LIMITS REVISITED

a review of the limits to growth debate

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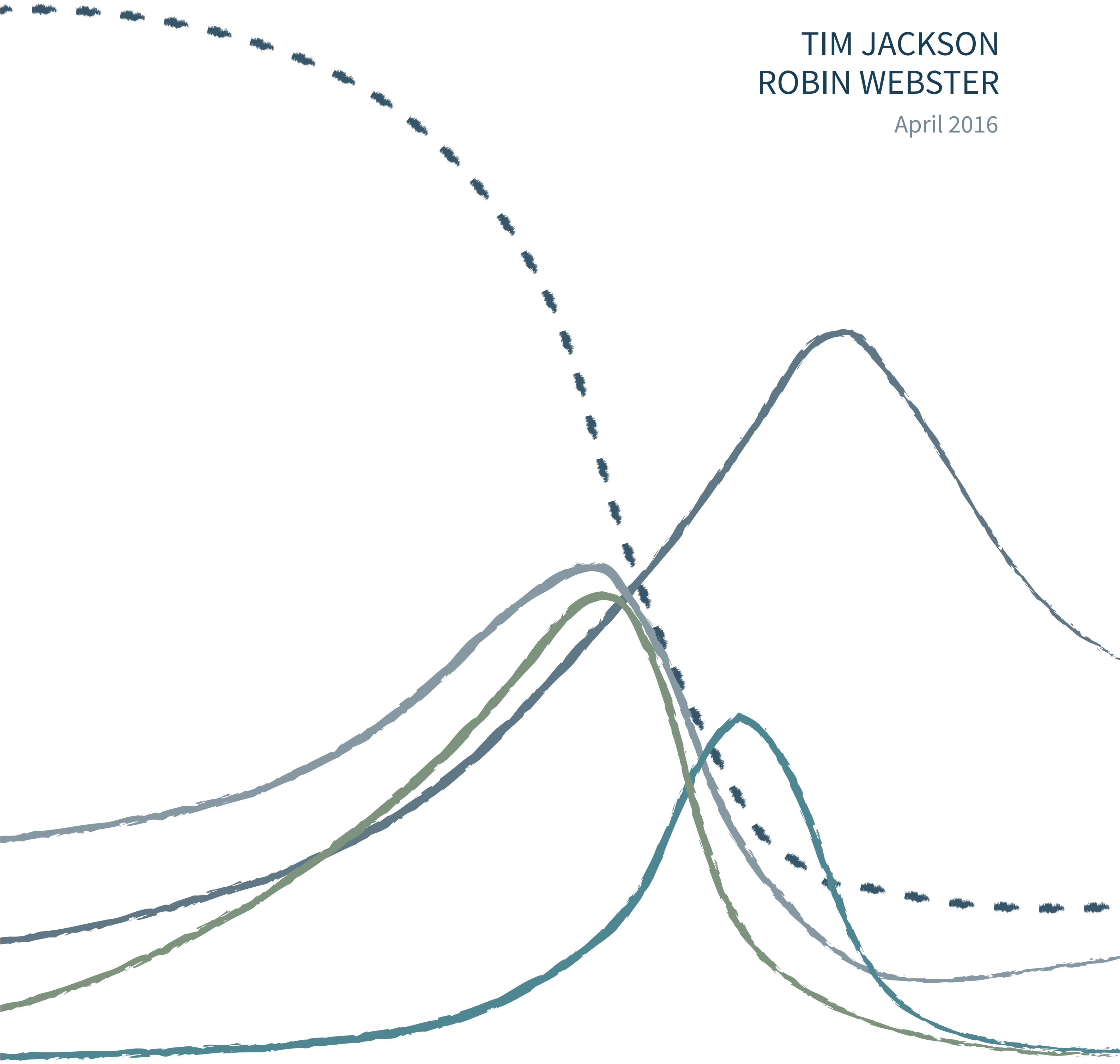
April 2016



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ABOUT THE ALL-PARTY PARLIAMENTARY GROUP ON LIMITS TO GROWTH

The aim of the All-Party Parliamentary Group (APPG) on Limits to Growth is to provide a new platform for cross-party dialogue on economic prosperity in a time of environmental and social transition. The APPG is chaired by Caroline Lucas MP (Green) and co-chaired by George Kerevan MP (SNP) and Daniel Zeichner MP (Labour). Its principal aims are:

- to create the space for cross-party dialogue on specific economic risks related to environmental and social limits;
- to assess the evidence for such limits, identify the risks and build support for appropriate responses; and
- to contribute to the international debate on redefining prosperity and measures of growth.

The Secretariat for the APPG on Limits to Growth is provided by the Centre for the Understanding of Sustainable Prosperity (CUSP) at the University of Surrey.

ABOUT THE AUTHORS

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Robin Webster is a researcher and writer on environmental issues. She was Friends of the Earth's senior campaigner on climate and energy for two and a half years. In 2010 Robin helped start up the climate blog Carbon Brief, where she worked as a fact checker and policy analyst until 2014. She has written extensively on UK energy policy and food sustainability issues. Robin has a masters from University College London in conservation and a degree in biology.

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EXECUTIVE SUMMARY

Four and a half decades after the Club of Rome published its landmark report on *Limits to Growth*, the study remains critical to our understanding of economic prosperity. This new review of the *Limits* debate has been written to mark the launch of the UK All Party Parliamentary Group (APPG) on the Limits to Growth.

The 1972 report articulated for the first time the dynamic nature of our dependency on physical resources and on ecological systems. It illustrated the processes of 'overshoot and collapse' that can occur when these limits are approached and suggested that, without a shift in direction, adverse consequences would become obvious "within the next century". The report attracted fierce controversy. It also inspired generations of environmental and social thinkers. It continues to offer challenging insights into the predicaments of the 21st Century economy.

Limits Revisited outlines the contents of the Club of Rome's report, traces the history of responses to it and dispels some of the myths surrounding it. We unravel the arguments that have raged for forty years in its aftermath and explore more recent findings which relate to the original hypothesis.

There is unsettling evidence that society is still following the 'standard run' of the original study – in which overshoot leads to an eventual collapse of production and living standards. Detailed recent studies suggests that production of some key resources may only be decades away.

Certain other limits to growth – less visible in the 1972 report – present equally pressing challenges to modern society. We highlight, in particular, recent work on our proximity to 'planetary boundaries' and illustrate this through the challenge of meeting the Paris Agreement on climate change. We also explore the economic challenge of a 'secular stagnation'.

If the Club of Rome is right, the next few decades are decisive. One of the most important lessons from the study is that early responses are absolutely vital as limits are approached. Faced with these challenges, there is also clearly a premium on creating political space for change and developing positive narratives of progress. A part of the aim of the APPG is create that space.

'Anyone who believes that exponential growth can go on forever in a finite world is either a madman or an economist.'
Kenneth Boulding, 1973[1]

'[There are] no great limits to growth because there are no limits on the human capacity for intelligence, imagination and wonder'.
US President Ronald Reagan, 1983[2]

INTRODUCTION

Limits to Growth was first published as a slim paperback volume in 1972 by the 'Club of Rome' - a group of about 30 leading thinkers, diplomats, academics and civil society leaders from ten different countries. First brought together by Italian industrialist Dr Aurelio Peccei to discuss "the present and future predicament of man", the Club of Rome was particularly concerned about the potential impacts of exponentially increasing consumption in a finite world.[3]

In 1970, it asked a team of expert modellers at the Massachusetts Institute of Technology (MIT) to forecast, as far as possible, what pressures the planet would experience if the same growth trends continued for the next 100 years.

»There's little doubt that *Limits to Growth* sparked a debate. That same debate has been raging now for over forty years.«

Ultimately, the MIT team was so worried by what they found that they published their results in a book. Revealing they were "overwhelmed" by the enormity of their findings, they expressed the hope that it would "spark debate in all societies...and lead thoughtful men and women in all fields of endeavor to consider the need for concerted action now if we are to preserve the habitability of this planet for ourselves and our children."[4]

There's little doubt that the publication of *Limits to Growth* sparked a debate. That same debate has been raging now for over forty years. But what exactly did the original report say? How robust were its findings? And what is the relevance of the limits debate today?

