Dinàmica Macroeconòmica 2019-2020

"Those who believe that economic growth can go on forever are either mentally deranged or they are economists." **Kenneth Boulding (quoted in Wijkman and Rockström, 2012)**

1. The Ehrlich equation (Paul R. Ehrlich)

"The Ehrlich equation states that environmental [impact] (I) is a product of population (P) times affluence or income level (A) times the technological intensity (T) of economic output.

$I = P \times A \times T$

For carbon dioxide emissions from fuel combustion, for example, the total emissions are given by the product of population (P) times income (measured as dollars of GDP/person) times the carbon intensity of economic activity (measured as $gCO_2/\$$)

$C = P \times \$/person \times gCO_2/\$$

Using this arithmetic for the year 2007, when the global population was about 6.6 billion, the average income level in constant 2000 dollars (at market prices) was $5900, and the carbon intensity was 760gCO2/$, we find that the total carbon dioxide emissions C were:

$6.6 \times 5.9 \times 0.77 = 30$ billion tonnes of CO_2.

In 1990, when the population was only 5.3 billion and the average income was $4700 but carbon intensity was $860gCO_2/\$$, total carbon dioxide emissions C were given by:

$5.3 \times 4.7 \times 0.87 = 21.7$ billion tonnes of CO_2."

Jackson, Tim (2008): *Prosperity without growth. Economics for a finite planet*, Earthscan, London & Sterling, VA.

The PAT formula: I = PAT. The environmental impact I of a society equals the product of population P (demographic causes/factors), affluence A (capital accumulation) and technology T (A and T summarize the socioeconomic cause). The component A can be expressed as $\frac{K}{L} \cdot \frac{Y}{K}$, where K represents the capital stock, L population and Y aggregate production (GDP). The ratio $\frac{K}{L}$ is a mesure of the intensification of the economy (how much capital per person is available to produce) and the ratio $\frac{Y}{K}$ is the average productivity of the capital stock (how much production each unit of capital generates). The component T can be decomposed as $\frac{E}{Y} \cdot \frac{impact}{E}$, where E stands for "energy" (so E/Y is the amount of energy per unit of product) and $\frac{impact}{E}$ measures the environmental impact per unit of energy used in production.

2. Economic growth is not sustainable

"The legitimacy of the means to live well is part of the glue that keeps society together. Collective meaning is extinguished when hope is lost. Morality itself is threatened. Getting the mechanism right is vital. One of the key messages of this book is that we're failing in that task. Our technologies, our economy and our social aspirations are all mis-aligned with any meaningful expression of prosperity. The vision of social progress that drives us – based on the continual expansion of material wants – is fundamentally untenable. And this failing is not a simple falling short from utopian ideals. It is much more basic. In pursuit of the good life today, we are systematically eroding the basis for well-being tomorrow. We stand in real danger of losing any prospect of a shared and lasting prosperity."

"In a world of finite resources, constrained by strict environmental limits, still characterized by 'islands of prosperity' within 'oceans of poverty', are ever-increasing incomes for the already-rich really a legitimate focus for our continued hopes and expectations? Or is there perhaps some other path towards a more sustainable, a more equitable form of prosperity?"

"Rising prosperity isn't self-evidently the same thing as economic growth. More isn't necessarily better. Until quite recently, prosperity was not cast specifically in terms of money at all; it was simply the opposite of adversity or affliction. The concept of economic prosperity – and the elision of rising prosperity with economic growth – is a modern construction. And it's a construction that has already come under considerable criticism. Amongst the charges against it is that growth has delivered its benefits, at best, unequally. A fifth of the world's population earns just 2 per cent of global income. The richest 20 per cent by contrast earn 74 per cent of the world's income (...) How – and for how long – is continued growth possible without coming up against the ecological limits of a finite planet?"

"The idea of a non-growing economy may be an anathema to an economist. But the idea of a continually growing economy is an anathema to an ecologist. No subsystem of a finite system can grow indefinitely, in physical terms. Economists have to be able to answer the question of how a continually growing economic system can fit within a finite ecological system (...) The uncomfortable reality is that we find ourselves faced with the imminent end of the era of cheap oil, the prospect of steadily rising commodity prices, the degradation of air, water and soil, conflicts over land use, resource use, water use, forestry and fishing rights, and the momentous challenge of stabilizing the global climate. And we face these tasks with an economy that is fundamentally broken, in desperate need of renewal. In these circumstances, a return to business as usual is not an option. Prosperity for the few founded on ecological destruction and persistent social injustice is no foundation for a civilized society."

"The economic crisis is not a consequence of isolated malpractice in selected parts of the banking sector. If there has been irresponsibility, it has been much more systematic, sanctioned from the top, and with one clear aim in mind: the continuation and protection of economic growth."

"... three closely related propositions in defence of economic growth. The first is that opulence – though not synonymous with prosperity – is a necessary condition for flourishing. The second is that economic growth is closely correlated with certain basic entitlements – for health or education, perhaps – that are essential to prosperity. The third is that growth is functional in maintaining economic and social stability."

Jackson, Tim (2008): *Prosperity without growth. Economics for a finite planet*, Earthscan, London & Sterling, VA.

3. The dilemma of growth

"Put in its simplest form the 'dilemma of growth' can now be stated in terms of two propositions:

• Growth is unsustainable – at least in its current form. Burgeoning resource consumption and rising environmental costs are compounding profound disparities in social well-being.

• 'De-growth' is unstable – at least under present conditions. Declining consumer demand leads to rising unemployment, falling competitiveness and a spiral of recession."

"The conventional response to the dilemma of growth is to appeal to the concept of 'decoupling'. Production processes are reconfigured. Goods and services are redesigned. Economic output becomes progressively less dependent on material throughput. In this way, it is hoped, the economy can continue to grow without breaching ecological limits – or running out of resources."

4. The myth of endless growth

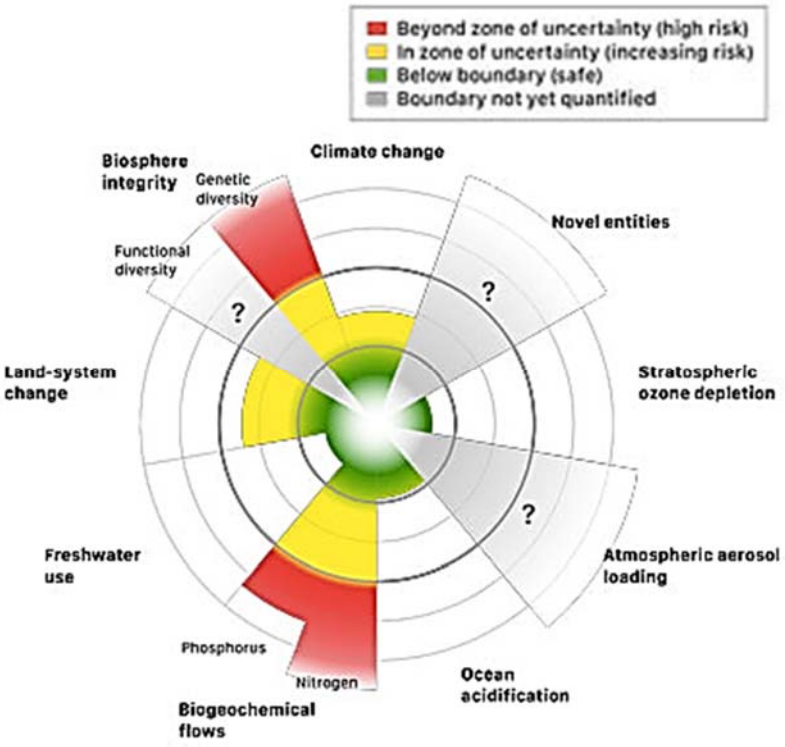
"... the conventional view (...) sees societal development and the environment as isolated (...) The economists' models, for example, focus foremost on the relationship between producers and consumers. Access to energy and raw materials –not to mention ecosystem functions– have more or less been taken for granted. We want to communicate that humanity is facing a critical reality. An abundance of scientific reports clearly point out that we are very close to a saturation point, where the biosphere cannot handle additional stress."

"Our society has long been built on the myth of endless growth. Nature's cupboard is perceived as infinitely large. Nature is also accorded an almost infinite capacity to take care of various wastes and

pollutants and render them harmless (...) Humanity is living far beyond its means. No previous generation has borrowed so freely from the future."

Wijkman, Anders; Johan Rockström (2012): *Bankrupting nature. Denying our planetary boundaries*, Routledge, London and New York.

5. The nine planetary boundaries



The green shaded polygon represents the safe operating space

• Stratospheric ozone depletion

"The stratospheric ozone layer in the atmosphere filters out ultraviolet (UV) radiation from the sun. If this layer decreases, increasing amounts of UV radiation will reach ground level. This can cause a higher incidence of skin cancer in humans as well as damage to terrestrial and marine biological systems."

• Loss of biosphere integrity (biodiversity loss and extinctions)

• Chemical pollution and the release of novel entities

"Emissions of toxic and long-lived substances such as synthetic organic pollutants, heavy metal compounds and radioactive materials represent some of the key human-driven changes to the planetary environment. These compounds can have potentially irreversible effects on living organisms and on the physical environment."

• Climate change

"Recent evidence suggests that the Earth, now passing 390 ppmv CO2 in the atmosphere, has already transgressed the planetary boundary and is approaching several Earth system thresholds. We have reached a point at which the loss of summer polar sea-ice is almost certainly irreversible (...) A major question is how long we can remain over this boundary before large, irreversible changes become unavoidable."

• Ocean acidification

"Around a quarter of the CO2 that humanity emits into the atmosphere is ultimately dissolved in the oceans. Here it forms carbonic acid, altering ocean chemistry and decreasing the pH of the surface water. This increased acidity reduces the amount of available carbonate ions, an essential 'building block' used by many marine species for shell and skeleton formation. Beyond a threshold concentration, this rising acidity makes it hard for organisms such as corals and some shellfish and plankton species to grow and survive. Losses of these species would change the structure and dynamics of ocean ecosystems and could potentially lead to drastic reductions in fish stocks. Compared to pre-industrial times, surface ocean acidity has already increased by 30 percent."

• Freshwater consumption and the global hydrological cycle

"Water is becoming increasingly scarce -by 2050 about half a billion people are likely to be subject to water-stress, increasing the pressure to intervene in water systems."

• Land system change

"Land is converted to human use all over the planet. Forests, grasslands, wetlands and other vegetation types have primarily been converted to agricultural land. This land-use change is one driving force behind the serious reductions in biodiversity, and it has impacts on water flows and on the biogeochemical cycling of carbon, nitrogen and phosphorus and other important elements."

• Nitrogen and phosphorus flows to the biosphere and oceans

"The biogeochemical cycles of nitrogen and phosphorus have been radically changed by humans as a result of many industrial and agricultural processes. Nitrogen and phosphorus are both essential elements for plant growth, so fertilizer production and application is the main concern. Human activities now convert more atmospheric nitrogen into reactive forms than all of the Earth's terrestrial processes combined. Much of this new reactive nitrogen is emitted to the atmosphere in various forms rather than taken up by crops. When it is rained out, it pollutes waterways and coastal zones or accumulates in the terrestrial biosphere. Similarly, a relatively small proportion of phosphorus fertilizers applied to food production systems is taken up by plants; much of the phosphorus mobilized by humans also ends up in aquatic systems. These can become oxygen-starved as bacteria consume the blooms of algae that grow in response to the high nutrient supply. A significant fraction of the applied nitrogen and phosphorus makes its way to the sea, and can push marine and aquatic systems across ecological thresholds of their own."

• Atmospheric aerosol loading

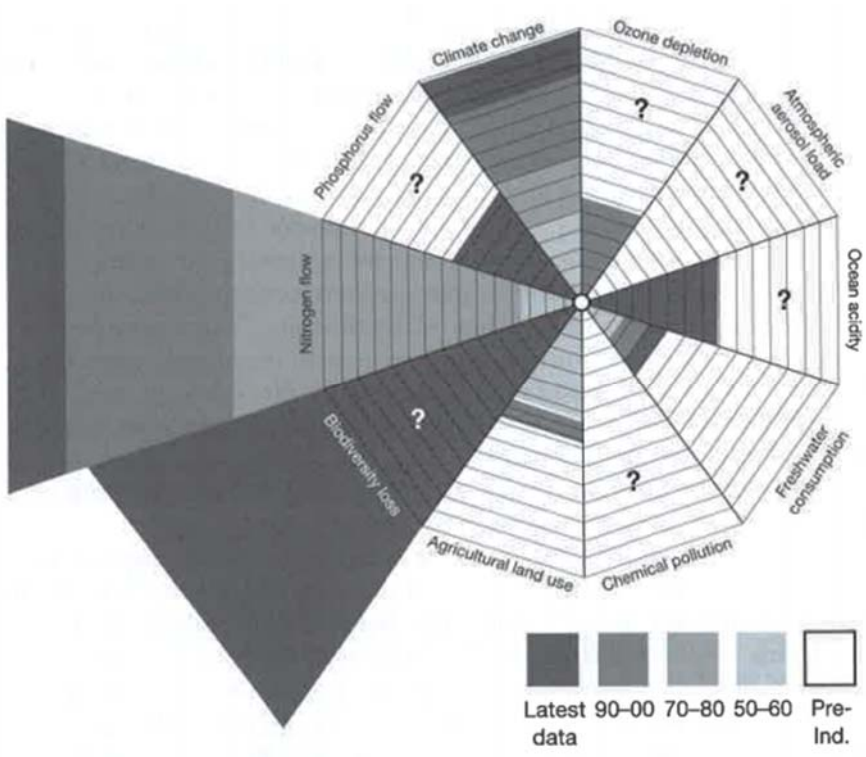
"Through their interaction with water vapour, aerosols play a critically important role in the hydrological cycle affecting cloud formation and global-scale and regional patterns of atmospheric circulation, such as the monsoon systems in tropical regions. They also have a direct effect on climate, by changing how much solar radiation is reflected or absorbed in the atmosphere. Humans change the aerosol loading by emitting atmospheric pollution (many pollutant gases condense into droplets and particles), and also through land-use change that increases the release of dust and smoke into the air (...) A further reason for an aerosol boundary is that aerosols have adverse effects on many living organisms. Inhaling highly polluted air causes roughly 800,000 people to die prematurely each year."

https://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html

Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship

Stockholm University

"The concept of 'planetary boundaries' is quite simple. The task was, on the one hand, to define the biophysical processes that are crucial for a stable development on Earth, and, on the other hand, to determine the risk of threshold effects relative to these processes and identify the key drivers that could lead to them. Based on such an analysis, it was reasoned that it should be possible to define a safe environmental space ('safe operating space') for human development on Earth."



"Economic development today is managed as if we are on a straight highway into the future. To use a

metaphor, humanity is rushing ahead on this highway like a vehicle with an oversized engine and the headlights turned off and there are no guardrails. By defining the boundaries for human development on the planet, the aim is to turn on the car's headlights (to be able to assess the risks) and to equip the road to the furure with guardrails. Such guardrails should be designed to minimize the risk of undesirable changes in the conditions for human development in the future."

