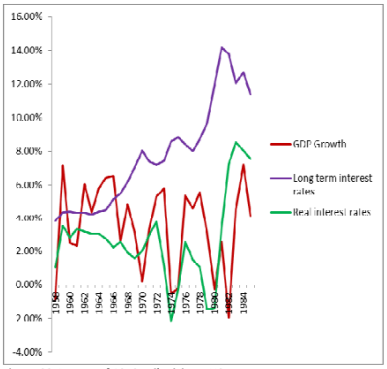


Figure 66: Impact of 1970s oil crisis on US economy

Actuarial Assumptions – Inflation

The paper makes a case for price inflation being linked to GDP growth – but highlights the disconnect with wage inflation that is possible - which is important for the DB schemes that there the focus of the actuarial analysis in the paper.

Also need to consider the extent to which resource constraints on many fronts could remove the ability for substitutes to dampen cost-push inflation.

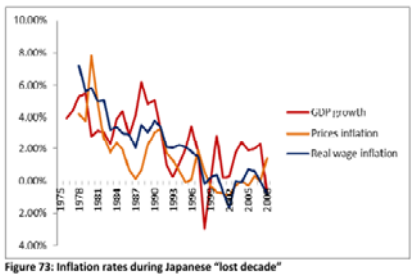


Figure 73: Inflation rates during Japanese "lost decade"

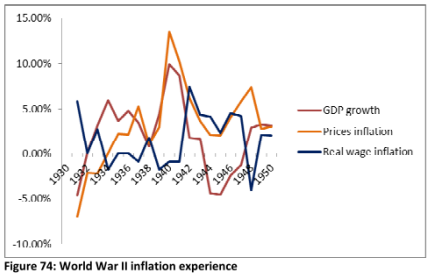


Figure 74: World War II inflation experience

Actuarial Assumptions – Mortality

The paper provides some historical evidence for the link between GDP and Mortality – using data from Russia post-communism and the US over 150 years.

We need to bear in mind that the linkages may be more subtle in future and mortality / morbidity may be selective with insured populations in wealthy countries perhaps less affected. However increased connectivity with the globe could increase transmission of disease – for example.

Figure 75: Life expectancy and GDP before and after the fall of the Soviet Union[819]

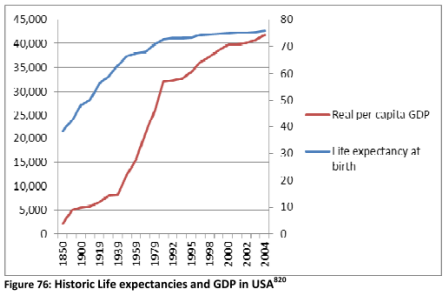


Figure 76: Historic Life expectancies and GDP in USA[820]

Where will the balance sheet be affected?

Financial Assets – Equities

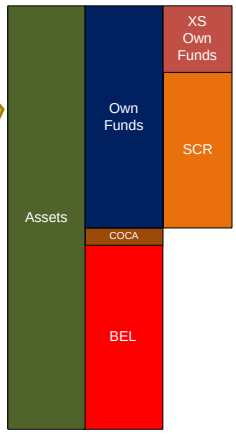
Trapped carbon reserves.
Sovereign default / Financial repression / Impaired capital flows

Financial Assets – Corporate Bonds

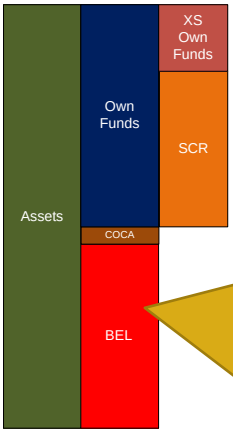
Spread widening / default due to lack of growth to pay accumulated debt / Sovereign default / Financial repression / Impaired capital flows.

VIF Asset

Falling asset values impact AMC recovery.
Lapse due to poor returns / cash-constrained savers.