To mark the launch of the UK All Party Parliamentary Group on Limits to Growth, this brief review reflects on four decades of controversy and explores the claims made on either side of the debate. We also draw out some of the implications of the debate for policy and for business in the 21st Century. We start with a little history.

WHAT DID *LIMITS TO GROWTH* ACTUALLY SAY?

In the 1950s and 60s, Jay Forrester, a professor at the Massachusetts Institute of Technology (MIT), had developed a new approach to understanding the behaviour of nonlinear systems. 'Systems dynamics' uses a computer model to predict how different components of a system interact with each other, often in feedback loops, or circular and interlocking ways, to influence what eventually happens.

Previously, MIT had largely used the technique to analyse patterns in business – the success or failure of different corporations, for example. In the *Limits to Growth* analysis, Forrester and his team applied it to world development patterns.[5]

One simple example is the relationship between population, mortality and food per capita. If a population falls, there may be more food available per head. But the lower population may then also bring down agricultural productivity, reducing the supply of food, increasing mortality and leading to a further fall in population.[6] The model included hundreds of causal relationships like this one.

Overall, *Limits to Growth* investigated trends in five major areas: population and industrialisation, pollution, resource depletion and land availability for food.

The MIT team presented and analysed 12 scenarios, each with a different pattern of world development from 1900 to 2100. Every component in the model was linked to mathematical equations informed by the laws of physics and calibrated against empirical data up to 1970.

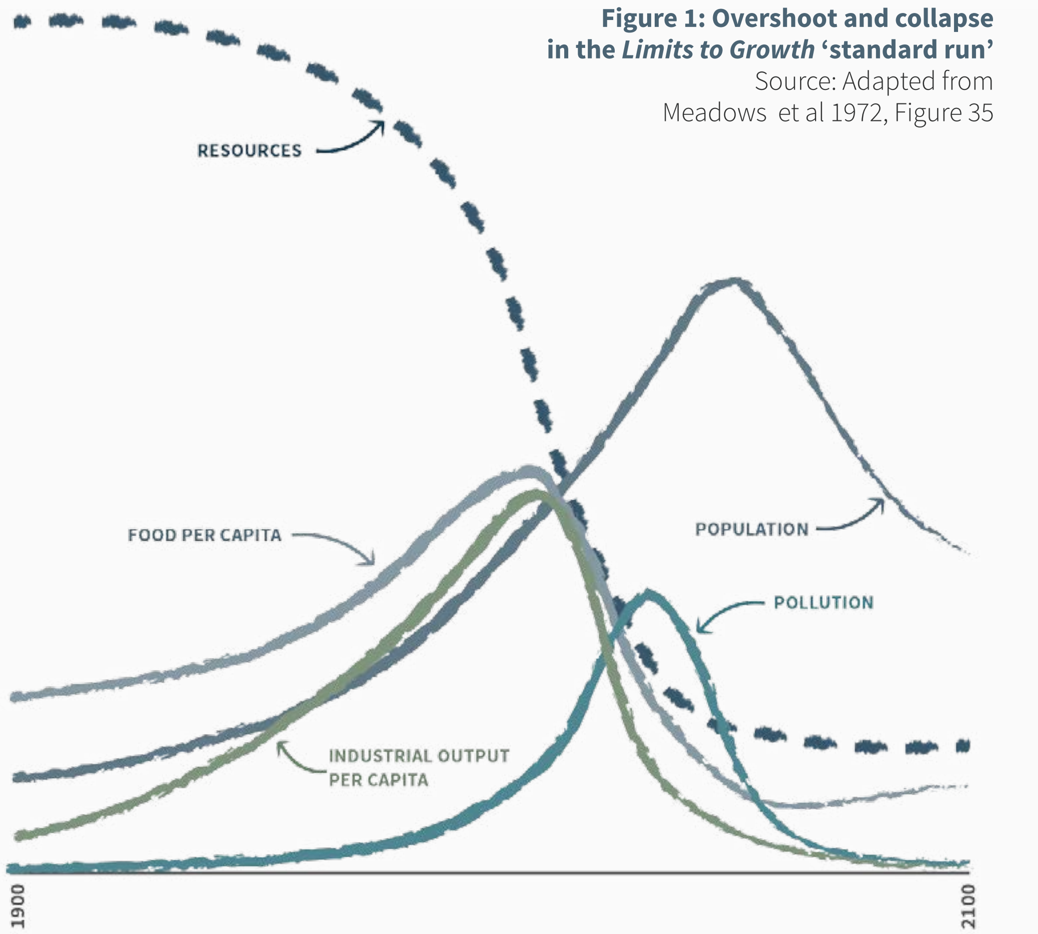
»Only four of the *Limits to Growth* scenarios avoided overshoot and collapse.«

The 12 scenarios were arranged into three broad groups. The 'standard run' or business-as-usual scenario assumed the same economic, social and physical patterns observed from 1900 to 1970 would continue into the future. Six subsequent 'technological scenarios' started with the same basic pattern, but assumed new advances in technology or that society would increase the amount of resources available, increase agricultural productivity, reduce pollution, or limit population growth. The final set of five 'stabilisation' scenarios looked at what would happen if either population growth, or industrial output, were stabilised.

Only four scenarios avoided overshoot and collapse.[7] These scenarios combined stabilising the human population with measures to restrict industrial output per person, as well as technological solutions like resource recycling and pollution control. One scenario which didn't introduce these measures until 2000 managed to reached equilibrium, but not permanently.

In the 'standard run' scenario (Figure 1), collapse came as a result of resource depletion forcing a slowdown in industrial growth, starting around 2015. The second scenario - the first of the 'technological' scenarios - assumed twice as many resources were available as a result of technological advances. In this projection, population collapse came about as a result of too much pollution.

Figure 1: Overshoot and collapse in the *Limits to Growth* 'standard run'
Source: Adapted from Meadows et al 1972, Figure 35



The majority of the scenarios show industrial output declining in the 2020s and population declining in the 2030s. The researchers didn't put precise dates on their projections. In fact, they deliberately left the timeline somewhat vague. They were interested in the general pattern of behaviour, rather than when exactly particular events might happen.[8]

Though the inter-dependencies in *Limits to Growth* investigated are complex, the dynamics of the MIT model are relatively straightforward to convey. As more and more people achieve higher and higher levels of affluence, they consume more and more of the world's resources. Consumption increases by a certain percentage each year - and population, industrialisation, pollution, food production and resource depletion all follow an exponential growth curve.

»Collapse doesn't happen because physical resources supporting humanity disappear entirely. It happens because the quality of a resource declines as more and more of it is extracted.«

Material growth cannot continue indefinitely, argued the MIT team, because planet earth is physically limited. Eventually, the scale of activity passes the carrying capacity of the environment, resulting in a sudden contraction - either controlled or uncontrolled. First, the resources supporting humanity – food, minerals, industrial output – begin to decline. This is followed by a collapse in population. The result is a series of bell-shaped curves (Figure 1).

The analysis follows a similar logic to predictions made by geoscientist M King Hubbert in 1956 about world oil supply. Hubbert observed that when oil is extracted from a well, the amount of oil it yields rises exponentially, reaches a point where it stops growing, peaks and enters a terminal decline as the well is exhausted. He suggested that oil production would follow the same pattern globally - a theory that later came to be known as 'peak oil'.[9]

It's important to note that contraction or collapse doesn't happen in the model because physical resources supporting humanity disappear entirely. It happens because the quality of a resource declines as more and more of it is extracted. Consequently, it takes more and more investment (both physical and financial) to extract usable high-quality resources from raw materials. This diverts resources away from productive industry and from agriculture and eventually the process becomes unsustainable.