"The planetary boundaries differ in character. Three of them are truly global in nature: maintaining climate stability, protecting against stratospheric ozone depletion, and the prevention of acidification of the oceans. In addition to these three boundaries, (...) four critical biophysical processes/systems, also with global dimensions, that regulate the function of biological systems and will thus determine Earth's resilience to future shocks and possible threshold effects. These are the nutrient cycles of nitrogen and phosphorus, the loss of biodiversity, the degradation of land resources and the over-exploitation of freshwater resources. (...) The two remaining areas of concern (...) the concentration of pollution from toxic chemicals and aerosol concentration."

Wijkman, Anders; Johan Rockström (2012): *Bankrupting nature. Denying our planetary boundaries*, Routledge, London and New York.

6. 'Theories from the 1700s control today's economy'

"To feed the Earth's increasing population is almost certainly the biggest challenge we face as a consequence of climate change. The paradox is that agriculture is the sector of the economy that contributes most to climate change: around a third of greenhouse gas emissions originate from agriculture and are therefore directly related to what we eat. At the same time agriculture is the first sector to be hit by climate change."

"In modern times we have already experienced a green revolution, which brought about a doubling in the production of staple cereals such as rice, corn and wheat. It occurred in Asia in the 1960s, the result of a new, modern 'farming package' with refined hybrid seeds, commercial fertilisers, diesel pumps for irrigation, and pesticides (...) A general lesson from systems research in ecology and agriculture is that biological diversify provides resilience and strength, while monocultures increase vulnerability."

"The present economic model is based on assumptions that go back to the infancy of industrialization. The theory is based on the writings of the British philosopher and economist Adam Smith (...) World population during Smith's lifetime was less than one billion. The world's total GDP was barely $200 billion. Under these circumstances it was perfectly reasonable to consider nature and its resources as infinitely large (...) We are facing a different reality. The population is seven times greater and is expected to increase by at least two billion people by 2050."

"The total amount of resources is essentially a given. Measured in biophysical terms, the planet is actually 'shrinking' as fish-stocks in the oceans are depleted, tropical forests disappear, farmland erodes, groundwater levels decline and biodiversity is becoming extinct. The only resource that continuously gives us more is the sun, which warms the Earth and which, in combination with photosynthesis, can stimulate the growth of the renewable resource base (...) The rapid erosion of the resource base seems to have escaped the attention of most economists (...) The tension between natural scientists and economists is not new."

7. Weaknesses in the economic model

"The current economic model is in need of re-evaluation. The current system has at least six key weaknesses:

• It is untenable from the standpoint of climate, environment and resources. While true market failures can be handled within the current framework, it does not at present give a fair valuation of natural capital. The same applies to phenomena such as the threshold effecs of non-linear systems. According to IUCN, we have already lost 75 per cent of genetic diversity in agriculture. At the same time it is estimated that up to 70 per cent of plants and animals face extinction.

• It is untenable from the standpoint of fairness. Income gaps are increasing rapidly, within countries and befween countries. In the US, 80 per cent of the increase in wealth between 1980 and 2005 went to the percentage of citizens with the highest incomes, leading to frequent claims that 'the middle class is disappearing'. Ariana Huffington's latest book, Third World America, is subtitled 'How our politicians are abandoning the middle class and betraying the American dream'. Even more tenuous is the situation for the citizen at the very bottom of the income ladder.

• It is unstable. The crisis in the financial system demonstrates this. Financial bubbles are a serious problem, with ordinary taxpayers being the real losers. The financial market is also less able to pursue is primary objective, which is to offer credit for long-term and sustainable investment.

• It is not capable of creating the necessary jobs. Especially serious are unemployment figures among young people. The present economic system is not able to provide jobs and decent living standards for a growing share of world citizens.

• It underperforms in the provision of public goods.

• It does not increase wellbeing. A large body of studies from a number of developed countries shows that once a certain material standard is achieved, the degree of wellbeing does not automatically increase with increased growth."

Wijkman, Anders; Johan Rockström (2012): *Bankrupting nature. Denying our planetary boundaries*, Routledge, London and New York.

8. The need to develop an ecological macroeconomics

"An economy predicated on the perpetual expansion of debt-driven materialistic consumption is unsustainable ecologically, problematic socially and unstable economically (…) Changing this requires the development of a new macroeconomics for sustainability (…): an economic engine that doesn't rely for its stability on relentless consumption growth and expanding material throughput. Building that new framework is an urgent priority. Policy can contribute to that task in several ways. A key step is to develop the technical capacity for what we might call an ecological macro-economics. Essentially this would mean being able to understand the behaviour of economies when they are subject to strict emission and resource use limits. And to explore how economies might work under different configurations of consumption, investment, labour employment and productivity growth."

Jackson, Tim (2008): *Prosperity without growth. Economics for a finite planet*, Earthscan, London & Sterling, VA.

9. Four ideas that will not change the world (Steinberg, 2015, pp. 215-219)

- **Misperception 1: technological breakthroughs and scientific advances happen by themselves.** Discoveries are not self-propelled: they occur in a social context. Political decisions are a fundamental force in scientific and technological discoveries and innovations.

- **Misperception 2: a society growing richer automatically improves its environmental conditions.** The environmental Kuznets curve (EKC, the conjecture that economic growth initially harms the environment and afterwards improves it) does not hold for all pollutants. Urban waste treatment seems to be consistent with the EKC, but carbon dioxide emissions or biodiversity loss do not. Even when EKC holds, it may be just a spurious correlation: some factor simultaneously contributes to economic growth and environmental quality.

- **Misperception 3: a good strategy to solve environmental problems is to let markets operate freely (without environmental regulations).** Markets will not save the planet. Environmental quality and sustainability are both public goods and unregulated markets are inadequate institutions to provide public goods (private agents underinvest in such goods).

- **Misperception 4: individual decisions and local, isolated initiatives are sufficient to solve global problems.** Working in isolation (like recycling alone) is not powerful enough to address the bigger issues. It is only through active engagement in politics that major improvements in environmental quality will be achieved. This misperception is an instance of the fallacy of composition: what is true or works at some scale, is also true or works at a larger scale. Big environmental problems require an adequate match: to think big and change rules. Installing solar panels at home is a move in the right direction but environmental legislation has the scope for inducing real change.

Steinberg, Paul F. (2015): *Who rules the Earth? How social rules shape our planet and our lives*, Oxford University Press, Oxford.

10. Limits to growth (Meadows et al., 2005)

- **Increasing cost of sustaining growth.** An expanding population combined with an increasing accumulation of physical capital requires more resources to be diverted to cope with global ecological constraints (depletable natural resources and limited absorption capacity of emissions). This will eventually restrain the capacity of expanding production and the sustainability of economic growth.

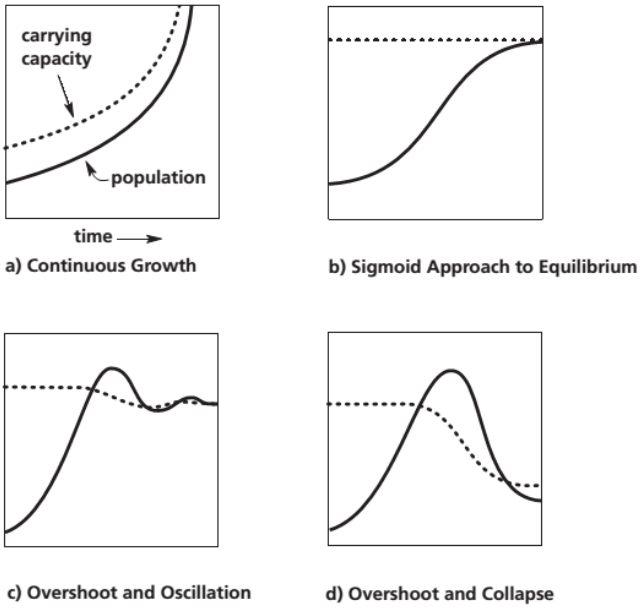
- **Scenarios.** The inability to continuosuly sustain an expansion of production will cause a population contraction. (1) The end of growth take the form of a collapse (rapid decline in output, population, health and an increase in conflict, inequality, ecological devastation following a growth overshoot). (2) It may take the form of a smooth adaptation to the Earth's support capacity (through some corrective action).

- **The big question.** Has humanity already overshot the Earth's carrying capacity (surpassed the global ecological constraints?).

- **Evidence of soft landing or apparent success in attaining sustainable growth?** During the last decades: new technologies to lower pollution have been developed, consumers have adapted habits, international agreements have been signed, new institutions have emerged, higher income levels have reduced population growth, more widespread awareness of environmental problems… humanity already overshot the Earth's carrying capacity.

- **The global challenge.** A sustainable world economy demands that the poorer countries reach higher consumption levels. This transition will have to be accompanied with technological, social and political changes consistent with long run goals. Those changes will need decades, but meanwhile the ecological footprints of humanity becomes bigger.

- **Three outlooks.** (1) Optimism: with adequate information, people will choose the right solution (global solutions to avert overshoot or, at least, collapse). (2) Cynicism: people will not stop responding to just short term goals and will not sacrifice current welfare levels to benefit future generations (reality will be ignored). (3) Middle road: lessons will be learned the hard way (a sustainable path will be reached, and collapse averted, only after having suffered global crises resulting from inaction or insufficient responses, but at the price of exhausting resources, losing attractive options, suffering more inequality and tolerating more conflict).



Meadows, Donella; Jorgen Randers; Dennis Meadows (2005): *Limits to growth: The 30-year update*, Earthscan, London.

11. Dynamics of World3 (Meadows et al., 2005, ch. 4)

- **World3.** World3 is a model of the world economy by Meadows et al. (2005) "to understand the broad sweep of the future": the ways in which the world economy will interact with the Earth's carrying capacity over many decades.

- **Ways to approach the carrying capacity.** Continuous growth, convergence to the carrying capacity from below, overshoot with cyclical convergence and overshoot followed with collapse (see the charts on p. 7). The authors believe that the world economy is already above the Earth's carrying capacity (overshoot).

- **Feedback loops.** Figs. 1 and 2 below show the feedback relationships regulation population growth and capital accumulation. Fig. 1 displays the connection between population and capital that goes through agriculture; Fig. 2, the one that goes through resources and services.

- **Scenario 1.** In Scenario 1 (see Fig. 3) the computer model World3 is run with parameter values that represent the continuation of the path the world economy followed during the 20th century. Population and production increase until the resource limit is reached. The impossibility of maintaining resource flows lead to a fall in output and life expectancy and a rise in death rates.

- **Scenario 6.** In Scenario 2 (see Fig. 4) the economy develops simultaneously (costly) technologies for pollution abatement, land yield enhancement, land protection, and conservation of nonrenewable resources. Full implementation of these technologies takes two decades but in the end the economy is relatively large and prosperous (though below the top level ever reached).

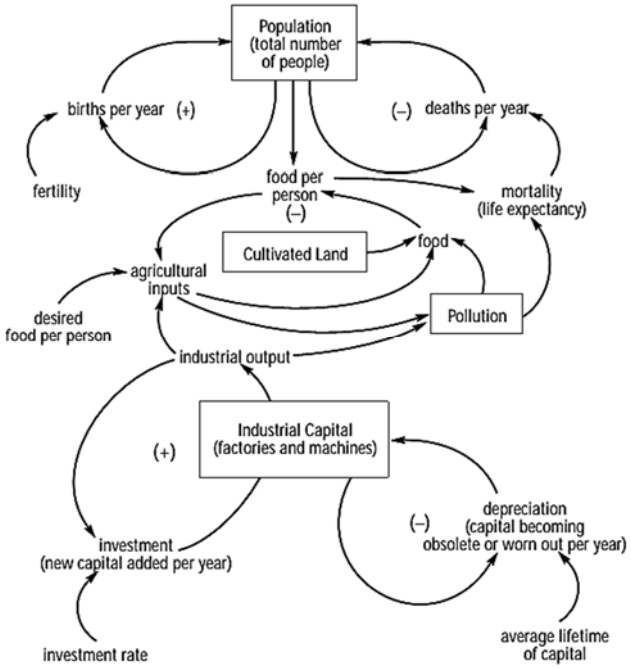


Fig. 1. Feedback Loops of Population, Capital, Agriculture, and Pollution (Meadows et al., 2005, p.144)

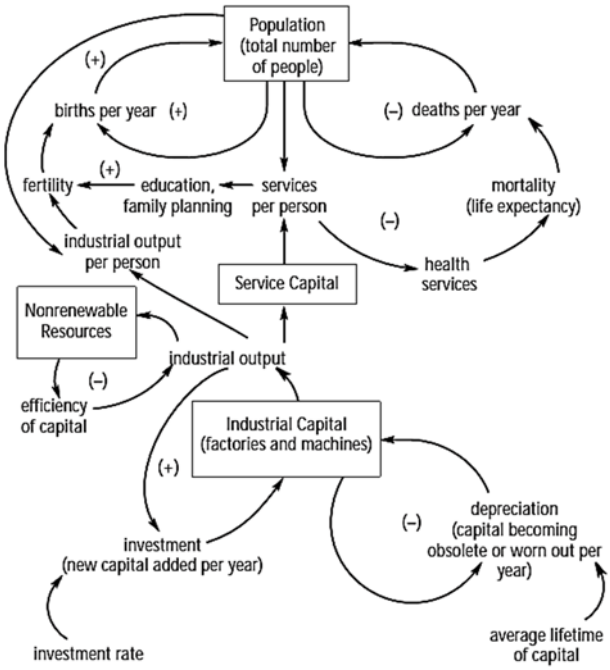
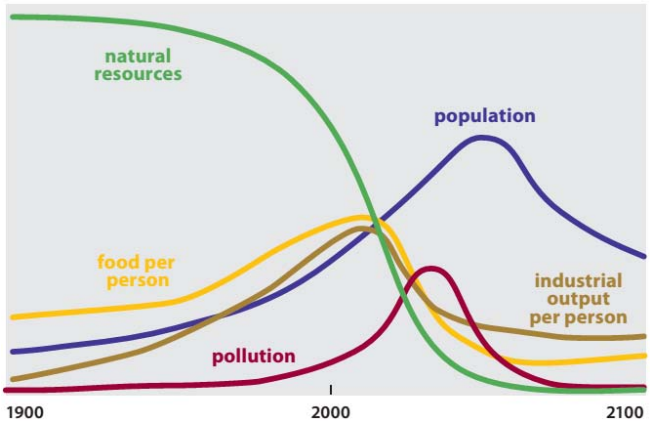


Fig. 2. Feedback Loops of Population, Capital, Services, and Resources (Meadows et al., 2005, p.145)

12. Empty vs full world

The world is facing a perfect storm of problems: overpopulation, overconsumption, environmentally malign technologies, inequalities. All of them seem sustained by the irrational belief that permanent growth is possible in a phusically finite economy. They are also the expression of the conflict between what economists believe and what physicists know. The dominant economic views and theories were created in an "empty



world": one in which population was small, natural resources did not represent a limit and the environment had enough capacity to absorb wastes. Economies in an empty world do not face planetary boundaries. If a "full world" damages to the environment and wastes play a dominant role. On the right a projection of the world economy under a business-as-usual assumption: the logic of an empty world is applied to a full world.

Horgan, John (2015): *The end of science: Facing the limits of knowledge in the twilight of the scientific age*, Basic Books, New York.