Where will the balance sheet be affected?



Best Estimate – Mortality / Longevity / Morbidity

- Vector borne diseases (climate change) causing pandemics.
- Summer Heat / Winter Cooling (climate change) affecting mortality.
- Spending redirected from healthcare.

Best Estimate - Guarantees

- Guarantees biting **as** asset values fall.

Best Estimate – Expected Default

- Higher expected default charges to reinsurers? (Climate change)
- Higher expected default charges to banks? (Lack of growth)

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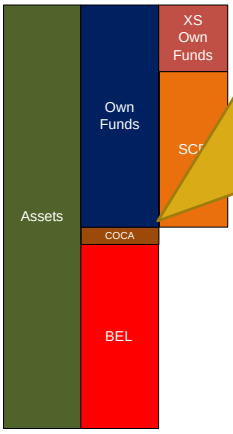
Where will the balance sheet be affected?



Cost of Capital

- Increased COCA if risk in the sector is perceived to increase.
- Capital raising becomes more expensive – more future profits ceded to providers of capital.
- Could (de facto) nationalisation be a possible outcome for the sector should the business model become unviable (for most of population)?

Required Capital

- Do regulators relax capital requirements – or does the regulatory / rating agency environment prevent relaxation.
- Does the risk appetite of the capital providers get larger / smaller?
  - Increased shareholder activism.

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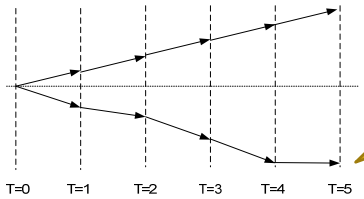
Actuarial – ORSA

- Business planning horizon of 3-5 years
  - Probably not enough time for a resource / climate event … but enough time for changing expectations about the future which will impact valuation assumptions.
  - Greater risk of regulation to curb climate change if science starts to be accepted by political class.
- Scenario Testing / Reverse Stress Testing
  - Do the scenarios include a future with resource constraints?
  - Which RST is likely to occur in a resource constrained scenario?



Typical scenarios are drawn from financial history – but could future crises look very different?

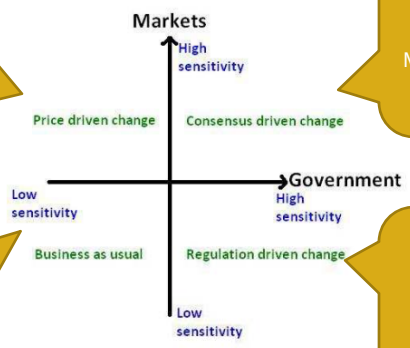
Actuarial – Scenarios in the Paper (Briefly)

Government NOT sensitive to long term projections.

Markets sensitive to long term projections.

Government sensitive to long term projections.

Markets sensitive to long term projections.



Government NOT sensitive to long term projections.

Markets NOT sensitive to long term projections.

Government sensitive to long term projections.

Markets NOT sensitive to long term projections.

Professionalism - Assumptions

Assumptions

C.4.18 The assumptions used in a **specification**, its **implementation** and **realisations** shall be **documented**.

C.4.19 Examples of assumptions used in **specifications**, which may be implicit or explicit, include qualitative assumptions about the relationships between phenomena and prior beliefs about the future behaviour of the phenomena being modelled (such as assumptions about the mean reversion of equity returns).

C.4.20 Examples of assumptions used in **implementations** and **realisations** include numerical and other parameters. **Documentation** will need to include records of the assumptions that were used for each **implementation** and **realisation**.

C.4.21 If an assumption has a description that is not uniquely defined, such as "best estimate" or "prudent", a statistical or other definition of the term in question will need to be **documented**. The **Generic TAS** on *Reporting Actuarial Information* requires descriptions of the intended meanings of such terms to be included in **aggregate reports**.