When applied to energy, ecologist Charles Hall has called this process of a declining return on resource extraction the 'Energy Return on Energy Invested' (EROEI). EROEI puts a value on the amount of energy obtained from a fuel like coal or oil, compared to the amount of energy that has to be spent to extract it in the first place.[10] If this value falls far enough, extraction becomes both financially and energetically unviable. The concept can also be applied to mineral resources like iron, chromium or phosphorous.[11] We'll explore the implications of this in more detail a little later on.

HOW DID PEOPLE REACT?

When the book was released in 1972 it caused a media storm. It sold 12 million copies in 37 languages and remains the top-selling environmental title ever published. Many still view it as a founding text of the environmental movement.[12]

Soon after it was published, the report began to attract heavy criticism - often by economists and business people. Three economists writing in the New York Times Book Review in 1972 called it "an empty and misleading work... and little more than polemical fiction" They also (incorrectly) claimed that all the study's simulations "invariably end in collapse" and that the book predicted depletion of key resources by 1990.[13]

Many critics argued that *Limits to Growth* did not give enough credence to human ingenuity and adaptability, ignoring humanity's ability to develop technological solutions to its problems. These assessments tended, however, to focus on the 'standard run' projection - downplaying the fact that many of the other 11 scenarios allowed for a far higher level of technological adaptation.[14]

In the 1990s, criticism tended to focus on the misconception that *Limits to Growth* predicted global resource depletion and social collapse by the end of the year 2000.

»The most amazing aspect of the book is how accurate many of the basic trend extrapolations still are.«

Climate sceptic Bjørn Lomborg promoted this idea, claiming to consign *Limits to Growth* to the "dustbin of history".[15] A famous bet between Paul Ehrlich and Julian Simon on the price of a basket of commodities rising or falling between 1980 and 1990 appeared to confirm this hypothesis. Ehrlich – who believed they would rise – lost the bet. But *Limits to Growth* never made such a prediction.[16]

The virulence of the critiques, and extent to which they misrepresented the work and criticised the authors personally, has led Professor Ugo Bardi from the University of Florence to draw parallels with campaigns against the science of climate change and tobacco health impacts.[17]

Despite the furore, or perhaps because of it, the work continues to generate debate and analysis more than forty years after it was published. Many are still dismissive. But on reading the work in 2000 energy analyst Matthew Simmons described himself as amazed. "The most amazing aspect of the book," he said, "is how accurate many of the basic trend extrapolations...still are some 30 years later."[18]

In the years since *Limits to Growth* was published, a number of studies have tracked how real world events matched up to its original scenarios. These studies show significant similarities between its projections and what has actually happened.

Limits to Growth's thirty year update, published by the Club of Rome in 2004, and two subsequent modelling studies in 2008 and 2014 from the University of Melbourne concluded that the world is tracking on Limits to Growth's 'standard run' projection.[19] Historical data from publications including the United Nations and the World Resources Institute's Earthwatch database show that the global population and economy has developed according to the patterns the researchers modelled in 1972.

As systems ecologist Charles Hall and a colleague remarked in a paper in 2009, "We are not aware of any model made by economists that is as accurate over such a long time span."[20]

ARE WE ALREADY FACING LIMITS?

What does this all mean for the future of our economy? In the standard run scenario, natural resources (for example oil, iron and chromium) become harder and harder to obtain. The diversion of more and more capital to extracting them leaves less for investment in industry, leading to industrial decline starting in about 2015. Around 2030, the world population peaks and begins to decrease as the death rate is driven upwards by lack of food and health services.[21]

The similarity between *Limits to Growth*'s standard run and the patterns observed over the last forty years doesn't necessarily mean that the same trends will continue into the future. Some researchers argue that it's possible, however. Author of the University of Melbourne studies, Dr Graham Turner, asked in 2014 whether global collapse could be "imminent". Turner explicitly linked the global financial crisis, high commodity prices and the *Limits to Growth* projections.[22]

Another set of studies has modelled the availability of over 40 essential materials using an updated and expanded version of the *Limits to Growth* model. Based on US Geological Survey data, the authors analysed changing patterns of resource extraction. Using earlier work, which suggests there is a time delay of about 40 years between 'peak discovery' and 'peak production' across a wide range of different minerals, the authors aim to forecast when 'peak production' might arrive.

The work, led by Harald Sverdrup from the University of Lund in Sweden and Vala Ragnarsdottír from the University of Iceland, concluded that most of the resources they studied had either already reached peak production or will do so within the next 50 years.[23] Phosphorous - which is critical to fertilising soil and sustaining agriculture - has already peaked, and will start declining around 2030-2040, they said. Coal production will peak in around 2015-20 and 'peak energy' around the same period. From that point on, they concluded, "we will no longer be able to take natural-resource fuelled global GDP growth for granted'.[24]

A book published by the Club of Rome in 2014 also examined the future availability of a wide variety of mined resources, including chromium, copper, tin, lithium, coal oil and gas. The book included specialist contributions from experts across a wide range of fields. It concluded that the rate of production of many mineral commodities is already on the verge of decline.[25]

These analyses are understandably controversial. In a technologically optimistic world, it is often assumed that enough food, water energy and minerals will be available for the foreseeable future, with the only problems being those of distribution.[26] Neo-classical economists also argue that when one resource runs out it can be substituted for another. But this is also controversial. In the case of some key elements (phosphorus is an example), there are no known substitutes.[27]

»Hundreds of experts surveyed by the World Economic Forum identified resource scarcity as the second most underestimated global issue after financial inequality.«

Experts themselves are clearly divided on the question of resource limits. In 2014, a World Economic Forum (WEF) survey of hundreds of experts identified resource scarcity as the second most underestimated global issue after financial inequality. But WEF's analysis also highlighted the contested nature of the debate. The WEF itself concluded that the world has sufficient mineral stocks to 2035, although "better management of the resource is needed after that point".[28]

PEAK OIL - FACT OR FICTION?

Probably the most well-known resource scarcity debate is the one surrounding 'peak oil' - M King Hubbert's prediction that world oil supply will peak and then start declining. Hubbert's theory and the *Limits to Growth* analysis were developed separately, but they follow the same logic. The resource, in this case oil, becomes harder and harder to extract, eventually forcing a decline in the rate of production.[29]

Hubbert originally suggested that US oil production would peak in 1970 and world oil production would peak sometime around the year 2000. In fact, US crude oil production did peak in 1970 and started to fall. Global oil production did not peak in 2000, but many considered the possibility that it would a serious concern in the first decade of this century.[30] A number of literature reviews now suggest conventional oil production has already peaked, or will do so within the next couple of decades.[31]

The expansion of 'unconventional oil' has changed the debate, however. It is now clear that production is rising again. New extraction techniques opened less accessible oil resources up to exploitation. Hydraulic fracturing ('fracking') allowed the expansion of an industry exploiting 'tight oil', most notably in the USA. Canada is now extracting 2.3 million barrels of oil a day from tar sands - in a project labelled "the largest industrial plan on earth".[32] Deepwater drilling - for example off the coast of Brazil - also allows companies to access new oil resources.[33]

As a result, some commentators announced the 'death' of the peak oil theory - putting forward the view that there are huge volumes of oil still to be developed.[34] The dramatic fall in oil prices from 2014 appears to further contradict the idea that production could struggle to meet demand in the near future.[35] Instead, argues the IEA, we are experiencing low oil prices, low demand, and an abundance of resources in the ground as companies seek out new conventional and unconventional supplies.[36]

From an environmental point of view this era of apparent abundance is not without drawbacks. Unconventional oil is difficult, expensive and environmentally destructive to get out of the ground. In fact, as the remaining global oil resources get more and more difficult to extract, less and less energy is gained relative to the energy that needs to be put in to get it in the first place – exactly in line with the principles in *Limits to Growth*.[37]