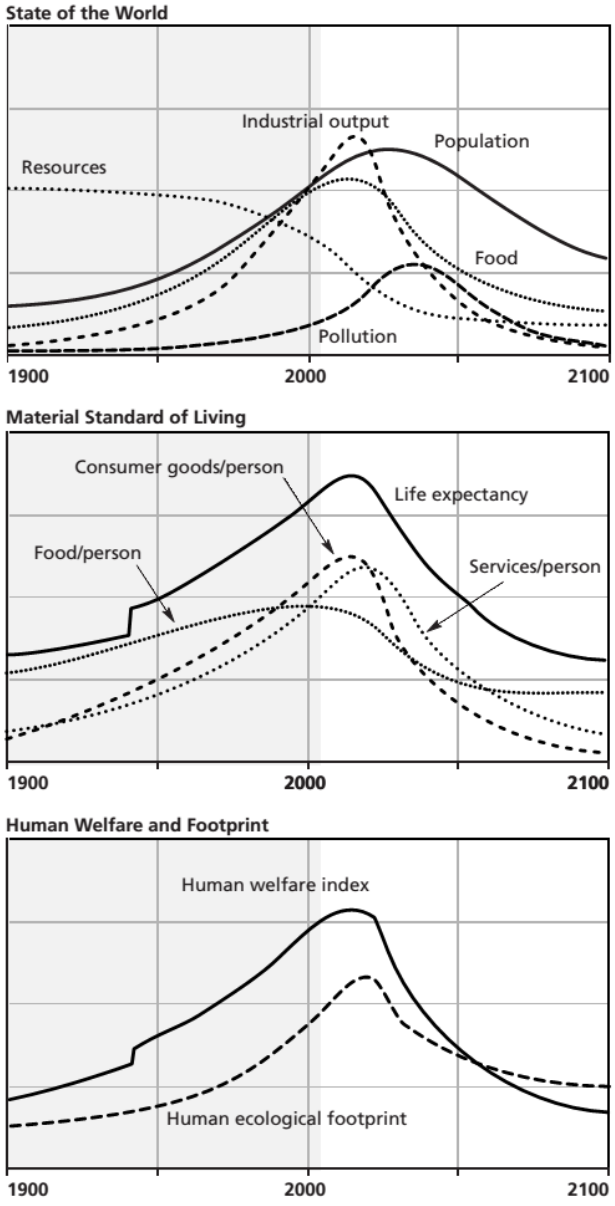


Fig. 3. Scenario 1 of World3 (Meadows et al., 2005, p.169)

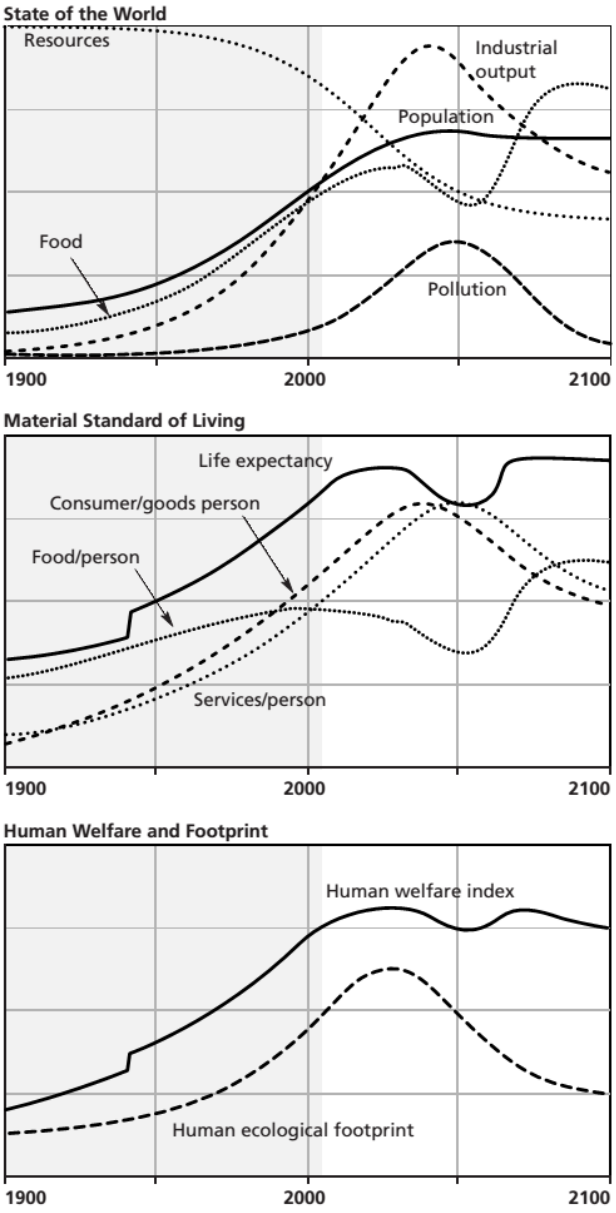


Fig. 4. Scenario 6 of World3 (Meadows et al., 2005, p.219)

13. People is the ultimate resource (Simon, 1996)

- **More people, good.** "Adding more people to any community causes problems, but people are also the means to solve these problems. The main fuel to speed the world's progress is our stock of knowledge, and the brake is our lack of imagination. The ultimate resource is people —skilled, spirited, hopeful people— who will exert their wills and imaginations for their own benefit as well as in a spirit of faith and social concern. Inevitably they will benefit not only themselves but the poor and the rest of us as well." Having more people creates more problems but people are the means to solve them.

- **Natural resources.** "…our supplies of natural resources are not finite in any economic sense. Nor does past experience give reason to expect natural resources to become more scarce. Rather, if history is any guide,

natural resources will progressively become less costly, hence less scarce, and will constitute a smaller proportion of our expenses in future years." The same conclusion is said to apply to energy: more people will speed the development of cheap energy supplies.

- **Doomsters.** "The doomsters reply that because there are more of us, we are eroding the basis of existence, and rendering more likely a 'crash' due to population 'overshoot'; that is, they say that our present or greater numbers are not sustainable. But the signs of incipient catastrophe are absent. Length of life and health are increasing, supplies of food and other natural resources are becoming ever more abundant, and pollutants in our environment are decreasing."

- **The world's problem.** "The world's problem is not too many people, but lack of political and economic freedom. Powerful evidence comes from pairs of countries that had the same culture and history and much the same standard of living when they split apan after World War II —East and West Germany, North and South Korea, Taiwan and China."

- **Simon's view: there are no limits.** "In the short run, all resources are limited. An example of such a finite resource is the amount of attention that you will devote to what I write. The longer run, however, is a different story. The standard of living has risen along with the size of the world's population since the beginning of recorded time. There is no convincing economic reason why these trends toward a better life should not continue indefinitely."

- **The economic dynamics that has worked in the past projected in the future *ad infinitum* (what has happened is not a fortuitous chain of circumstances).** "Greater consumption due to an increase in population and growth of income heightens scarcity and induces price run-ups. A higher price represents an opportunity that leads inventors and business people to seek new ways to satisfy the shortages. Some fail, at cost to themselves. A few succeed, and the final result is that we end up better off than if the original shortage problems had never arisen. (...) The most important benefit of population size and growth is the increase it brings to the stock of useful knowledge. (...) Progress is limited largely by the availability of trained workers. In the long run the basic forces influencing the state of humanity and its progress are (a) the number of people who are alive to consume, but also to produce goods and knowledge; and (b) the level of wealth. Those are the great variables which control the advance of civilization."

- **What is new.** What differentiates our age from previous ages is the fall in mortality and the rise of life expectation. What is common is the desire for improvement, the continuous search for betterment. To achieve this, complacency must be avoided: improvement needs effort.

Simon, Julian Lincoln (1996): *The ultimate resource 2*, Princeton University Press, Princeton, NJ.

14. The technological bluff (Ellul, 1990)

- **Opposition between people and machines.** People adapt badly to modern techniques: people do not adapt to machines nor machines to people. There is a permanent maladaptation between the social and the technical world. Societies evolve slowly; techniques and machines evolve quickly. Societies rely on the past (habits, traditions, rules, conventions); technologies look at the future.

- **The great technical innovation.** The eventual integration of the social into the technical world, from which a new humanity will emerge.

- **Technolatry.** Ellul views Simon's overoptimistic claims as pseudoscientific absurdities: Simon just projects tendencies (without justifying on which grounds the projection is legitimate) and simply presumes that every discovery/invention will have beneficial effects (masquerading inconvenient phenomena for his theses, like the simultaneity of rural depopulation and urban overpopulation). What is good in a computer virus?

- **Rise of the technocrats.** "The technocrats have a strange blindness to the complex reality of the world and to the lessons of common sense (e.g., that no system can grow indefinitely in a closed and finite universe, a truth that they treat sarcastically). Their great knowledge and narrow specialization prevent them from

understanding questions outside their field. Yet they write authoritatively about tomorrow's world (…) They are thus plunged into electronics and computers without a thought that perhaps in the future being able to till a bit of ground or light a wood fire or do proper grooming might be more useful than being able to tap on a keyboard. Such is their casual ignorance of most of what constitutes our world (…) They immediately retort that what opponents want is a return to the Middle Ages. As they see it, there has to be growth. They will not accept any other hypothesis. They find their justification in the fact that increasingly everything depends on the application of techniques. Not only is technique good, not only is it indispensable, but also (…) it alone can also achieve all that human beings have been seeking throughout the centuries: liberty, democracy, justice, happiness (by a high standard of living), reduction of work, etc. "

- **Technology is ambivalent.** Technique and technology are not neutral: they may have good and bad effects. For technological optimists, technology is globally good. Technology's ambivalence is captured by for theses:
  (1) all technical progress has its price (creation involves destruction, frequently people's lives: no progress is free from shadows);
  (2) at each stage it raises more and greater problems than it solves (law that problems grow with the growth of techniques);
  (3) its harmful effects are inseparable from its beneficial effects (cars generate congestion; more and cheaper food available, obesity): favourable effects tend to be apparent in the short-term (and be concrete and clearly identifiable), whereas the negative effects tend to become evident is the long run (and are perhaps diffuse and abstract);
  (4) apart from the desired and the foreseen, it has a great number of unforeseen effects (surgical interventions replace one infirmity by another; cultivation impoverishes the soil; unexpected harmful effects of DDT; accidents of new technologies).

- **Technology is essentially unpredictable.** Technical change is not teleological: it has no goal. There is no predetermined destination for technical change: it is errhatic. Therefore, it is unpredictable (and that makes social evolution also unpredictable).

- **The paradox of Harvey Brooks.** The costs and risk of a new technology are usually assumed by a small fraction of the population, while its advantages tend to be widespread.

Ellul, Jacques (1990): *The technological bluff*, W. B. Eerdmans Publishing

15. The Seneca effect

- **The Seneca effect.** "Increases are of sluggish growth, but the way to ruin is rapid." (*Nunc incrementa lente exeunt, festinatur in damnum*, Lucius Anneaus Seneca, Letters to Lucilius 91, 6.)

- **Taxonomy of collapses.** (1) **Black elephants** (Donald Rumsfeld's 'known unknowns'). You choose to ignore (or understimate the effects of) an elephant that you know is in the room (a pyramid scheme). (2) **Gray swans**. A specific occurrence of this kind of event cannot be predicted but its frequency can be determined (so precautions against it could be taken: earthquakes). (3) **Dragon Kings**. They are outliers of a distribution in terms of their large size (the size of Paris in comparison with the rest of French cities). Though their existence is conceivable on the basis of some trend, they are largely unpredictable and no precaution against them is in practice feasible. (4) **Black swans** (Donald Rumsfeld's 'unknown unknowns'). They lie outside the distribution: they are absolutely unpredictable (financial crashes, massive terrorist attacks) and are then capable of generating the biggest collapses.

- **Tiffany's fallacy.** Existence of resources cannot be equated to having them: to actually get known resources one must invest other resources to locate, reach, extract, process and transport them (in the 1961 movie *Breakfast at Tiffany's* the female leading character enjoyed having breakfast while looking at jewels on display behind a glass, which is not the same thing as possessing the jewels).

Bardi, Ugo (2017): *The Seneca effect: Why growth is slow but collapse is rapid*, Springer, Cham, Switzerland.

16. 'The paradox of our times', Held (2010, p. 4)

The paradox is that the current collective issues (or core sets of problems) increasingly trascend political borders but the tools to handle these issues are inadequate or insufficient (problems addressed in an ad hoc manner, lack of coordination among international institutions, not accountable global organizations). The paradox expresses a problem of global governance: global problems cannot be solved at the national level or by nations acting alone. Worse still, the gap between the need for global solutions and the inability of multilateral institutions to meet that need is growing.

Held, David (2010): *Cosmopolitanism: Ideals and realities*, Polity Press, Cambridge, UK.

17. Technological progress as a social struggle

The evolution of technology (which technologies become triumphant) cannot be explained on exclusively technical considerations. Technology can always follow alternative paths and it is social forces that select the path to follow: technologies are involved in a process of elimination of technological designs whose outcome is socially determined (by the struggle between social groups pursuing their interests).

Once a technological design wins out and is adopted as the standard, the technology maybe used for purposes different from the one motivating the technology. Initially, education and public programming dominated radio broadcasting; similarly, television was originally conceived for surveillance and education. When businesses gained control over the two technologies they transformed them into entertainment media.

Feenberg, Andrew; Norm Friesen (eds) (2012): *(Re)Inventing the Internet: Critical case studies*, Sense Publishers, Rotterdam.

18. How deterministic is the history of technology?

Heilbroner (1967) contends that technological development must proceed in a relatively fixed sequence: some developments must necessarily precede others. For instance, societies must pass through the hand-mill before making a transition to the steam-mill, which is necessary to moving to hydroelectric plants; or mastering electricity is necessary before mastering nuclear power.

Evidence for the deterministic view. (1) Examples of simultaneous inventions and discoveries. (2) Absence of technological leaps. Most technological advances seem to be incremental and evolutionary. (3) Predictability of technology. There are two constraints to technological capacity in a given time: the accumulated stock of available knowledge (which only expands gradually) and the level of technical expertise (the material competence). Both determine the ability of industries to produce the equipment corresponding to higher technological levels. That ability also depends on the size of the capital stock. Hence, within certain limits, at least the short- to mediium-run evolution of technology appears predictable.

Does technology create social orders? That is, does technology impose social and political traits on societies that adopts the technology? There are at least two elements of influence: the composition of labour force and the hierarchical organization of work.

Some questions on technology. What fuels technology? Itself? Is the recent explosive technological development a bubble? Is technology necessarily expansionary? Are there limits for technological expansion? Is technology potentially a *perpetuum mobile*? What are the essential resources for technological growth? Are these resources exhaustible? Can technology's strain of nature reach a limit point? Will technology be the new nature? Could a new nature be technologically built? Are the laws of nature subject to technological manipulation? Can laws of nature be technologically created or modified?

Heilbroner, Robert L. (1967): "Do machines make history?", Technology & Culture 8, 335-345.

Economic revolution by confluence of technologies. A confluence of technologies will lead to the next production revolution: digital technologies (3D printing, internet of things, advanced robotics), new materials (bio- or nano-based) and new processes (datadriven production, artificial intelligence, synthetic biology).