TAS-M

Assumptions need to be made clear and include implicit assumptions about relationship between phenomena.

Assumptions

C.4.4 An **aggregate report** shall state:

a) the **material** assumptions on which any calculations or judgements are based; and

b) any differences between the assumptions used or recommended in different parts of the work.

C.4.5 Paragraph C.4.4 applies to all **material** assumptions, whether they are implicit or explicit, qualitative or quantitative.

TAS-R

Assumptions need to be made clear – even if these are implicit.

Professionalism – Uncertainty

Considering what information is available about the future

The board's evaluation of the principal solvency and liquidity risks should consider what the board knows or should reasonably be expected to know about the future. The assessment does not have regard to a specific period. Knowledge about the future is a matter of judgement not fact and reflects the expertise and experience of those making the evaluations about the likely development of events and conditions in future periods as part of the assessment process. The board should satisfy itself that it has sufficient information to make this assessment.

FRC / Corporate Governance Code CP

The board need to ensure they have sufficient information about the future. What can they *reasonably* be expected to know.

Uncertainty

C.5.2 An **aggregate report** shall indicate the nature and extent of any **material** uncertainty in the information it contains.

C.5.3 Uncertainty may concern the results of calculations, assumptions on which information is based or other aspects. It may arise from random variations, lack of information or other sources. The extent of any **material** uncertainty may itself be subject to uncertainty.

C.5.4 There are many ways of indicating the extent of uncertainty, such as:

- giving a range, measure of the value at risk or other statistical calculation;
- showing the numerical consequences of changes in assumptions;
- presenting the outcomes of scenarios, possibly including extreme scenarios; and
- describing the uncertainty and explaining why it has not been quantified.

TAS-R

Material uncertainty needs to be presented.

Scenarios are suggested as a way in which the uncertainties can be explored

Agenda

- Exponential Growth
- Opinions on Future Growth
- Resource Limits
- Actuarial Impact
- Resource Limits and (Life) Actuaries

Why Can Actuaries Help?

- **Global problems made worse by:**
  - Lack of understanding of risk and uncertainty
  - Lack of understanding of exponential growth
  - Disregard for science and data
- **Actuaries' core skills are in the following areas:**
  - Risk and uncertainty
  - Exponential growth
  - Actuarial science and data based decisions
- **Life Insurance Extension**
  - Application of the scenarios to a life insurer would be a good extension

Activity - Institute & Faculty

- Resource & Environment Board (REG) has c.500 members following their activities with excellent support from the profession.
- Past Activity
  - Recruiting a deputy chair and board members
  - Literature review in 2010 focusing on climate change
  - Literature review in 2011 focusing on energy
  - Research into the limits to growth published January 2013
  - Networking evenings in 2011, 2012 and 2013
  - 2012 thought leadership lecture on climate change by Professor Sir Brian Hoskins
- Current Activity
  - 3rd Literature review due June 2014, working with Professor Richard Werner, focusing on sustainability of the financial system
  - Volunteers for the 3rd literature review are very welcome!

Activity – International Actuaries

- IAA Resource and Environment Working Group (REWG)
  - Meeting in The Hague, 23rd May 2013
  - Sessions at the 2014 Congress of Actuaries, Washington DC
- CAS / SOA / Canadian Institute Climate Change Committee
  - Have commissioned research and created a climate change index
- IAA
  - Working group to report on climate change to IAA
  - Working group to report on sustainable economics
- Society of Actuaries in Ireland wider fields group

Summary

- Exponential Growth
- Opinions on Future Growth
- Resource Limits
- Actuarial Impact
- Resource Limits and (Life) Actuaries

Thanks due for selected slides

- Dr Aled Jones
- Oliver Bettis
- Claire Jones
- Elliot Varnell

Institute
and Faculty
of Actuaries

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- LinkedIn: http://uk.linkedin.com/pub/matthew-donnery/70/336/b2a

Questions

Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

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

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