Not everyone is convinced that this era of abundance is here to stay. In the conventional economic view, we should be able to tell something about scarcity from prices. But the price dynamics of oil markets are notoriously difficult to predict. Oil prices rose to a peak of $147 a barrel in July of 2008. After an extremely volatile period, prices began to collapse through 2014 and 2015. By December 2015, they stood at only $30 a barrel. Low oil price is no more reliable an indicator of abundance, however, than the very high oil price in 2008 was an indicator of immediate scarcity.[38]

There's an interesting theory – called the 'green paradox' – that low oil prices are in part the reaction of an industry fearful of the impacts of climate change policy on its future revenues. The German economist Hans-Werner Sinn has argued that "if suppliers feel threatened by a gradual greening of economic policies.. they will extract their stocks more rapidly" thus pushing their prices down.[39]

In the short term, low oil prices certainly present a problem for unconventional oils. Getting the oil out of the ground is so difficult that it needs a high price to make the investment financially viable.[40] Weak economic activity, increased energy efficiency, high unconventional

»As the remaining global oil resources get more and more difficult to extract, less and less energy is gained relative to the energy that needs to be put in to get it in the first place – exactly in line with the principles in *Limits to Growth.*«

production from the USA, and a market decision made by OPEC to keep producing at lower prices in order to maintain their market share have all played a part in pushing the price down. In the future, these dynamics could all change.[41] The IEA expects oil prices to start rising again before 2020.[42]

A 2015 analysis of the remaining fossil fuel resources in China, USA, Canada and Australia, which includes unconventional resources, suggests that overall oil production is in fact peaking already. The combination of declining conventional oil with increasing unconventional oil supplies then results in a 'plateau' in supplies to the end of the century, before a decline begins. In a 'high' oil supplies scenario, strong growth continues to 2025, before being replaced by very weak growth to the end of the century, when a decline begins. In a 'low' scenario, the decline begins by 2050.[43]

Overall, the study reaches a striking conclusion. World fossil fuel production is likely to peak in around 2025, it suggests, largely as a result of Chinese coal production peaking. In short, unconventional oil seems to buy us several more decades before resource depletion starts to bite. But if the fear of peak oil has receded slightly, another set of concerns has emerged that was virtually unforeseen in the original *Limits to Growth* work.

FACING UP TO 'PLANETARY BOUNDARIES'

In one respect at least, history has turned out considerably worse than the Club of Rome's projections. The original report made only passing reference to some of the most pressing environmental issues of today. This prompted another set of researchers to take the ideas in *Limits to Growth* one step further. A large cross-disciplinary team led by Dr Johan Rockström of the Stockholm Resilience Centre identified a set of nine ecological processes that regulate the land, ocean and atmosphere.

For each process they identified a series of thresholds beyond which humans would cause unacceptable environmental change. Acknowledging the uncertainty inherent in defining these thresholds, the team also defined a set of 'planetary boundaries' which taken together represent a 'safe operating space' for humanity. This new framing was intended as a shift away from *Limits to Growth*'s approach of analysing the impact of different human activities towards "the estimation of a safe space for human development".[44]

The nine planetary boundaries relate respectively to: climate change, ocean acidification, biodiversity loss, interference with global nitrogen and phosphorous cycles, ozone depletion, global freshwater use, land system change, atmospheric aerosol loading and chemical pollution.

For each process, the team identified a 'zone of uncertainty' and a 'danger zone'. Crossing over these thresholds could mean "non-linear, possibly abrupt and irreversible earth system responses" with disastrous consequences for society, the research said.

An update of the work in 2015 found that four of these planetary boundaries had already been crossed. Biodiversity loss, damage to phosphorous and nitrogen cycles, climate change and land use have all slid into or beyond the 'uncertainty zone'.[45] Virtually none of this was picked up by the original *Limits to Growth* report.

CLIMATE CHANGE

In 1972, the MIT team referred only in passing to the potential impacts of global climate change, concentrating mostly on the local warming effects from burning fossil fuels. Forty years later, climate change is recognised as one of the pre-eminent environmental threats in the world. Scientific evidence gathered by the Intergovernmental Panel on

Climate Change (IPCC) suggests that humanity is already in 'overshoot' on our carbon emissions.[46]

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In 2015, carbon dioxide levels hit 400 parts per million (ppm). The last time levels were this high was more than a million years ago.[47] Humans are pumping carbon into the atmosphere at a rate higher than any point in the last 66 million years - and the effects are being felt.[48] 2015 was the warmest year on record and the first year that temperatures rose 1⁰C above pre-industrial levels.[49]

The Stockholm researchers set a concentration of 350 parts per million (ppm) of carbon dioxide in the atmosphere as one of the boundaries for climate change.[50] This is partially as a result of paleoclimatic data suggesting large polar ice sheets are at risk of collapse at higher carbon dioxide concentrations.[51] It is roughly consistent with a temperature rise of 1.5⁰C above pre-industrial levels.

At the 21st Conference of the Parties to the Climate Change Convention, in Paris in December 2015, the international community agreed to "pursue efforts" to limit temperature rise to no more than 1.5⁰C above the pre-industrial average, in order to prevent the dangerous effects of climate change.[52]

The challenge of this task is quite extraordinary. The IPCC has identified a range of 'carbon budgets' which define the maximum amount of carbon dioxide that can be emitted for any given likelihood of remaining below a given temperature rise.[53]

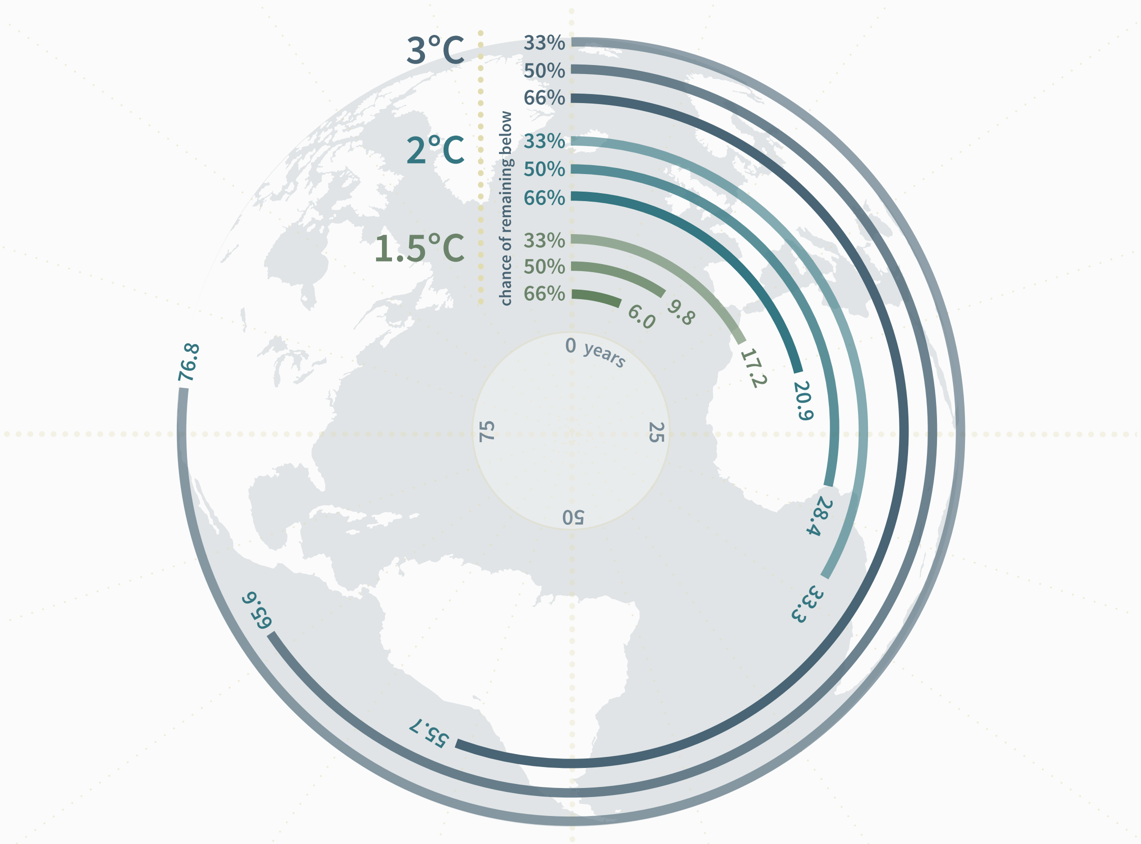


Figure 2: Years left (at current annual emission level) to limit temperature rise
Source: Adapted from Carbon Brief; data from IPCC 2014 (note 54)