OECD (2017): *The next production revolution: Implications for governments and business*, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264271036-en

19. Is capitalism eventually self-destructive?

The industrial capitalist society has created a chasm between society and nature, when the former cannot subsist independently of the latter. By destroying nature, the capitalist society destroys itself. The expansionary trends of a global capitalist economy places burdens on the planet and endangers its regenerative capacity.

20. Anthropocene

Term coined by atmospheric chemist Paul Crutzen that refers to the geological epoch in which humanity is capable of causing short-term changes in the planet. Fronts on which the planet is being assaulted by human activities: climate, ocean acidification, stratospheric ozone depletion, the nitrogen and the phosphorus cycles, global freshwater use, land use, biodiversity loss, chemical pollution. The term captures the idea that biogeochemical cycles, the atmosphere, the ocean, and the earth system as a whole are no longer immune to the human economy. It is preceded by the Holocene (the period started 10k-12k years ago)

21. The global ecological rift

The global ecological rift represents the break in the relationship between the world economy and the planet arising from a continously expanding world economy. There are insurmountable physical boundaries to economic expansion beyond which the planet's ecological viability is compromised. Are there thresholds (tipping points) for those fronts from which no return is possible? Has any of those thresholds been already crossed?

22. Social vs natural scientists ('the two cultures')

Social scientists do not appear to have risen to the challenge: even if the global problem is acknowledged, no real attack has been proposed or deemed necessary. "Sustainable (green) capitalism" is claimed to provide the solution. The real objective seems to be preserving capitalism rather than preserving the planet. "Saving" the planet is a new opportunity to make profits. A new capitalism can coexist with the planet. It is natural scientists who appear to be more concerned about the burdens industrial capitalism imposes on the planet.

Social sciences and social order. J. D. Bernal: "the backwardness and emptiness of the social sciences are due to the overriding reason that in all class societies they are inevitably corrupt". The reason for the comparative underdevelopment of the social sciences is that they are circumscribed by and often subservient to the established order of power. Social sciences seem in practice more concerned with preserving the existing social order than facilitating (necesary or desirable) changes in the social order. In normal circumstances, the social sciences do not lead: they follow (stable social environment creates a conservative social science). When the social order is disrupted, social sciences have the best opportunity to advance and make relevant achievements.

Social sciences. Mainstream social science has developed a static and ahistorical (sometimes anti-historical) character and adopted reductionism, abstract empiricism, and anti-naturalism (divorce from the natural environment in which societies exists).

"Little or nothing in human society makes sense except in the light of history".

Foster, John Bellamy; Brett Clark; Richard York (2010): *The ecological rift: Capitalism's war on the earth*, Monthly Review Press, New York.

23. Herman Daly's impossibility theorem

"It is impossible for the world economy to grow its way out of poverty and environmental degradation. In other words, sustainable growth is impossible".

24. Western civilization = cancer for the Earth

"Our civilization thus operates in the same way as a cancerous cell that goes on destroying the organism off which it lives." (p. 3)

de Rivero, Oswaldo (2010): *The myth of development: Non-viable cconomies and the crisis of civilization*, Zed Books, London and New York.

25. The Malthusian law: humanity cannot defeat nature

Thomas Robert Malthus (1766–1834) put forward the thesis that population growth is (at least eventually) faster than agricultural growth (food production) and that, in fact, population tends to increase beyond the numbers that can be fed. This thesis questioned the sustainability of an increasing population. As a result of the different potential capacity of population and food supplies to expand, a continued population growth will be negatively checked by food shortages, poverty, deprivation and diseases. Hence, if population is not positively checked (measures that reduce fertility), its growth will come to an end through famine (insufficient food supply). Malthus did not see in technological progress an escape from this law: increases in population are always dangerous and stimulated by increasing prosperity, so technological improvements merely increase the size of population checked down by famine. A modern, environmental version of the Malthusian law is that population growth is, by necessity, limited by the natural environment.

The Malthusian view. By extension, a Malthusian view can be defined according to which population (population growth, specifically) is the source of all problems. A continued population growth will worsen existing problems and generate new ones. According to Robert May (1993), "the continuing growth of human populations (…) is the engine that drives everything."

26. Kenneth Boulding's theorems on population

- **The Dismal Theorem.** If the only ultimate check on the growth of population is misery, then the population will grow until it is miserable enough to stop its growth.
- **The Utterly Dismal Theorem.** Technical improvements can only relieve misery temporarily: since, by The Dismal Theorem, misery will ultimately check population, the final result of any technical improvement is increase the amount of people that will live in misery and, accordingly, the total amount of human misery.
- **The Moderately Cheerful Form Dismal Theorem.** If misery and starvation is not the only way to keep a prosperous population in check, population does not have to grow until it is miserable and starves, so it can be stably prosperous.

27. Bartlett's Laws of Sustainability

- "Population growth and/or growth in the rates of consumption of resources cannot be sustained".
- "The larger the population of a society and/or the larger its rates of consumption of resources, the more difficult it will be to transform the society to a condition of sustainability".

These two laws imply that the concept of sustainable growth is an oxymoron.

28. Walt Disney's First Law

"Wishing will make it so." (A. A. Bartlett). A variation, in the form of a Ponzi-type motto, is: "We can grow our way out of the problems." An example: Julian Simon's (1995) claim that "Even if no new knowledge were ever gained (…) we would be able to go on increasing our population forever."

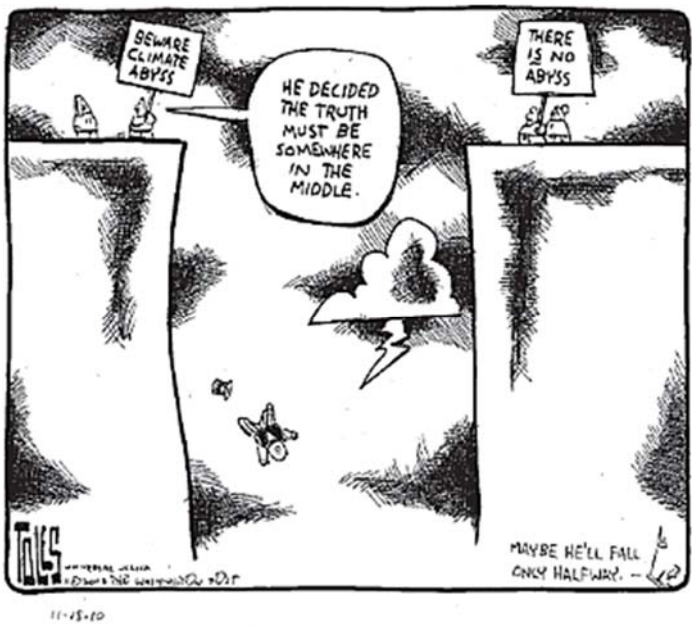
Bartlett, Albert A. (1998): "Malthus marginalized: The massive movement to marginalize the man's message", The Social Contract, 239-252

Boulding, Kenneth (1971): "Foreword to T. R. Malthus, Population, The First Essay", in Collected Papers, Vol. II, Colorado Associated University Press, Boulder, pp. 137-142.

Bartlett, A.A., (1994), "Reflections on sustainability, population growth, and the environment", Population & Environment 16(1), pp. 5-35.

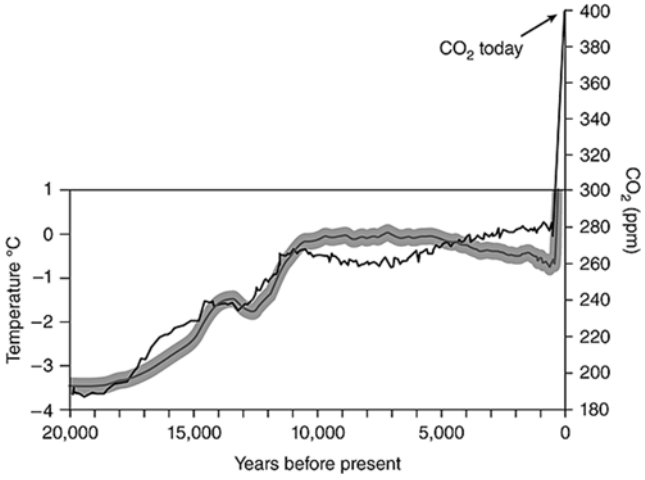
29. Global environmental threats

Ozone depletion. The stratospheric ozone layer (acting like a sunscreen) absorbs the portion of the ultraviolet light (UV-B radiation) that is harmful to most life on Earth (UV-B radiation cause damage to eyes, skin, genetic material, the immune system...). Excessive UV-B exposure is likely to compound its effects on the ecosystem with other global environmental threats: global warming, ocean acidification and pollution. The 2008 Antarctic ozone hole was one of the largest and most long-lived. The biggest ozone hole over the Arctic occurred in 2011.

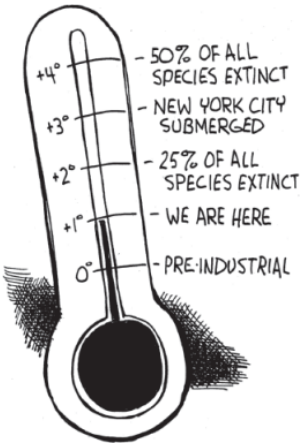


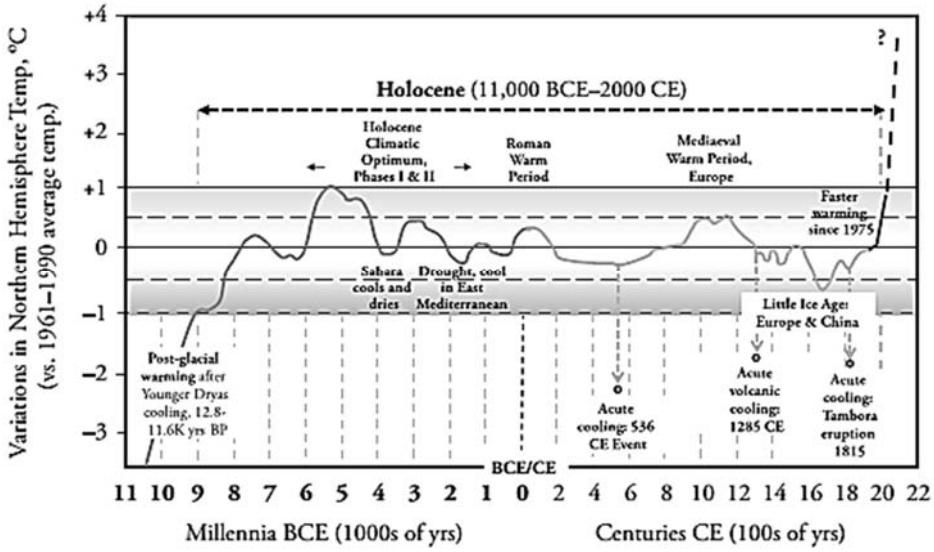
Abbasi, S. A.; Tasneem Abbasi (2017): *Ozone hole: Past, present, future*, Springer, New York.

The virtue is not always on the middle ground. On certain debates that rely on matters of fact and objective information (like climate change) supporting the view that there are two equal sides implicitly justifies bad-faith skepticism (skepticism that does not intend to improve understanding of reality and that simply claims that it is legitimate to doubt about everything). Regarding the issue of whether climate change is human-caused, the weight of the sides (publishing scientists) is something like 97% against 3%.



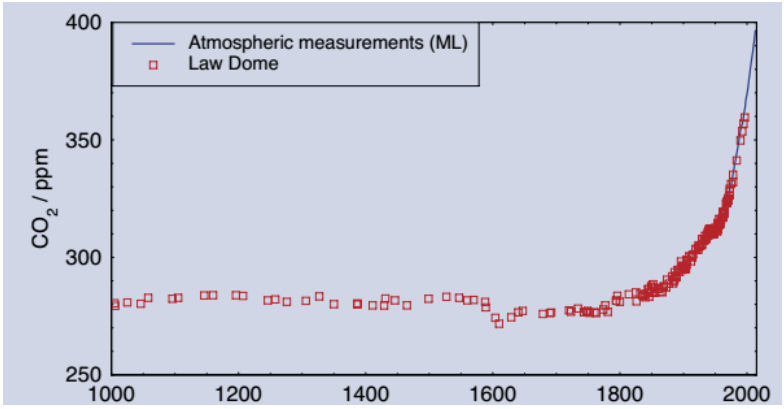
The hockey stick curve. It is a graph depicting temperature trends in the last millennium. It shows the unprecedented nature of modern global warming. The scientific community has reached a general consensus that climate change is real (it is actually occurring), caused by the activity of human beings and already a problem.



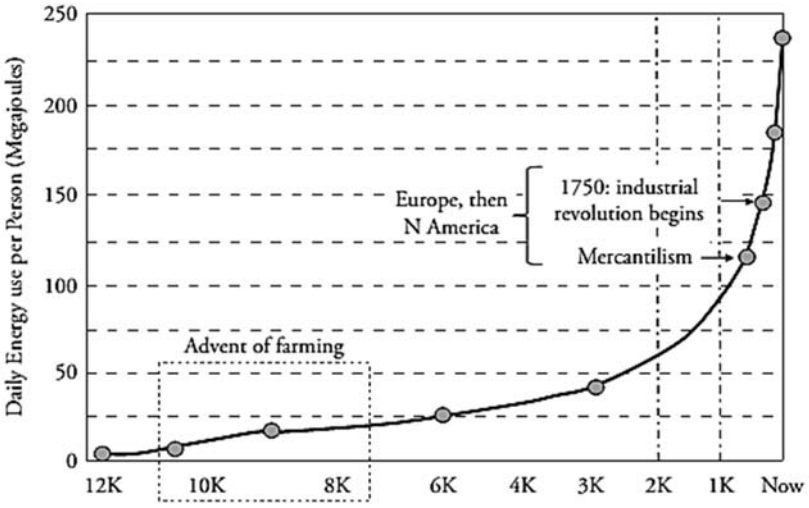


CO_2 emissions. Human activity generates more than 30 billion tons of CO_2 pollution per year. Averaging the weight of a human being at 70 kg, these 30 gigatons are equivalent to the weight of 428,5 billion people. So the annual weight of CO_2 emissions is some 60 times the total number of people on the Earth.

Ecological footprint. The ecological footprint is an estimate of the amount of resources, production, consumption and waste used by an individual. Its units are planet units: the number of planet Earths needed if every individual lived the way the individual lives. This footprint is growing. Total human demands exceeded Earth's biocapacity around 1980. Currently the demand requires the equivalent biocapacity of 1.5 Earths to feed, provide materials, regenerate, self- replenish and absorb wastes.



Energy use. At the onset of the agricultural revolution (some 10,000 years ago) farmers used 20 megajoules of energy (physical labor) daily. The average North American now operates daily on at least 1,000 megajoules. The current global average is around 250 megajoules.



Has humanity been climately fortunate? During the Holocene, the last 12,000 years, the global climate has been relatively constant. Average global surface temperature: 15^0C. Regional decadal- average temperatures rarely have exceeded 2^0C. In Europe, temperatures between the peak Medieval Warm and the Little Ice Age nadir differed by some 1.5^0C. So the trajectory of the world economy since the agricultural revolution has been blessed by a (extraordinary?) stable global climate. How much could this lucky conditions last? Now, humanity faces changes in the global climate greater and faster than anything in recorded human history. The world may be heading towards an average global warming of up to 4^0C during the 21st century.