Figure 2 shows the number of years it would take to use up those budgets, if the level of annual emissions remained as they are today. The available carbon budget - if we want a two thirds chance of meeting the 1.5°C target - is just 240 Gt CO_2. At the current rate of annual emissions this would be used up in just six years. After that point, there would have to be 'net zero' carbon emissions for the rest of the century.[54]

BIODIVERSITY

The term 'biodiversity' - meaning the diversity of plants and animals on the planet - was first used in a publication by biologist E O Wilson in 1988. In the same book, Wilson concluded that the extinction rate for the world's species was at that time already "about 1,000 to 10,000 times more than before human intervention".[55]

The diversity of vertebrates - which includes mammals, birds, reptiles, amphibians and fish - declined by 52% in the four decades since Limits to Growth was published, according to conservation organisation WWF. The greatest decline was in freshwater species, where the populations WWF monitored for its 'Living Planet Report' declined by three quarters (76%) between 1970 and 2010. Species are affected by habitat loss and degradation and exploitation through hunting and fishing.

WWF calculates that 1.5 earths would be required to meet the demands humanity makes on nature each year. The 'overshoot' is possible because - for now - humanity can destroy forests faster than they grow again, harvest more fish than will be replaced or emit more carbon than the forests or oceans can absorb again. In the long term, however, this is unsustainable, because natural systems cannot renew themselves.[56]

> »The world has entered a new era known as the Anthropocene, where the activities of humans are the dominant influence on the atmosphere and environment.«

NITROGEN AND PHOSPHOROUS

Artificial fertiliser converts nitrogen from the air into a reactive form that plants need to grow. The development of artificial fertiliser has dramatically increased agricultural yields, but excessive nitrogen pollution from fertiliser is upsetting the balance of ecosystems and the global cycle of this element. Phosphorous is also a key element in the soil, critical to food production. According to the planetary boundaries analysis, both of these elements have moved beyond the 'uncertainty zone' and into the 'high risk' zone.

LAND USE

The amount of land we're converting from one use to another - for example by destroying forests - has also reached a point where it is in the 'uncertainty zone'. This means it also poses a risk to the global climate.[57]

Humanity has changed the natural environment so profoundly that we may have created a new - and far more unpredictable - geological epoch, according to recent research. The relatively stable environment of the Holocene, an interglacial period that began about 10,000 years ago, has provided the conditions for human societies to develop and thrive. Now, however, the world has entered a new era known as the Anthropocene, where the activities of humans are the dominant influence on the atmosphere and environment.[58]

Hundreds of papers have now been published on the Anthropocene. The official body, the International Commission on Stratigraphy, is due to vote on whether the term should formally be declared another epoch later this year.[59]

RESPONDING TO THE LIMITS

It is clear enough from this analysis that the economy cannot realistically countenance much more in the way of material growth. Even if more optimistic assumptions about resource availability are adopted, our proximity to several key 'planetary boundaries' is troubling. This is most obviously the case for climate change.

Economic growth is not, however, the same thing as growth in carbon emissions, or growth in the consumption of resources. Economic output is measured in dollars. Material throughput is measured in tonnes. It is clearly sometimes possible to 'decouple' growth in dollars from growth in physical throughputs and environmental impacts.

Between 1980 and 2008, for example, the intensity of material use (per dollar of economic activity) fell by 42% across OECD member countries, and per capita consumption fell by 1.5% over the same period.[60]

In both 2014 and 2015, carbon emissions from burning fossil fuels and industry flattened and even fell slightly, while GDP increased by 3.4% and 3.1% respectively. This was partly as a result of a global economic slowdown, but also as a result of a shift away from coal and towards renewables - particularly in China.[61] Across the world, renewables are now being built faster than fossil fuels. Interestingly, the transition to clean energy is taking place faster in poor countries than rich ones.[62]

This kind of evidence has led the IEA, for example, to argue that greenhouse gas emissions are now "decoupling from economic growth".[63] Other commentators have been even more optimistic. 'To the degree to which there are fixed physical boundaries to human consumption,' claims a recently published *Ecomodernist Manifesto*, 'they are so theoretical as to be functionally irrelevant.'[64]

Some argue that we can decouple material throughput from economic output indefinitely, and continue to do so, however much the economy expands. This position is characterised by concepts such as 'green growth', 'clean growth' and 'sustainable growth' and is arguably the dominant response to the Limits debate, in recent years.[65] At its most optimistic it portrays a comforting conclusion that economic growth can continue forever.[66]

There are clearly some technological avenues which promise a more efficient, less material society. Digitisation, artificial intelligence, robotisation seem poised to make extraordinary changes both on our working lives and on our lifestyles.[67]

But assessing the material and environmental impacts of these changes is complex. In the first place, it's essential to distinguish between what's called relative decoupling – a decline in the material intensity of economic output – and absolute decoupling – an absolute fall in material use or emissions. Much of what is celebrated as decoupling is relative rather than absolute decoupling. And where absolute decoupling does occur, it has so far been relatively minor.[68]

»In the last two years, carbon emissions from burning fossil fuels and industry flattened and even fell slightly, while GDP increased by 3.4% and 3.1% respectively.«

There are some clear reasons for this. One of them is that making things more efficient (relative decoupling) tends to make them cheaper and this encourages us to use more of them. This phenomenon is called the 'rebound effect'. Our attempt to reduce consumption or emissions can sometimes even have the perverse effect of increasing them – an effect known as 'backlash'.[69]

Another difficulty arises from the 'permeability' of trade boundaries. The 'footprint' from our material lives often falls outside the national boundary. Apparent dematerialisation in advanced nations is sometimes just the result of failing to account for the impacts of the production which occur in other countries.

For example, the domestic material consumption measured across the OECD between 1980 and 2008 left out any account of the raw material extraction associated with the manufacture of imported finished and semi-finished goods. Once the inputs from other countries are added in, the 'material footprint' of the OECD nations as a whole rose by almost 50% between 1990 and 2008, according to two studies published in 2015.[70]

Similar reservations apply in the climate change debate. Carbon emissions are usually measured on a territorial basis, allowing rich countries to 'export' their emissions elsewhere. This partially explains why, in the first decade of this century, the emissions of emerging economies like China and India increased at such a rapid rate, while those in advanced economies stabilised or declined.[71]

»Where absolute decoupling does occur, it has so far been relatively minor«

The stabilisation of emissions observed over the last two years has occurred globally, not just in one region. But it is clear that if economic growth continues at predicted rates, the task of fully decoupling emissions from growth is a ferociously difficult one. Since the middle of the 20th Century, the global economy has expanded at around 3.65% each year. If it were to continue to expand at the same rate, it would be more than 200 times bigger in 2100 than it was in 1950.[72]

A world in which everyone around the world achieved the level of affluence currently expected in the west would mean global economic output growing by 30 times by the end of 2100, related to current levels. Meeting carbon targets in such a world would demand quite astonishing rates of decoupling – much higher than anything that has been observed historically.[73]

The heroic nature of conventional assumptions that growth can continue indefinitely without reaching overshoot and collapse has prompted a different kind of reaction to the Limits debate. Writing in 1977, former World Bank economist Herman Daly argued that society should move towards a ‘steady state economy’.[74]