30. Message on Climate Change to World Leaders

> "Human-induced climate change is an issue beyond politics. It transcends parties, nations, and even generations. For the first time in human history, the very health of the planet, and therefore the bases for future economic development, the end of poverty, and human wellbeing, are in the balance. If we were facing an imminent threat from beyond Earth, there is no doubt that humanity would immediately unite in common cause. The fact that the threat comes from within —indeed from ourselves— and that it develops over an extended period of time does not alter the urgency of cooperation and decisive action."
>
> Signed by over 4,000 scientists worldwide, July-August 2014.

Mann, Michael E.; Tom Holes (2016): ***The madhouse effect: How climate change denial is threatening our planet*****, Columbia University Press, New York.**

Maslin, Mark (2014): ***Climate change: A very short introduction*****, Oxford University Press, Oxford, UK.**

McMichael, Anthony J.; Alistair Woodward; Cameron Muir (2017): ***Climate change and the health of nations: Famines, fevers, and the fate of populations*****, Oxford University Press, New York.**

National Academy of Sciences; The Royal Society (non-dated): ***Climate change: Evidence and causes*****.**

Westergård, Rune (2018): ***One planet is enough: Tackling climate change and environmental threats through technology*****, Cham, Switzerland.**

31. The Shock Doctrine

How do societies respond to extreme shocks, like wars, natural disasters, economic crises, epidemics, terrorism? Naomi Klein contends that, in the last decades, corporate interests have exploited episodes of crisis to the advantage of a small elite. This has been achieved by promoting and supporting policies beneficial to the elite (privatization, deregulation, social spending cuts…) and by restraining civil liberties and rights. Klein claims that climate change is another opportunity to apply the shock doctrine: instead of seeing the implementation of measures to address the cause of the problem, we should expect the climate change crisis to be exploited to transfer more benefits and privileges to the top 1%. For instance, financial investors will use this opportunity to gamble on possible futures; insurance companies will devise and sell new protection schemes to the potential victims of the crisis; commons privatized; new markets will arise (markets for carbon credits) to exploit lucratively a potentially disastrous situation… No opportunity to profiting from disaster will be missed.

Klein, Naomi (2014): *This changes everything: Capitalism vs. the climate*, Simon & Schuster, New York.

Klein, Naomi (2007): *The shock doctrine: The rise of disaster capitalism*, Metropolitan Books, New York.

32. The Tragedy of the Commons: "freedom in a commons brings ruin to all"

The 'tragedy of the commons' is parable questioning the idea that unregulated markets yield socially good outcomes: self-interest is eventually inconsistent with social stability. The tragedy applies to the exploitation of a free resource (a common), like a pasture. Self-interest compels every herdsman to maximize the cattle on the pasture. But if a sufficiently large number of herdsmen develop the same strategy of increasing the herd without restrictions, the pasture will be exhausted and all the herdsmen will be ruined for trying to take too much from the pasture. Hence, a commonly owned and freely accessible resource tends to be depleted when it is exploited by a sufficiently large number of people. Infinite demands are not consistent with a finite and fragile supply. The logic of the tragedy of the commons seems to explain resource depletion and environmental degradation: taking without concern for preservation (the present matters more than the future).

Hardin, Garrett (1968): "The tragedy of the commons", Science 162(3859), 1243-1248.

Machan, Tibor R. (ed) (2001): *The commons: Its tragedies and other follies*, Hoover Institution Press, Stanford, CA.

33. Law of accelerating returns and the singularity

Ray Kurzweil's law of accelerating returns holds that the rate of evolution inherently accelerates, shows continual acceleration (every stage in evolution uses the capabilities and results from the previous stage and, for each stage, going from one stage to the next takes a shorter time).

Six epochs of evolution (Ray Kurzweil). These epochs express the continued evolution of information: physics and chemistry (information captured by patterns of matter and energy); biology and DNA (self-replicating mechanisms created: life); brains (mechanisms to acquire and process information biologically); technology (human creations); merger of human technology with human intelligence; and "the universe wakes up" ("the 'dumb' matter and mechanisms of the universe will be transformed into exquisitely sublime forms of intelligence, which will constitute the sixth epoch in the evolution of patterns of information. This is the ultimate destiny of the Singularity and of the universe", Kurzweil, 2005, ch.1).

The Singularity (Ray Kurzweil). It is the era defined by intelligence becoming nonbiological and countless of times higher than the current level of human intelligence as a result of rapid technological change. The impact of this change will transform human life: biological limitations will be trascended out, creativity will be amplified, humans and machines will become integrated, we could occupy different bodies and all human problems will be solved (aging, illness, pollution, hunger, poverty… even death). Nanotechnology will make it possible to produce anything inexpensively. The Singularity culminates the merger of biology with technology: it is the time when machine intelligence merges with, and surpasses, human intelligence.

The law of accelerating returns and related 'laws' work until they stop working (Paul Allen). Are such laws simple, not guaranteed extrapolations of past regularities and trends? What ensures that end of a technological paradigm (vacuum tubes) is followed by a new one (transistors)?

34. Technology

- **A conceptualization of technology** (W. Brian Arthur). A technology is a means to fulfill a purpose or need by reliably exploiting some natural effect or phenomenon. A technology puts together assemblies, which work together on the grounds of some base principle of the technology (for instance, counting the beats of a stable frequency is the base principle of a clock). The base principle of a technology is the idea of using a phenomenon to accomplish some purpose. In sum, a technology involves a purpose, an architecture of components and a phenomenon exploited by some base principle: technologies take advantage of predictable and replicable events. Innovation can be seen as the discovery of new links (base principles) between purposes and phenomena that can be exploited to meet the purposes. Invention is then a process connecting a purpose with a principle that can satisfy it.
- **General approaches to the relationship between technology and society**. (1) Internalist approach: technology develops in isolation from society. (2) Technological determinism: certain inventions or innovations cause major changes in society (social development is related to the development of techniques). (3) Dialectical approach: technological and social changes interact mutually.
- **African societies as example of the lack of adoption of superior technologies** (resistance to foreign ideas). (i) Tools from Eurasian preindustrial technology (cart, plow, potter's wheel) were not adopted, despite contact with Eurasia. (2) Advanced industrial technology was imported but not successfully integrated with existing locally-based economic structures. African economies remain based on human energy and linear-reciprocal motion (non-human energy sources and technologies based on rotary motion did not spread). Despite exposition to presumably more advanced technologies, material and cultural reasons led to a general rejection of the technologies. The technological gap with Eurasia reinforced rejection: the introduction of more advanced production technologies in precolonial Africa failed to generate transformations in the rest of the economy (failed to create an economy where those technologies could thrive and develop). The benefits of the new technologies were appropriated by ruling elites, which reinforced their privileged position. Precolonial Africa illustrates the possibility that technology spurs economic growth but not development (innovations can be transferred without the technological capacity embodied in those innovation being simultaneously transferred).

Allen, Paul G.; Mark Greaves (2011): "Paul Allen: The Singularity isn't near", Technology Review.

Arthur, W. Brian (2007): "The structure of invention", Research Policy 36, 274-287.

Aunger, Robert (2010): "What's special about human technology?", Cambridge Journal of Economics 34, 115-123.

Austen, Ralph A.; Daniel Headrick (1983): "The role of technology in the African past", African Studies Review 26(3/4), 163-184.

Brynjolfsson, Erik; Andrew McAfee (2014): *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*, W. W. Norton, New York.

Kurzweil, Ray (2005): *The Singularity is near: When humans transcend biology*, Viking, New York.

Kurzweil, Ray (2012): *How to create a mind: The secret of human thought revealed*, Viking, New York.

35. Jared Diamond's (2000) explanation of collapse

"… people living in fragile environments, adopting solutions that were brilliantly successful and understandable in the short run, but that failed or else created fatal problems in the long run when confronted with external environmental changes or human-caused environmental changes that people

without written histories or archaeologists could not have anticipated.""Past societies faced frequent ecological crises of small amplitude over small areas. Modern global society faces less frequent but bigger crises over larger areas."

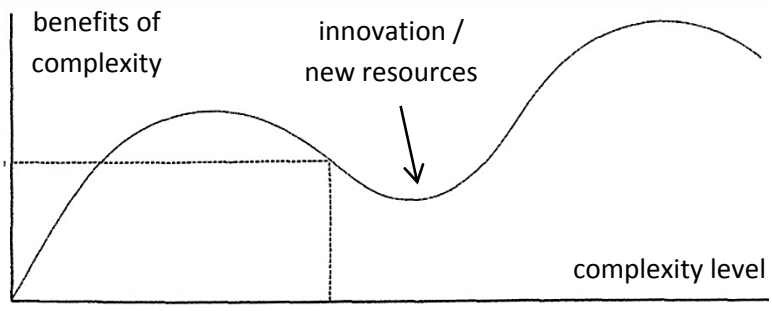
36. Are non-ambiguous the lessons of the past?

The response to the environmental crises in Western Europe between the 14th and 18th centuries was innovation and intensification. This response was flexible, broad, decentralized and protracted. Based on this experience, is alarmist the claim that, under the current pattern of global resource exploitation, the future of humanity is at risk? Butzer (2012) contends that one should not ignore the resilience and the capacity of readaptation of societies. Social stress creates the conditions and incentives to try new ideas and solutions, above all in societies favouring bottom-up options, in contrast to the authoritarian strategies characteristic of pre-industrial societies.

According to Tainter (2006), the big question at present is whether intensification can continue indefinitely. The view of orthodox economists is that new technologies and new resources to address all kinds of problems will always be found: the future is always promising. The alternative view is that the present global civilization is like any other previous civilization, in the sense that no civilization can survive the destruction of its natural base. Economies depend on ecosystems. What is the future of an economy shrinking forests, eroding soils, depleting aquifers, collapsing fisheries, raising temperature, melting ice sheets…? Collapse in the past was typically preceded by the spread of hunger (hunger at the global scale has not yet disappeared).

37. Joseph Tainter's (1988) theory of why societies collapse

Collapse means that a society experiences a rapid and significant loss of sociopolitical complexity. Tainter's explanation is based on four ideas. (1) Societies are problem-solving organizations. (2) The sociopolitical organization of societies requires energy for its maintenance. (3) Higher complexity levels of a sociopolitical organization correspond to higher per capita costs: a rising complexity is increasing costly for each member of the more complex system. (4) Solving social problems by investing in sociopolitical complexity has diminishing marginal returns: each complexity upgrading is less capable of solving problems. The productivity (the benefits) of the investment in complexity is eventually declining. Given (1)-(4), collapse arises when the benefits of investing in complexity are insufficient to cover its costs. Collapse is the natural mechanism to downsize a complexity level whose maintenance is excessively costly. Innovation or discovery of new resources (energy subsidies) are common ways to overcome the diminishing returns to investment in complexity.



38. Magdoff and Foster (2011, p. 7) corollary to Herman Daly's Impossibility Theorem of unlimited economic growth in a limited environment e

"The continuation for any length of time of capitalism, as a grow-or-die system dedicated to unlimited capital accumulation, is itself a flat impossibility". "We are constantly being told by the vested interests (…) that capitalism offers the solution to the environmental problem: as if the further growth of capital markets, green consumption, and new technology provide us with miraculous ways out of our global ecological dilemma. Such views are rooted in an absolute denial of reality."

39. X-events

Modern societies rely on a continued improvement of technology. This makes economies increasing complex and all its components more interdependent. As a result, economies are more vulnerable to shocks. The infrastructures required to maintain the stability and complexity of modern economies (electrical power, water and food supply, communication, transportation, health care, defense, finance) are increasingly intertwined, so that troubles in one component more easily may spread to other components.

X-events are high-surprise, high-impact events. In a society, the source of X-events is the 'complexity gap' between the complexity of the control system (the government) and the increasing complexity of the controlled systems (the citizens). The gap must be bridged: either the government forces a reduction in complexity in the population (repression) or raises its own complexity to match the population's higher complexity (free elections are held, civil rights and liberties granted, social mobility allowed, openness accepted). An X-event is the default path of bridging the complexity gap, the vehicle that narrows the different complexity levels of two interacting systems. When a government is not able to bridge the gap, a revolution (an example of an X-event) is likely to break out. Examples of X events: supervolcano explosions (Toba, 74kya, probably responsible for the near extinction of humanity), the 1918 Spanish influenza epidemic, high magnitude earthquakes, bees massively dying off, 9-11 terrorist attack… Societies today are more vulnerable than ever to X-events: the complex structures of modern societies are extremely fragile.

- **Law of requisite complexity**: to regulate a system, the complexity of the controller has to be at least as great as the complexity of the system to be controlled.

The 2011 revolts in the Arab world are examples of X-events. Modern communication and social-networking services (Google, Twitter, Facebook) have increased social complexity (citizens become more empowered, self-aware, informed, connected). Governments responding by restricting access to those services, or shutting them down, made the complexity gap widen to unsustainable levels. A complexity gap is synonymous with trouble and the political expression of trouble is revolt/revolution. The result in the Arab world was regime change in some countries (Tunisia, Libya, Egypt) and challenge to ruling elites (the Assad dynasty in Syria, the monarchy in Bahrain).

Manufacturing sectors in developed economies have become more complex (minimum-wage laws, health and safety standards, unionization) than those from developing economies. When both sectors interact through globalization, with a complexity gap becoming too large to be sustainable, the gap is closed by an X-event: outsourcing (manufacturing jobs transferred from developed to developing countries). This X-event downsizes by force the comparatively excessive complexity of the most developed sector. In this respect, globalization creates new X-events and magnifies the consequences of existing X-events.

The rules for dealing with normal events (for which there is abundant past experience) are different from those for handling X-events (which are rare and unexpected).

The increasing complexity of the global society is the direct cause of X-events. The complexity is expressed in many ways: integration, interdependence of systems and infrastructures; accumulation of bureaucratic layers; mismatch in complexity levels between interacting systems (national and foreign economies; governments and citizens; economies and ecosystems)…

40. Complexity principles

- **Emergence**: the whole is not just the sum of its parts. Even if the characteristics of the individual components of a system are perfectly known, its interaction may give rise to systemic properties that are difficult to predict from the individual properties.
- **Red Queen hypothesis**: one must run to stay in the same place (do the same is a recipe for failure). A system consisting of adaptive, evolving organisms forces the players to adapt and evolve fast and continuously just to remain in the game. This permanent race between the players tends to increase the overall complexity of the system.

- **No free lunch**. To increase the efficiency with which a system operates, its resilience (to shocks or changes) must be reduced. Conversely, survival in an uncertain environment demands efficiency sacrifices.
- **The Goldilocks principle** (food cannot be too hot not too hold). In an open, dynamic and competitive environment, systems can operate only within a limited range of conditions: the 'edge of chaos'. Policymakers, for instance, must select the right mix of market freedom and market regulation: too much regulation may harm growth; too much *laissez-faire*, may be destabilizing.
- **Undecidability**: deductive reasoning (logic alone, rational argumentation) is not always enough to handle problems.
- **The Butterfly effect** (ripple, domino, snow-ball effect). Complex systems tend to be very sensitive to apparently minor changes: small changes may have large effects. (7) Law of requisite variety: the control system has to be at least as complex (sophisticated) as the system to be controlled (higher complexity is required to manage lower complexity). Complexity gaps do not tend to last and its involuntary adjustement is likely to be traumatic for the system.