Daly took his inspiration from some surprising sources. As early as 1848, one of the founders of classical economics, John Stuart Mill, had already written of a ‘stationary state of population and capital’. He also argued that there would be ‘as much scope as ever for all kinds of mental culture, and moral and social progress’ within such a stationary state.[75]

The idea that economic and material growth is not the same thing as social progress has inspired a wide range of responses to the challenge of Limits. Writing in in 2015, Pope Francis argued that ‘the time has come to accept decreased growth in some parts of the world, in order to provide resources for other places to experience healthy growth’.[76]

This call has much in common with the ‘degrowth’ movement, which has argued that we should aim to simplify lifestyles and reduce material dependencies, irrespective of the impact on conventionally measured growth.[77]

In the words of its proponents, degrowth is a ‘missile concept’ designed to “open up a debate silenced by the ‘sustainable development’ consensus”. It is about “imagining and enacting alternative visions to modern growth-based development”. Several grassroots movements, most notably the Transition Town movement, have adopted similar ideas.[78]

Policy and media have not yet given much credence to these ideas. They are clearly challenging to an economics built around assumptions of continued exponential growth.[79] But in the wake of the financial crisis, degrowth has emerged as a critical challenge to the mainstream orthodoxy.

»Apparent decoupling in advanced nations is sometimes just the result of failing to account for the impacts of the production which occur in other countries.«

One of the most frequently encountered objections to degrowth is that it doesn’t offer enough of a positive vision. The terminology of green growth suggests (perhaps falsely) that we can continue to flourish. The terminology of degrowth intimates some kind of decline. “Instead of a degrowth campaign, I would urge us to develop together a positive narrative,” writes the current Club of Rome Co-Chair, Anders Wijkman, “where growth and development are discussed in qualitative rather than quantitative terms.”[80]

Within the degrowth movement, and indeed outside it, a variety of more positive visions for development do already exist. Some of these are framed around the idea of prosperity. Others are framed around our ability to ‘flourish within limits’. Debates about wellbeing and quality of life also contribute to this call for positive narratives.[81]

Some elements within these narratives have considerable traction on both sides of the debate. Addressing social justice, reducing resource dependency, increasing material efficiency, protecting social welfare, investing in low carbon technologies and infrastructures: all of these strategies have a wide appeal.

The key remaining difference between degrowth and green growth is whether or not a strategy of economic growth, as conventionally measured by the GDP, can get us there. Fascinatingly, this may turn out to be a purely academic difference. Secular trends suggest that growth itself may already be declining.

IS ECONOMIC GROWTH OVER?

Described by the BBC in 2015 as “probably the biggest and most important controversy in macroeconomics today”, the idea of ‘secular stagnation’ was first put forward in the 1930s.[82] Economist Alvin Hansen argued that in the wake of the Great Depression, US growth may have stopped permanently.[83]

A subsequent world war and population boom quickly proved Hansen wrong, and the term was forgotten. But at an IMF conference in 2013, former US Treasury secretary Larry Summers suggested it might be time to revive the concept.[84] After the 2007-8 financial crisis, Summers argued, the economies of developed countries were failing to recover to their previous levels - and show no prospect of doing so.[85]

Summers theorises that from the late 1990s or early 2000s, economic growth in the USA was reliant on a series of financial bubbles – particularly in housing – and a huge expansion of private debt. This generated enough investment and employment to keep growth going, he says, but it was unsustainable. In the aftermath of the 2007-9 financial crisis, as businesses, households and governments seek to reduce their level of debt, the long-term weakness of the system is becoming visible.[86]

This idea is controversial, but no fringe theory. It has prompted debate between Summers, former Federal Reserve chairman Ben Bernanke and Nobel Prize winner Paul Krugman.[87] In 2014, Summers and then UK shadow chancellor Ed Balls co-chaired a commission to explore the idea in depth.[88]

Modelling shows the idea of being “mired in a recession forever” is possible.[89] Although Summers applied the idea to the US, he suggests the “spectre of secular stagnation” is greater in Europe and Japan.[90]

Economist Robert Gordon goes a step further. His 2012 paper “Is US growth over?” puts forward the “audacious idea” that rapid economic growth was a one-off event in human history, now coming to an end.[91]

Before 1750, Gordon points out, there was virtually no economic growth at all. The invention of steam and railroads created a slight increase in living standards from around 1750 to 1830. The USA’s second industrial revolution took place as a result of the invention of electricity, the internal combustion engine and indoor plumbing between 1870 to 1900. It drove rapid increases in productivity – in particular, in labour productivity – which continued into the middle of the 20th Century.

The third revolution - in computers, the internet and mobile phones - had early benefits, removing the need for repetitive and clerical labour from the 1970s and 80s onwards. But inventions since 2000 have centred on entertainment and communication devices, altering society but not fundamentally improving working or living standards in the way that electric light, motor cars or indoor plumbing did.[92]

Combined with six ‘deflationary headwinds’, including an aging population, rising inequality, and the ‘overhang’ of

»The time has come to accept decreased growth in some parts of the world, in order to provide resources for other places to experience healthy growth.«

Pope Francis

consumer and government debt, this slowing down of productivity growth could well account for decline in growth in the USA and elsewhere.

Gordon's analysis comes from a US perspective. The picture for the UK is even more striking (Figure 3). A phenomenal slowdown in productivity growth has occurred in just half a century. The trend growth rate rose from less than 1% per year in 1900 to reach 4% per year in 1966. It declined sharply past that point. Digital and information technology slowed (but did not reverse) the decline through the 1980s and 1990s.[93]

Soon after the bursting of the 'Dot Com' bubble at the turn of the millennium, and long before the financial crisis, the decline began to accelerate. By 2013 trend labour productivity growth was negative. The amount of output produced in each hour of work is currently declining in the UK.

»Secular trends suggest that growth itself may already be declining. In the aftermath of the financial crisis the long-term weakness of the system is becoming visible. «

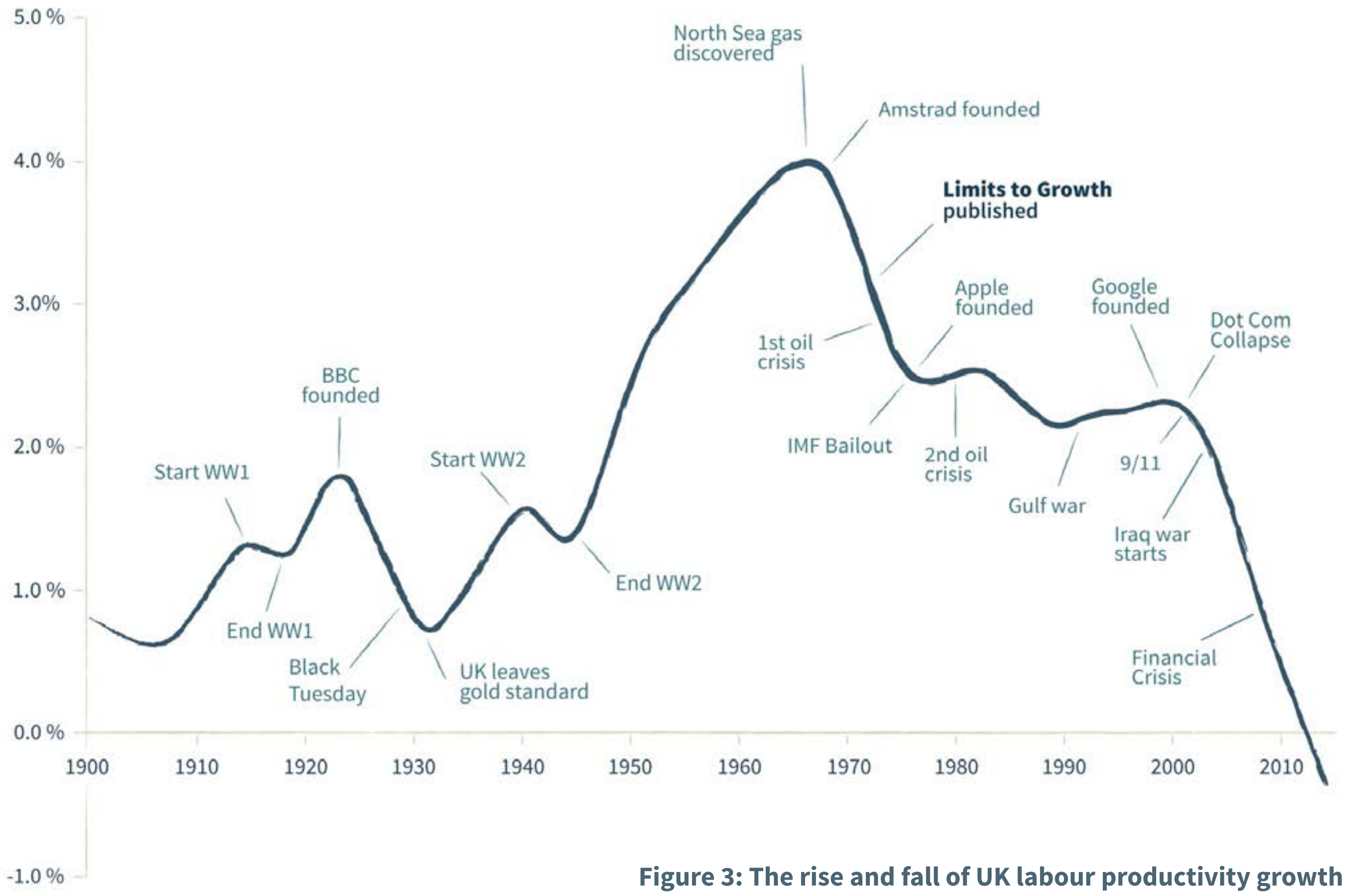


Figure 3: The rise and fall of UK labour productivity growth
Source: Authors' calculations from Bank of England data (see note 93)

Not all economists accept that falling productivity growth is to blame.[94] At the global level, the economic slowdown is clearly being driven by a variety of changes - not least a change of policy in China – to move away from an export economy and to increase domestic goods and services.[95] Nonetheless, it seems relatively clear that in the advanced economies, at least, economic growth is experiencing the law of diminishing returns.

Resource limits and planetary boundaries aside, these factors offer a very real possibility that, as Gordon puts it , "future economic growth may gradually sputter out." In these circumstances, of course, there is an absolute premium on any strategy that will help us to protect human welfare and deliver social progress.

»There is an absolute premium on any strategy that will help us to protect human welfare and deliver social progress.«

CONCLUSIONS

More than four decades after the Club of Rome published its controversial landmark report, debates about the *Limits to Growth* still thrive. These debates remain a vital element in understanding the challenges of economic progress in the 21st Century.

If the Club of Rome's projections are right, then the next few decades are decisive. There is unsettling evidence that society is tracking the 'standard run' of the original study – which leads ultimately to collapse. Detailed and recent analyses suggest that production peaks for some key resources may only be decades away.

The evidence of our proximity to planetary boundaries is even more striking. 'Even before we run out of oil,' argues climate change activist Bill McKibben, 'we're running out of planet.'[96] Meeting the Paris Agreement on climate change alone means a radical transformation of our investment portfolios, our technologies and our consumption patterns.

Responses to the *Limits* debate still remain tantalisingly poised between the pessimism of resource constraints and the optimism of technological progress. Kenneth Boulding's warning of the 'madness' of endless exponential growth (cited at the top of this paper) still resonates. But Ronald Reagan's appeal to human ingenuity (also cited above) is not without foundations. Human creativity has provided for enormous social progress in the space of just a few centuries.

The economy itself is a product both of physical (and therefore limited) processes and of creative (and therefore unlimited) ones. Figuring out an institutional and social balance between the limited and the unlimited is a key challenge for modernity. But this clearly doesn't mean allowing business-as-usual assumptions about economic growth free rein. The lessons of the original report remain poignant.

Perhaps most striking amongst those lessons are the dynamics of overshoot and collapse. One of the most important of these dynamics is that collapse proceeds not from the absolute exhaustion of resources but from a simple and inevitable decline in resource quality. Given that this decline is already visible for many resources, prudency dictates that we take these dynamics seriously.

Another critical lesson from the original report is about the speed and timing of overshoot and collapse. At the point at which peaks in production become obvious and declines are imminent, our options are much more limited than they are while growth is still in progress.

This is sometimes called the Seneca effect. The Roman philosopher Lucius Annaeus Seneca once wrote to his friend Lucilius that "increases are of sluggish growth, but the way to ruin is rapid."[97] The critical point is that collapse is a more or less uncontrollable process. Prudency resides in taking action early to transform technological systems, economic institutions and lifestyles. An early policy response matters.

This early response remains conspicuous by its absence, particularly in policy, even forty years after the Club of Rome's clear warning. Many business leaders are now openly preparing for a world of resource constraints.[98] But governments are still reticent to think beyond the short-term. The demands of *Limits to Growth* suggest an urgent need for policy-makers and politicians to take a longer term perspective: not just on urgent challenges such as climate change but also on resource horizons which are at best a few generations away.

There is another vital issue raised by the *Limits to Growth* debate: namely its implications for social justice. Most of the overshoot, as Anders Wijkman has pointed out, is due to "wasteful lifestyles in industrialized countries. Poverty is still rampant—more than 3 billion people live on less than 2 US dollars a day."[99]

> »If the Club of Rome's projections are right, then the next few decades are decisive.«

An interesting avenue of progress arises from the body of evidence which suggests that there are also social limits to growth.[100] In the advanced economies at least, economic growth shows diminishing returns in terms of happiness and wellbeing. In some cases, economic expansion undermines the quality of life. This evidence offers the tantalising possibility – reflected by John Stuart Mill's remarks on moral and social progress – that it may be possible to live better and yet to consume less. Limits to growth offer both challenges and opportunities.[101]

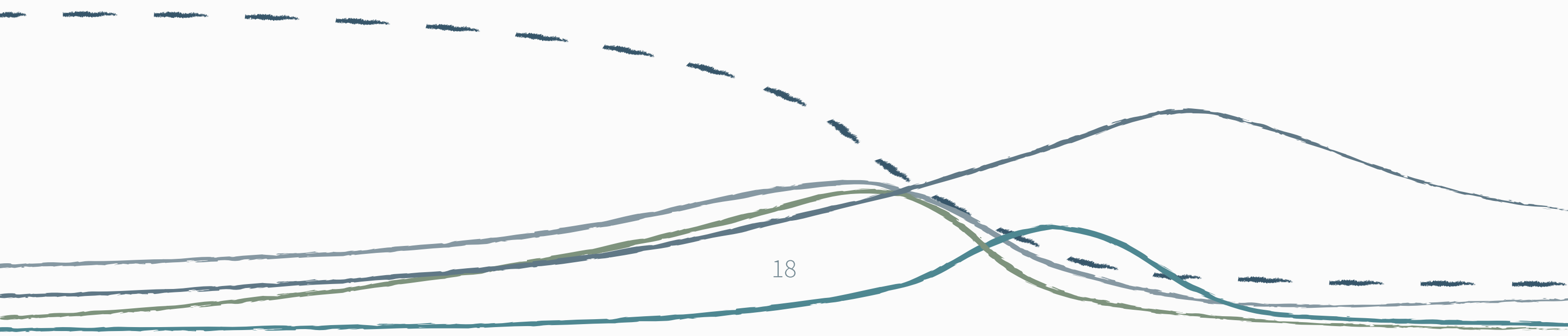
Visions for prosperity which provide the capabilities for everyone to flourish, while society as a whole remains within the safe operating space of the planet, are clearly at a premium here. A number of such visions already exist. Developing and operationalising them is vital.