41. Systems self-organized critically

The property of self-organized criticality means that individual behaviour tends to cause a system both to self-organize and converge to critical/tipping points where small events may have big global effects. An example: sand falling on a fixed point in a table. The sand accumulates forming a pile until a state of repose is reached (at a certain angle of the pile). After that state, further grains create avalanches (a potentially catastrophic global event) and part of the sand falls off of the table.

42. Punctuated equilibrium (Stephen Gould, Nils Eldredge)

'Punctuated equilibrium' refers to a theory of evolutionary processes according to which evolutionary processes do not occur slowly and gradually, but quickly and suddenly. Long periods of apparent stability and lack of significant change are suddenly followed by a period of radical, dramatic evolutionary changes take place (like the Cambrian explosion, 650 mya, where animals with shells and external skeletons appeared).

Barbier, Edward B. (2011): *Scarcity and frontiers: How economies have developed through natural resource exploitation*, Cambridge University Press, New York.

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Casti, John L. (2013): *X-events: The collapse of everything*, William Morrow, London.

Clark, Gregory (2008): "In defense of the Malthusian interpretation of history", European Review of Economic History 12, 175-199.

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Magdoff, Fred; John Bellamy Foster (2011): *What every environmentalist needs to know about capitalism: A citizen's guide to capitalism and the environment*, Monthly Review Press, New York.

Oreskes, Naomi; Erik M. Conway (2014): *The collapse of western civilization: A view from the future*, Columbia University Press, New York.

Streeck, Wolfgang (2016): *How will capitalism end: Essays on a failing system*, Verso, London.

Tainter, Joseph (2006): "Archaeology of overshoot and collapse", Annual Review of Anthropology 35, 59-74.

Tainter, Joseph (1988): *The collapse of complex societies*, Cambridge University Press, Cambridge, UK.

43. Is globalized finance destroying the economy?

Technological advances reduce the need for labour in production. Instead of creating a leisure economy it appears that those advances are forcing employees to work overtime to repay debts incurred because of insufficient wages. There is a global debt overhead that increases faster than the value of global production (the economy's ability to pay). Economies (national and global) are endangered by the privilege granted to the financial sector to generate debts without regard to the wealth creation process that ensures debt repayment. It is very difficult for physical wealth to expand exponentially but financial wealth can grow exponentially with certain ease (money is just numbers on a computer screen, mere accounting entries: can be created in huge amounts immediately). The financial sector is autonomous and plays according to its own rules: the casino rules.

44. Two kinds of progress

Traditional idea of progress: from 1945 to 1980, the dominant idea was growth in living standards (children inherit a better world than their fathers). The neoliberal (pro-financial) idea: since 1980, the financial sector (banks, financial investors) want the economic surplus (growth in wages and corporate profits) for themselves, so the benefits of an expanding economy are concentrated on a small percentage of population (which does not leave much room for the rise in living standards).

Hudson, Michael (2012): Finance capitalism and its discontents: Interviews and speeches 2003–2012, ISLET, Dresden.

45. Past and future

"Those who suffer from historical amnesia, the belief that we are unique in history and have nothing to learn from the past, remain children. They live in an illusion." Chris Hedges, 2010, *Empire of illusion: The end of literacy and the triumph of spectacle*.

"To me and many others, the most fundamental question concerning our human future is whether the inhabitants of planet Earth will be able to cooperate in achieving the goal of reaching a more or less sustainable future in reasonable harmony, or whether the current large division between more and less wealthy people, as well as the unequal distribution of power within and among societies, will play havoc with such intentions." Spier (2010, p. 203)

Spier, Fred (2010): *Big history and the future of humanity*, Wiley-Blackwell, Chichester, UK.

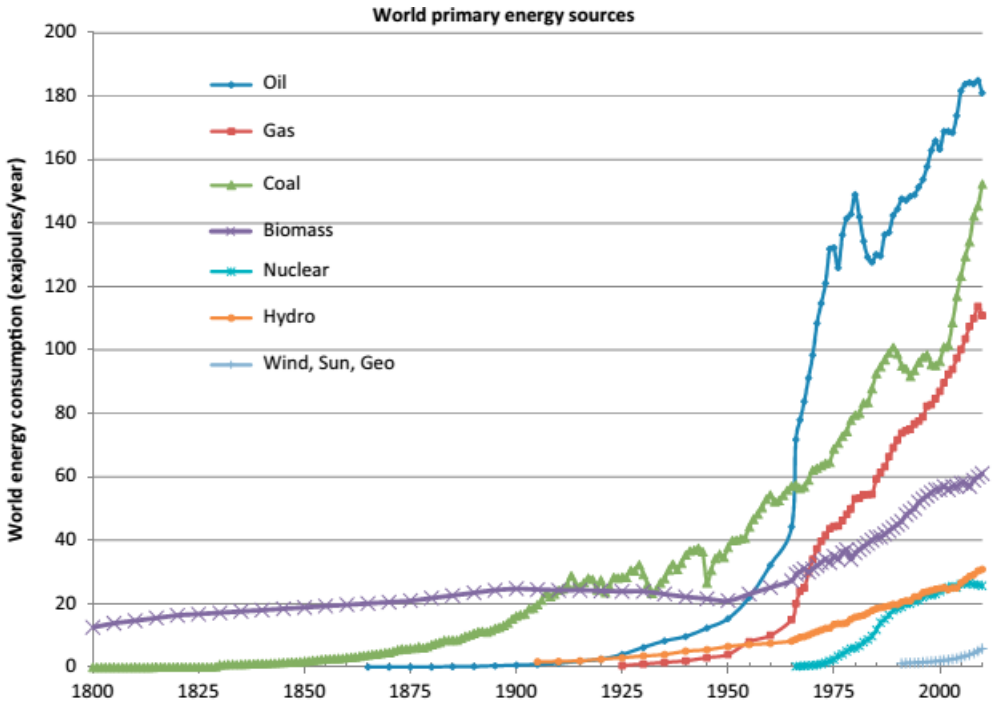
	Energy Use in Watt per Capita
Hunting man	200
Primitive agricultural man	480
Advanced agricultural man	1,040
Industrial man	3,080
Technological man	9,200

Cook, Earl (1971): "The flow of energy in an industrial society", Scientific American 225(3), 134-147.

46. The Towler principle

"It is not possible to extract energy from the environment without having an impact on the environment." (Towler, p. 2)

Towler, Brian F. (2014): *The future of energy*, Academic Press, London.



Primary sources of energy in the world, 1800-2010 (Towler, p. 7)

47. The paradox of prosperity (Todd G. Buchholz, 2016)

Buchholz suggests the following 'paradox of prosperity': "It is a common and dangerous mistake to think that societies are less vulnerable when they are relatively prosperous (…) even relatively prosperous societies have a tendency to come apart." He identifies five "potent forces that can shatter even a rich nation: (1) falling birthrates, (2) globalized trade, (3) rising debt loads, (4) eroding work ethics, and (5) the challenge of patriotism in a multicultural country." As regards (1):

"As countries grow rich, their birthrates fall and the average age of the population climbs. In order to keep up a lofty standard of living, citizens need workers to serve them, whether as neurosurgeons in hospitals, waiters in restaurants, or manicurists in nail salons. This requires an influx of new workers, which means opening up the gates to more immigrants. Unless a country has strong cultural and civic institutions, new immigrants can splinter the dominant culture. Thus countries face either (1) declining relative wealth or (2) fraying cultural fabric. Prosperous nations cannot enjoy their prosperity without becoming multicultural. But if they become multicultural, they struggle to pursue unified, national goals."

Buchholz derives the following general rule from his research: the fertility rate falls to 2.5 children per women when GDP grows above 2.5 percent for two generations (some 50 years). A third generation of growth and the rate falls below 2.1.

Buchholz, Todd G. (2016): *The price of prosperity: Why rich nations fail and how to renew them*, Harper, New York.

48. Dr Bob's Third Law (in honour of Robert Hargrove Montgomery by John F. Weeks)

> "You don't need an economist to understand the basic workings of the economy." (Weeks, 2014, p. xi) Presumably, the first law is "People can rule themselves without kings and queens" and the second one is "People do not need a priest to read the Bible."

John F. Weeks (2014): *Economics of the 1%. How mainstream economics serves the rich, obscures reality and distorts policy*, Anthem Press, London and New York.

49. Stephen Hawking (2018) on the survival of humanity

"I regard it as almost inevitable that either a nuclear confrontation or environmental catastrophe will cripple the Earth at some point in the next 1,000 years which, as geological time goes, is the mere blink of an eye. By then I hope and believe that our ingenious race will have found a way to slip the surly bonds of Earth and will therefore survive the disaster.

(…) I think we are acting with reckless indifference to our future on planet Earth (…) To leave Earth demands a concerted global approach—everyone should join in (…) The technology is almost within our grasp. It is time to

explore other solar systems. Spreading out may be the only thing that saves us from ourselves. I am convinced that humans need to leave Earth. If we stay, we risk being annihilated." (ch. 7)

"When we invented fire, we messed up repeatedly, then invented the fire extinguisher. With more powerful technologies such as nuclear weapons, synthetic biology and strong artificial intelligence, we should instead plan ahead and aim to get things right the first time, because it may be the only chance we will get. Our future is a race between the growing power of our technology and the wisdom with which we use it. Let's make sure that wisdom wins." (ch. 9)

"The second development which will impact on the future of humanity is the rise of artificial intelligence (…) But the advent of super-intelligent AI would be either the best or the worst thing ever to happen to humanity. We cannot know if we will be infinitely helped by AI, or ignored by it and sidelined, or conceivably destroyed by it. As an optimist, I believe that we can create AI for the good of the world, that it can work in harmony with us. We simply need to be aware of the dangers, identify them, employ the best possible practice and management and prepare for its consequences well in advance." (ch. 10)

"I am advocating that all young people should be familiar with and confident around scientific subjects, whatever they choose to do. They need to be scientifically literate, and inspired to engage with developments in science and technology in order to learn more. A world where only a tiny super-elite are capable of understanding advanced science and technology and its applications would be, to my mind, a dangerous and limited one. I seriously doubt whether long-range beneficial projects such as cleaning up the oceans or curing diseases in the developing world would be given priority. Worse, we could find that technology is used against us and that we might have no power to stop it." (ch. 10)

Hawking, Stephen (2018): *Brief answers to the big questions*, Bantam Books, New York.

50. The greatest risk to humanity in coming decades (Diamond, 2000)

> "The greatest risk to humanity in coming decades is the risk that we may continue to damage our environment to a degree incompatible with our current standard of living, or even incompatible with our existence."

Diamond, Jared (2000): *Ecological collapses of pre-industrial societies*, The Tanner Lectures on Human Values.

51. Paradoxical big threats to the 21st century world economy

- Threat 1: the threat of scarcity. This threat is associated with a possible ecological catastrophe and how this will affect the future of life on Earth.
- Threat 2: the threat of abundance. This threat is created by automation and is defined in terms of how automation will affect the future of work.

52. A technological paradox

> "In a *laissez faire* capitalist economy, the choice boils down to two perspectives: 1) if one introduces policies to safeguard the standard of living of workers by establishing that the minimum wage cannot fall below a certain threshold (moderate left policy), the system produces 'technological unemployment;' 2) if it is established that the government must not interfere in negotiations between capitalists and workers, letting the market decide wage levels (moderate right policy), the system produces 'technological impoverishment.' All this happens when an impressive technological development may *potentially* improve the life condition of everybody. Thus, contemporary society seems to be inherently characterized by a 'technological paradox.'"

Campa, Riccardo (2018): *Still think robots can't do your job: Essays on automation and technological unemployment*, D Editore, Rome.

53. Three generalizations of historical dynamics (Peter Turchin and Sergey A. Nefedov, 2009)

- **Overpopulation.** "One generalization can be called the neo-Malthusian principle: during periods of sustained population growth, if the output of the agrarian economy does not keep pace with the population, a number of relative price trends will be observed. One trend is rising prices for basic foodstuffs, energy, and land. Another one is falling real wages for labor. These trends are simply a consequence of the law of supply and demand. Thus, as the supply of labor increases, and if the demand for it is limited (which it is in agrarian economies), the price of labor inevitably decreases."

- **Elite overproduction.** "Another generalization, dealing with the elite dynamics, is also a consequence of the law of supply and demand. The principal kind of wealth in agrarian societies is land. The elite landowners profit from overpopulation in two ways. First, they are consumers of labor: they need peasants to work their land, servants to carry out domestic chores, and craftsmen and artisans for producing items for status consumption. Second, their property, land, produces food and other commodities, such as fuel and raw materials, the demand for which increases together with the growing population. Because the items they consume become cheaper while the items they produce increase in value, the elites greatly profit from overpopulation (…) In the end, elite numbers and appetites outgrow their "carrying capacity" (based on the labor of commoners). Just as overpopulation results in large segments of commoner population becoming immiserated, elite overproduction similarly results in large segments of elites becoming impoverished (not in absolute terms, as with common populace, but relatively to the standards of consumption needed to maintain the elite status). This generalization thus may be called the principle of elite overproduction."

Turchin, Peter; Sergey A. Nefedov (2009): *Secular cycles*, Princeton University Press, Princeton, NJ.

54. The human gamble

Many features of modern societies (emergence of agriculture, literacy, market institutions, the government, legal system) can be viewed as adaptations to an increase in population. A population increase reduces per capita wealth and changes wealth distribution. This induces those at the lower scale of wealth distribution to take more risks (bet on novel, revolutionary, innovative ideas; engage in illegal acts; become more creative; gamble more). The more envious individuals are more prone to gamble more as a way to try to improve their relative position. Those succeeding in the bet for novel ideas create a positive externality on the rest: innovations eventually spread.

Brenner, Reuven (1983): *History: The human gamble*, The University of Chicago Press, Chicago.

55. The imperial mode of living

"By [imperial mode of living] we aim to understand both the persistence and, at the same time, crisis-deepening patterns of production and consumption that are based on an –in principle– unlimited appropriation of the resources and labour capacity of both the global North and the global South and of a disproportionate claim to global sinks (like forests and oceans in the case of CO_2)."

"We argue that the increase of productivity and material prosperity in the capitalist centres depends on a world resource system and international division of labour that favours the global North and is rendered invisible through the imperial mode of living, so that the domination and power relations it implies are normalized. Since the beginning of industrial capitalism, the imperial mode of living gained certain stability and hegemony at the cost of environmental destruction and the exploitation of labour. Societal relations as well as societal nature relations were stabilized (…) due to its environmentally and socially unsustainable character.

(…) Due to the imperial mode of living and its global spread, societies seem to be approaching the limits to capitalist nature. This does not necessarily mean that the imperial mode of living is leading into a great crash. The limits are not absolute (…) The authoritarian stabilization of the imperial mode of living is not the only strategy to cope with the multiple crises and to shift the limits to capitalist nature in an exclusive manner.

Another one (...) is the selective ecological modernization of the imperial mode of living which may result in what can be called a *green capitalism*."

Brand, Ulrich ; Markus Wissen (2018): *The limits to capitalist nature: Theorizing and overcoming the imperial mode of living*, Rowman & Littlefield, London.