In summary, it's possible to distil a number of key issues which could usefully inform political debate and provide the foundations for an ongoing work programme on the limits to growth. These certainly include the following:

- the economic implications of declining resource quality;
- the financial market implications of low-carbon investment strategies;
- the political implications of the need for precautionary, long-term thinking;
- the social implications of inequality in the distribution of available resources;
- the macroeconomic implications of secular stagnation or degrowth.

Perhaps the most important priority of all is to ensure that the *Limits* debate doesn't become mired in ideological conflict or side-lined by political intractability. The consequences for society as a whole are too important.

A vital element in that process must be the ability to open out political space for a balanced and informed conversation both about limits and about the possibilities for change. One of the key aims of the APPG on Limits to Growth is to provide that opportunity.



NOTES

1 Boulding made this comment at a hearing of the US Congress in 1973. See US Congress 1973.
2 'Remarks at Convocation Ceremonies at University of South Carolina, September 20th 1983. Online at: http://www.reagan.utexas.edu/archives/speeches/1983/92083c.htm
3 Club of Rome website http://www.clubofrome.org/?p=324.
4 Meadows et al. 1972
5 Radzicki and Taylor 2008
6 Meadows et al. 1972
7 It's notable that even within these four 'stabilized' scenarios, resources are still being depleted over time. But the MIT team maintain that this process is slow enough that technology and society can adapt to it, preventing collapse in the long run (Meadows et al 1972, p166).
8 Meadows et al. 2004
9 Hubbert 1962
10 Hall et al 2014
11 Sverdrup et al. 2012
12 Club of Rome website. http://www.clubofrome.org/?p=326; Parenti 2012
13 Passell et al. 1972
14 Cole et al 1973; Norgard et al. 2010
15 Lomborg and Olivier 2009.
16 Sabin 2013.
17 Bardi 2011
18 Simmons 2000
19 Meadows et al. 2004.; Turner 2008; Turner 2014. See also Pasqualino et al 2015.
20 Hall and Day 2009
21 Meadows et al. 2004
22 Turner 2014
23 Sverdrup et al. 2012; Sverdrup and Ragnarsdottir 2014; Ragnarsdottir and Sverdrup 2015.
24 Ragnarsdottir and Sverdrup 2015
25 Bardi 2014
26 See for example Stiglitz 2008
27 Neumayer 2000
28 World Economic Forum 2014
29 Hubbert 1962
30 See for example IEA 2008 World Energy Outlook 2008.
31 See for example Miller and Sorrell 2013
32 Alberta Energy website. http://www.energy.alberta.ca/oilsands/791.asp. Accessed March 2016. Greenpeace International website. http://www.greenpeace.org/international/en/campaigns/climate-change/stop-the-tar-sands, Accessed April 2016.
33 Energy Information Administration. Overview: Brazil. https://www.eia.gov/beta/international/analysis_includes/countries_long/Brazil/brazil.pdf
34 Wile 2013; Viner 2013; Maugeri 2012
35 IEA 2016.
36 IEA 2016
37 Turner 2014
38 See eg: http://oilprice.com/commodity-price-charts?1&page=chart&sym=CB*1&name=Brent%20Crude
39 Sinn 2008.
40 Arthur 2015; The Economist 2014. The same is true of course for some renewable energy technologies.
41 IEA 2015; World Energy Outlook 2015.
42 IEA 2015. It's interesting to note that oil prices were rising again between January and April 2016. It's also possible that a small drop in oil production could trigger a large decrease in global output, perhaps as high as 2% each year, in effect wiping out more than half of global GDP growth. (Kumhof and Muir 2012).
43 Mohr et al. 2015
44 Rockström et al. 2009
45 Steffen et al. 2015
46 IPCC 2014
47 NASA. 2015. NASA scientists react to 400ppm milestone. http://climate.nasa.gov/400ppmquotes; NOAA. 2015. Greenhouse benchmark reached. http://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/11153/Greenhouse-gas-benchmark-reached-.aspx
48 Zeebe et al. 2016
49 Met Office. 2016. 2015: the warmest year on record, say scientists. http://www.metoffice.gov.uk/news/releases/archive/2016/2015-global-temperature
50 Rockstrom et al. 2009.
51 Hansen et al. 2008
52 UNFCCC. 2015. Adoption of the Paris Agreement. https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf
53 IPCC 2014; Schaeffer et al 2015. Net negative emissions means essentially that economic activity is taking carbon out of the atmosphere rather than adding carbon to it.
54 Raw data for the graph are collated from IPCC 2014. The original graphic was produced by Carbon Brief and is available at: http://www.carbonbrief.org/six-years-worth-of-current-emissions-would-blow-the-carbon-budget-for-1-5-degrees. Net zero emissions means that carbon emissions from energy technologies could be greater than zero only to the extent that these were offset by 'negative emission technologies'.
55 Wilson 1988
56 WWF 2014
57 Steffen et al. 2015.
58 See for example Lewis, S., and Maslin, M. 2015. Defining the Anthropocene. Nature. 171-180.
59 Monastersky 2015
60 OECD 2011
61 Wales 2015; IEA 2016.

62 Bloomberg New Energy Finance 2015; Climatescope 2015.
63 IEA 2016.
64 For a very recent take on eco-modernism see for instance Breakthrough 2015. The concept of ecological modernisation has been around since at least the late 1980s. See for instance Simonis 1989.
65 NCE 2014; Krugman 2014; Füchs 2015.
66 Harford 2014.
67 See for instance EuroCase 2013; see also initiatives such as Industrie 4.0. Online at: http://www.2b1stconsulting.com/future-of-manufacturing.
68 For a fuller discussion of this point see Jackson 2009/2016, Chapters 4 and5.
69 See Sorrell 2010; Chitnis et al 2014.
70 Wiedmann et al 2015; UNEP 2015. Note however that a recent UK study does show a decline in absolute material use in the UK since 2001 (ONS 2016).
71 Jackson 2016, Chapter 5, Figure 12
72 Jackson 2016, Chapter 1.
73 Jackson 2016, Chapter 5, Figure 15.
74 Daly 1977
75 Mill 1848
76 Encyclical letter (Laudato Si') online at: http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html
77 D'Alisa et al 2014, Demaria et al 2014, Fournier 2013, Kallis 2015.
78 Bardi 2014, p232-233; Coke 2014.
79 For a discussion of these challenges see Jackson 2016, Jackson et al 2016.
80 Wijkman 2015.
81 Jackson 2016; Jørgensen et al 2015; Raworth 2012; Skidelsky and Skidelsky 2012, Victor 2008.
82 Weldon 2015. Secular stagnation refers to a permanent (non-cyclical) decline in economic growth.
83 Hansen 1939.
84 Summers 2013.
85 Summers 2014.
86 Summers 2015.
87 Weldon 2015.
88 Summers Balls 2015.
89 Eggertson and Merhrotra 2014.
90 Bernanke 2015a.
91 Gordon 2012; see also Gordon 2016.
92 Gordon op cit, Figure 2, p6.
93 The analysis in Figure 3 was carried out by the authors for this study based on raw data from the Bank of England (Hills et al 2015). The trend line was estimated using the Hodrick-Prescott (HP) filter (https://en.wikipedia.org/wiki/Hodrick%E2%80%93Prescott_filter) with the multiplier λ set to 100.
94 Bernanke 2015b.
95 Allen 2015.
96 McKibben 2007, p18.
97 Bardi 2014, p170.
98 See for example Institute and Faculty of Actuaries 2013.
99 Wijkman 2015.
100 Hirsch 1977.
101 Inglehart et al 2008; Jackson 2009/2016; Skidelsky and Skidelsky 2012; Layard 2005; Read 2012; Blewitt and Cunningham 2015.

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LIMITS REVISITED

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by Tim Jackson and Robin Webster

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