56. The long descent (John Michael Greer, 2008)

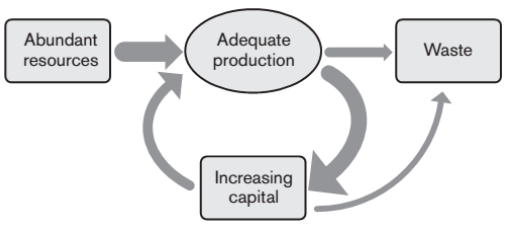
"This is the process I've named the Long Descent — the declining arc of industrial civilization's trajectory through time. Like the vanished civilizations of the past, ours will likely face a gradual decline, punctuated by sudden crises and periods of partial recovery. The fall of a civilization is like tumbling down a slope, not like falling off a cliff. It's not a single massive catastrophe, or even a series of lesser disasters, but a gradual slide down statistical curves that will ease modern industrial civilization into history's dumpster."

"At this point it's almost certainly too late to manage a transition to sustainability on a global or national scale, even if the political will to attempt it existed — which it clearly does not. It's not too late, though, for individuals, groups, and communities to make that transition themselves, and to do what they can to preserve essential cultural and practical knowledge for the future. The chance that today's political and business interests will do anything useful in our present situation is small enough that it's probably not worth considering. Our civilization is in the early stages of the same curve of decline and fall that so many others have followed before it, and the crises of the present — peak oil, global warming and the like — are the current versions of the historical patterns of ecological dysfunction. To judge by prior examples, we can't count on the future to bring us a better and brighter world — or even a continuation of the status quo. Instead, what most likely lies in wait for us is a long, uneven decline into a new Dark Age from which, centuries from now, the civilizations of the future will gradually emerge."

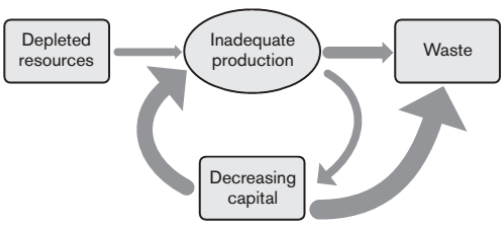
57. Catabolic collapse (John Michael Greer, 2008)

"The word "catabolism" comes from the Greek, by way of the life sciences. In today's biology it refers to processes by which a living thing feeds on itself. One of the most striking features of the dead civilizations of the past is that they go through precisely this process as they move through the stages of decline and fall."

"... civilizations are complex, expensive, fragile things. To keep one going, you have to maintain and replace a whole series of capital stocks: physical (such as buildings); human (such as trained workers); informational (such as agricultural knowledge); social (such as market systems); and more. If you can do this within the 'monthly budget' of resources provided by the natural world and the efforts of your labor force, your civilization can last a very long time. Over time, though, civilizations tend to build their capital stocks up to levels that can't be maintained; each king (or industrial magnate) wants to build a bigger palace (or skyscraper) than the one before him, and so on. That puts a civilization into the same bind as the homeowner with the oversized house."



"In a growing or stable society, the resource base is abundant enough that production can stay ahead of the maintenance costs of society's capital – that is, the physical structures, trained people, information, and organizational systems that constitute the society. Capital used up in production or turned into waste can easily be replaced."



"In a society in catabolic collapse, resources have become so depleted that not enough is available for production to meet the maintenance costs of capital. As production falters, more and more of society's capital becomes waste, or is turned into raw material for production via salvage. If resource depletion can be stopped, the loss of capital brings maintenance costs back down

below what production can meet, and the catabolic process ends; if resource depletion continues, the catabolic process continues until all capital becomes waste."

Greer, John Michael (2008): *The long descent: A user's guide to the end of the industrial age*, New Society Publishers, Gabriola Island, Canada.

58. Dominant paradigms (world views, tacit set of beliefs, default interpretations) in the West

- 'Markets' are good: economies based on a system of markets produce efficient outcomes and are endowed with a self-correcting ability.
- Democracy is good: political systems based on a system of representative democracy produce effcient political outcomes and are endowed with a self-correcting ability.
- Capitalist growth is good: societies organized on the basis of a capitalist system that exploits fossil fuels and natural resources reach unlimited growth.
- Globalization is good: a global economy favouring free trade and global integration delivers a growing welfare.

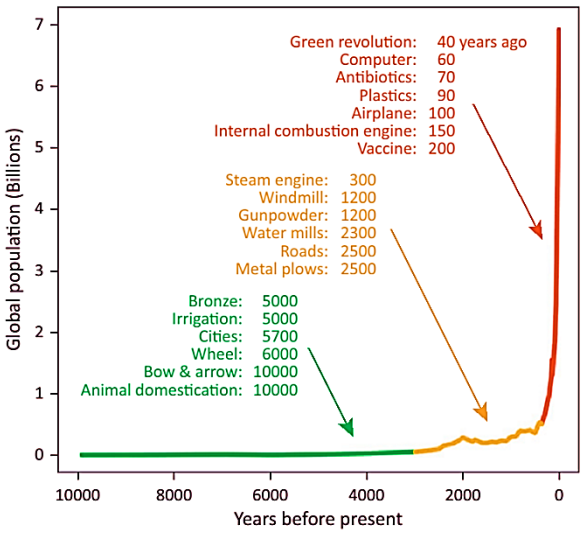
Randers, Jorgen (2012): *2052: A global forecast for the next forty years*, Chelsea Green Publishing, White River Junction, VT.

59. Jorgen Randers' (2012) 'grocline'

"In the last third of the twenty-first century I believe the world economy will have entered into an era where the combination of individual growth and societal decline has become the norm. Per capita consumption will be growing year by year, just as in the good old days. And at the same time the total economy—the GDP—will be in constant decline. This could be called 'grocline'—simultaneous growth and decline. The grocline world is one where the individual situation improves while the total pie shrinks. It's good and bad at the same time—decade after decade."

60. Two social dynamic forces and the sustainable future

"Two interacting forces influence all populations: the Malthusian dynamic of exponential growth until resource limits are reached, and the Darwinian dynamic of innovation and adaptation to circumvent these limits through biological and/or cultural evolution. The Malthusian dynamic pushes a population to increase until it reaches its environmental limits. The Darwinian dynamic pushes against these limits by incorporating new traits and technologies that enhance survival and reproduction. There are restrictions to this Malthusian-Darwinian Dynamic (MDD) (...): it is logically, physically, and biologically impossible for exponential growth to continue indefinitely within a finite world."



"A central feature of human ecology has been the positive feedback between growth and innovation. As populations grew and aggregated into larger and more complex social groups, more information was acquired and processed. This led to new technologies that further pushed back ecological limits, allowing for continued population growth. The result has been an ascending spiral of exponential processes feeding back on each other: population growth and aggregation begot technological innovation, which in turn allowed for more resource extraction and a greater ability to overcome ecological constraints, begetting still more population growth and socioeconomic development."

"The ruins of Mohenjo Daro, Mesopotamia, Egypt, Greece, Rome, the Maya, Hohokam, Angkor Wat, and Easter Island are enduring evidence that many earlier societies were unable to innovate their way out of local limits and therefore collapsed despite attaining dense populations and advanced cultures (…) Until now, both Malthusians and Cornucopians have been correct: some populations have crashed and cultures have vanished, but our species has endured because these events have been localized. However, behavioral changes and technological innovations over the last century now intricately interconnect us in a single global society. As a result, local perturbations currently have the ability to reverberate across all of humanity."

"Within the context of our now highly globalized society, the essential question is how much potential exists for the Darwinian side of the MDD to allow for continued adaptation and innovation to push back against global scale constraints (…) The bad news is that the MDD has left humans ill prepared to make the necessary ecological and behavioral changes required to avoid civilization collapse (…) The good news is that the MDD may also provide valuable insights into potential solutions from both natural (in particular evolutionary biology and ecology) and social (in particular economics and sociology) science perspectives."

"We must recognize that a sustainable future will ultimately require: (i) negative population growth for a number of generations, followed by zero growth; (ii) a steady-state economy based on sustainable use of renewable energy and material resources; and (iii) new social norms that favor the welfare of the entire global population over that of specific individuals and groups. It is also essential that we recognize that humanity has not yet evolved the genetic or cultural adaptations needed to accomplish these tasks."

Jeffrey C. Nekola et al. (2013): "The Malthusian-Darwinian dynamic and the trajectory of civilization", Trends in Ecology and Evolution 1643.

61. Some facts on technology (Trevor Kletz, 1996)

"Every error is a human error because: Someone has to decide what to do. Someone has to decide how to do it. Someone has to do it."

- "We cannot have the benefits of modern technology without some disadvantages in terms of pollution and safety."
- **"**New technologies are usually less hazardous than old ones."
- "The cost of reducing pollution and increasing safety has to be paid for in the end by the public."
- "People, not technology, create hazards and pollution." "To blame pollution on technology is the ultimate dodge of a society unwilling to take the blame for its own errors and stupidity. It is not computers and automation that cause unemployment but the way we use them."

"MYTH M5. The best way of conveying information to people is to tell them."

"If we have to convey messages that people want to receive ('where to get free beer,' for example), almost all methods of communication are effective. However, if there is some resistance to the message, as there often is when we are making recommendations to increase safety, for example, then we should choose the most effective method of communication: discussion (…) Discussions take longer than a lecture, but more is remembered and people are more committed to the conclusions because they have not been told what to do but have worked it out for themselves (…) The best size for a discussion group is 12-20. If fewer than 12 are present, the group may not be 'critical' (in the atomic energy sense) and discussion may not take off. If more than 20 are present, the quieter members may not be able to contribute."

"MYTH M10. We need to know what is new."

"We do need to know what is new, but that should not negate our concern with what is old. In my own area of expertise, namely, loss prevention and process safety, the majority of accidents have well-known causes (…) Spend less time reading magazines that tell what is new and more time reading books that tell what is old.

Today, 'old' implies outdated; in the past, it implied something of enduring value; it had to be good to have lasted so long."

Kletz, Trevor (1996): *Dispelling chemical industry myths*, 3rd edition, CRC Press, Boca Raton, FL.

62. Views on the future of artificial intelligence

Turner (2019, p. 16) defines artificial intelligence as "the ability of a non-natural entity to make choices by an evaluative process."

- "The optimists emphasise the benefits of AI and downplay any dangers (...) Fundamentally, optimists think humanity can and will overcome any challenges AI poses."
- "The pessimists include Nick Bostrom, whose 'paperclip machine' thought experiment imagines an AI system asked to make paperclips which decides to seize and consume all resources in existence, in its blind aderence to that goal (...) Likewise, Elon Musk has said we risk 'summoning a demon' and called AI "our biggest existential threat'."
- "The pragmatists acknowledge the benefts predicted by the optimists as well as the potential disasters forecast by the pessimists. Pragmatists argue for caution and control."

Turner, Jacob (2019): *Robot rules: Regulating artificial intelligence*, Palgrave Macmillan, Cham, Switzerland.

63. Six supertrends shaping the future (Edward Cornish, 2004)

- **Technological progress.** "We can think of technological progress as the growing capability of humans to achieve their purposes. Technological progress has been the supremely important trend in human evolution for millions of years."

- **Economic growth.** "Technological progress promotes economic growth (...) because people are eager to use their know-how to produce goods and services, both for their own use and to sell to others. Economic growth is also a self-sustaining process."

- **Improving health.** "Technological progress and economic growth have led to improving human health because they have produced more food, more effective sanitation, better health services, and so on. Improving health leads to increasing longevity, which has two very important consequences: population growth and a rise in the average age of the population."

- **Increasing mobility.** "People, goods, and information move from place to place faster and in greater quantity than ever before (...) Mobility can also cause social and cultural disruption."

- **Environmental decline.** "Environemtal decline is continuing for the world as a whole because of continuing high population growth and economic development."

Three Technological Revolutions

	Agricultural	Industrial	Cybernetic
Origin	Near East, 11,000 years ago	Britain, 1750	United States, 1944
Catalytic Technology	Grain cultivation (wheat)	Steam engine	Computer
Benefits	More food per unit of land; grain storable and tradable	Inexpensive, dependable source of power	Fast, cheap decision making for problems soluble by algorithms
Uses	Feeding people, safeguarding food supply, trading goods (functions like money)	Mechanized pumps, machine powered vehicles, power machinery in factories	Mathematical calculations, processing records, word processing, database management, telephone exchanges, etc.
Effects	Population increase, early cities, roads, shipping, accounting, metal-working, wheeled vehicles, writing, scholarship, science	Factory towns, urbanization, railroads, automobiles, rising living standards, airplanes, surging demand for natural resources—metal ores, coal, petroleum	Faster, cheaper information handling; better management of communications; tighter inventory controls; better distribution of goods; higher standard of living
Workers Displaced	Hunters, gatherers	Farmers, weavers, craftsmen, home workers	Clerks, typists, telephone operators, typesetters, small grocers, middle managers
New Jobs	Early: Farmers, construction workers, carters, brewers, specialized crafts. Later: scribes, scholars	Miners, factory workers, ironworkers, steamship builders, railroaders, steel workers	Computer operators, programmers, repairers, systems analysts, Webmasters, electronic game designers

• **Increasing deculturation (loss of traditional culture).** "Deculturation occurs when people lose their culture or cannot use it because of changed circumstances (...) Today, the world is estimated to have 6,000 languages, but the number is expected to dwindle to about 3,000 by the end of the twenty-first century due to high mobility, globalization of economic activities, and other factors. Urbanization also contributes to deculturation."

Cornish, Edward (2004): *Futuring: The exploration of the future*, World Future Society, Bethesda, Maryland.

The Problems of Progress

In general, what we call "progress" can lead to abuse of the natural environment, the burden of learning new jobs, and general disorientation due to change itself. Examples of other negative consequences of "progress":

Better machines →	Displaced workers, loss of status
Growing wealth →	Increase in rich/poor disparity, fewer workers for less-desired tasks
New products →	Difficulty of making choices
More, better food →	Obesity, clogged arteries
Better health care →	Rising costs, higher expectations
Longer lives →	Cost of supporting idle elderly, increase in disability, stress on natural resources
Saving newborn →	More birth defects
Better transport →	Decline of local communities
More TV programs →	Inactivity, desocialization
Increasing comfort →	Boredom, apathy
Portable telephones →	Forced exposure to noxious chatter
Easy bill paying →	Credit-card fraud, identity theft
Quick information →	Internet hoaxes, scams, viruses
Cheap, easy messaging →	Junk e-mail, insensitive comments

64. Postcapitalism: network vs hierarchy

"Neoliberalism is the doctrine of uncontrolled markets: it says that the best route to prosperity is individuals pursuing their own self-interest, and the market is the only way to express that self-interest. It says the state should be small (except for its riot squad and secret police); that financial speculation is good; that inequality is good; that the natural state of humankind is to be a bunch of ruthless individuals, competing with each other."

"Capitalism is more than just an economic structure or a set of laws and institutions. It is the whole system – social, economic, demographic, cultural, ideological – needed to make a developed society function through markets and private ownership. That includes companies, markets and states. But it also includes criminal gangs, secret power networks, miracle preachers in a Lagos slum, rogue analysts on Wall Street."

"That, in short, is the argument of this book: that capitalism is a complex, adaptive system which has reached the limits of its capacity to adapt (...) Capitalism (...) will not be abolished by forced-march techniques. It will be abolished by creating something more dynamic that exists, at first, almost unseen within the old system, but which breaks through, reshaping the economy around new values, behaviours and norms."

"Postcapitalism is possible because of three impacts of the new technology in the past twenty-five years. First, information technology has reduced the need for work, blurred the edges between work and free time and loosened the relationship between work and wages. Second, information goods are corroding the market's ability to form prices correctly. That is because markets are based on scarcity while information is abundant. The system's defence mechanism is to form monopolies on a scale not seen in the past 200 years – yet these cannot last. Third, we're seeing the spontaneous rise of collaborative production: goods, services and organizations are appearing that no longer respond to the dictates of the market and the managerial hierarchy. The biggest information product in the world – Wikipedia – is made by 27,000 volunteers, for free, abolishing the encyclopaedia business and depriving the advertising industry of an estimated $3 billion a year in revenue (...) Parallel currencies, time banks, cooperatives and self-managed spaces have proliferated, barely noticed by the economics profession, and often as a direct result of the shattering of old structures after the 2008 crisis. New forms of ownership, new forms of lending, new legal contracts: a whole business subculture has emerged over the past ten years, which the media has dubbed the 'sharing economy'. Buzzterms such as the 'commons' and 'peer-production' are thrown around, but few have bothered to ask what this means for capitalism itself. I believe it offers an escape route – but only if these micro-level projects are nurtured, promoted and protected by a massive change in what governments do. This must in turn be driven by a change in our thinking about technology, ownership and work itself."

"Collaborative production, using network technology to produce goods and services that work only when they are free, or shared, defines the route beyond the market system. It will need the state to create the framework, and the postcapitalist sector might coexist with the market sector for decades. But it is

happening (...) The main contradiction today is between the possibility of free, abundant goods and information and a system of monopolies, banks and governments trying to keep things private, scarce and commercial. Everything comes down to the struggle between the network and the hierarchy, between old forms of society moulded around capitalism and new forms of society that prefigure what comes next."

Mason, Paul (2015): *Postcapitalism: A guide to our future*, Allen Lane.

65. Suggestions for a post-labour world (Peter Fleming, 2015)

"We work, pay taxes, take care of the bills and commuting costs for one single reason: not to 'survive' but so that the governing elite gains its privileges for nothing. Our labour is designed to provide freedom to the rich. Our work exists in order to subsidize the costs of their existence (...) The more the neoliberal elite desires complete exemption from the social systems we are forced to participate in, the more we have to work. And because neoliberal capitalism entails such extreme inequalities of wealth distribution, work must become an inexorable way of life for most of us, rather than something we do among other things."

- "**A surplus living wage.** Everybody in society ought to be paid at least an average of £30,000 irrespective of what they do. And no one should be paid more than £95,000 a year (roughly a 1:3 income ratio between the poorest and richest in society)."

- "**Post-state democratic organizations.** The governmental structure as it currently stands should be abandoned and a more direct form of participatory democracy should be instituted. Parliamentary democracy is neither parliamentary nor democratic, but a vehicle of direct oppression to enhance the interests of an elite so minute and removed from everyday life that we have little idea who most of them are."

- "**The transfer of all monopolistic and oligopolistic enterprises into public hands**, that is, under the direct control of their own users. Railways, banks, healthcare providers, suppliers of water, electricity and foodstuffs, for example, have completely lost sight of their respective purposes under neoliberal capitalism."

- "**The three-day work week.** From a historical viewpoint, societies that insisted people work more than three days a week were usually slave societies. The maintenance of even a 'sophisticated self-subsistence' does not require more than 20 hours of work a week (...) No economic value is added after a certain threshold is passed. Little of interest is created over and above the three days a week."

[Parkinson's Law: the time used to perform a task is adapted to the time given to perform it. "If we are given eight hours to perform a task, it usually takes eight hours to do so successfully. If we are only given three hours to do the same task, it typically takes three hours to do so successfully."]

- "**Demassifying society as a positive global movement.** A friend recently sent me this: 'About 70 per cent of agricultural land and freshwater is used for livestock –more for grains as livestock feed. Beef production uses three-fifths of global farmland. It yields under 5 per cent of protein. A kilogram of beef requires 15,000 liters of water. Shouldn't we stop eating meat?' Slowing down meat consumption is a metaphor for a wider process: slowing down the massification of ways of life that not only have little ethical purpose but are incredible self-destructive (...) Contemporary capitalist work patterns and coercive state communism share a set of elective affinities in this regard. And much of this has to do with the pointless and self-referential aspects of work –accelerated actions that go nowhere, that use up more energy than they give back, and so forth. Capitalism does not equate to individual freedom of expression; exactly the opposite is true."

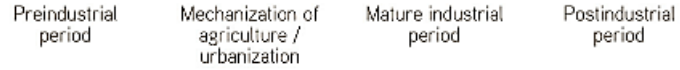
- "**Demonetarizing incentive structures.** (...) We are currently imprisoned in a theory of money that suggests that its endless accumulation is the only thing that makes us do anything –getting out of bed in the morning, acquiring an education, going to work (...) But the theory is false (...) A panoply of research tells us that we become our creative, moral, insightful, inventive and productive best (i.e. happy people) when motivated by intrinsic rewards rather than financial ones (...). After a certain threshold is passed, money tends to spoil things; our desire for it (to buy things, obtain status, etc.) quickly becomes self-

referential and tautological (we want money for its own sake) (...) We tend to be at our best when we do things that we are inherently interested in for their own worth or geared towards important social goals."

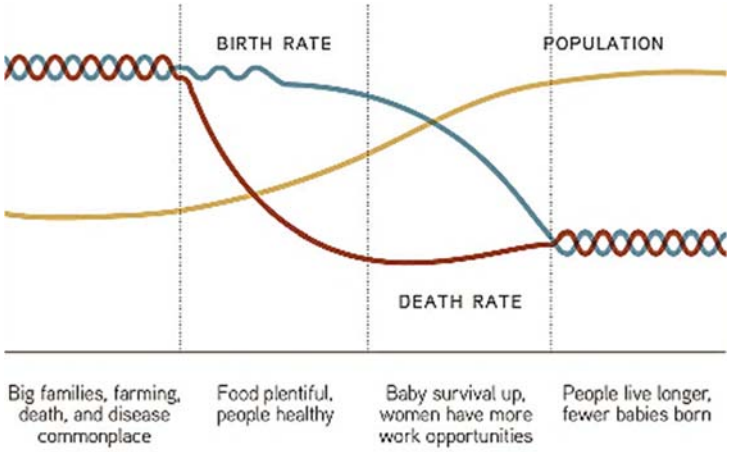
Fleming, Peter (2015): *The mythology of work: How capitalism persists despite itself*, Pluto Press, London.

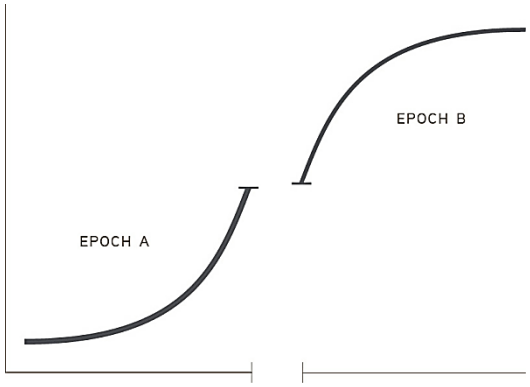
66. Epochs A and B (Jonas Salk and Jonathan Salk, 2018)

"The sigmoid growth curve consists of two sections of different shape: the upturned portion describes a phase of progressive acceleration of growth; the second portion is downturned and describes a phase of progressive deceleration. The difference in shape between the two portions of the curve suggests both quantitative and qualitative differences in human life between the two periods of time."



"We are moving from an era dominated by limitless growth, competitive strategies, short-range thinking, and independence to one characterizedby awareness of limits, cooperation, long-range thinking, and interdependence (...) We are on a frontier, but it is not territorial or technological; it is human and social (...) In the years to come, we face the challenge of understanding and facilitating a slowing of human population growth and, ultimately, of adapting to conditions associated with a relatively constant population size at a level far beyond anything we have previously experienced."

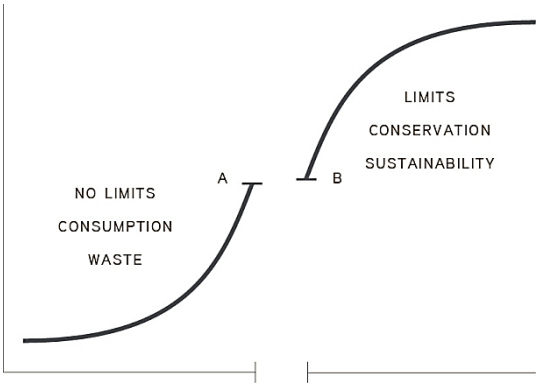


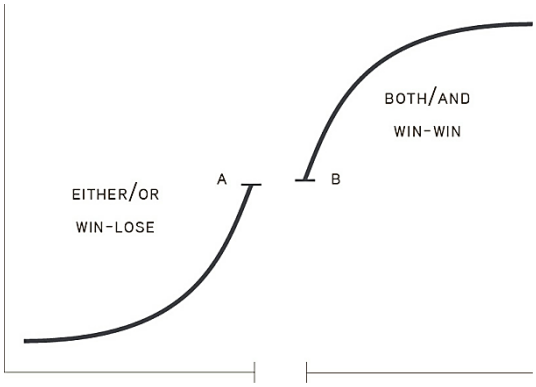


"To someone born in Epoch A, the future would appear to have few limitations in terms of growth, resources, and available energy. Someone living in Epoch B would, however, have a distinct sense of limitations and of the necessity to adapt to the approaching of a plateau in population growth."

"In Epoch A, progressive increase in population was seen to be positive; in Epoch B, this increase is now of negative value and, if left unchecked, threatens our very existence."

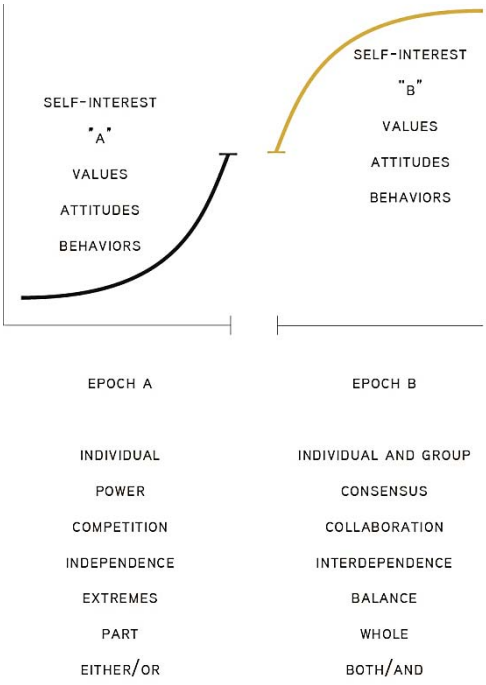
"In Epoch A, competition and the demands of persistent, accelerating growth were inherently associated with either/or attitudes and philosophies and the prevalence of win-lose strategies in the resolution of conflict. People or nations saw the world as a place in which any benefit to the other is a loss or detriment to the self. In Epoch B, however, the tendency toward balance, collaboration, and interdependence will be based upon and evoke a philosophy of both/and and the development of win-win strategies."



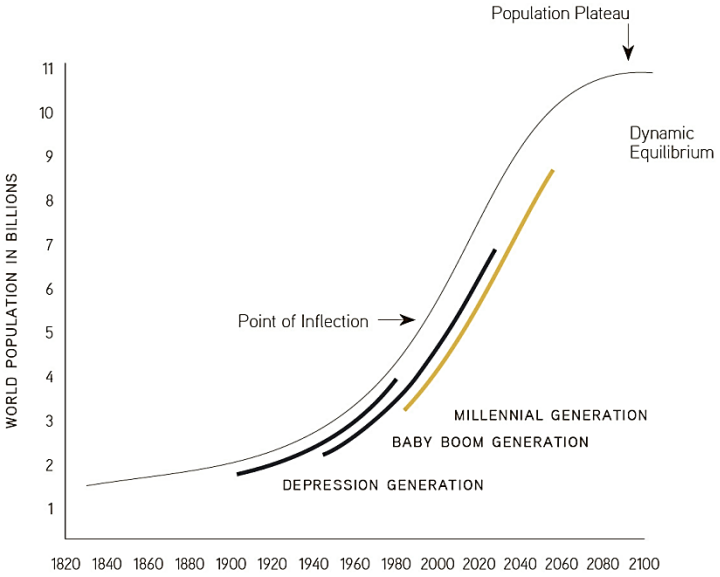


"Epoch B values, attitudes, and behaviors are emerging not only because they are humane but also because they are advantageous to individuals and to society. During this transition, it can be expected that conflict, at all levels

of human life, will increase. In the long term, such conflict will be most effectively and constructively resolved with both/and rather than either/or strategies and through the integration of the values of Epoch A and Epoch B. The present period is especially sensitive. In resisting change, we may cling to values that are obsolete and exceed the tolerance of nature. Resisting change may ameliorate some problems in the short term but will not provide the basic shift in values needed in this epochal transition."



"Those in the Baby Boom generation were born just before the point of inflection; however, the inflection of the curve occurred during their lifetimes. Thus, they were born in the reality of Epoch A but have lived the later part of their lives in Epoch B—the part of the curve where growth is slowing. Those in the Millennial generation were born after the point of inflection of the growth curve, fully in Epoch B. From the time of their birth, the reality they have experienced has been one of awareness of limits, the need to conserve, and the sense of the planet as an integrated whole. Thus, their attitudes, values, and behaviors have been shaped by and are adapted to a reality very different from that experienced by any generation before them."



"The epochal change now taking place affects every aspect of human life—individual and institutional, emotional and cognitive, personal and technological. It calls for the resolution of imbalances and conflicts that have arisen in the course of preceding centuries and for the integration of divergent tendencies in human life. This integration will occur in ways that will differ according to local history, culture, and ecological conditions, but it must occur."

Salk, Jonas; Jonathan Salk (2018): *A new reality: Human evolution for a sustainable future*, City Point Press, Stratford, CT.

67. The growth imperative/trap (Douglas Rushkoff, 2016)

"Plants grow, people grow, even whole forests, jungles, and coral reefs grow—but eventually, they stop. This doesn't mean they're dead. They've simply reached a level of maturity where health is no longer about getting bigger but about sustaining vitality. There may be a turnover of cells, organisms, and even entire species, but the whole system learns to maintain itself over time, without the obligation to grow. Companies deserve to work this way as well. They should be allowed to get to an appropriate size and then stay there, or even get smaller if the marketplace changes for a while. But in the current business landscape, that's just not permitted. Corporations in particular are duty bound to grow by any means necessary. For Coke, Pepsi, Exxon, and Citibank, there's no such thing as "big enough"; every aspect of their operations is geared toward meeting new growth targets perpetually. That's because, like a shark that must move in order to breathe, corporations must grow in order to survive (…) A corporation is just a set of rules, and so is software. It's all code, and it doesn't care about people, our priorities, or our future unless we bother to program those concerns into it."

"The corporation has no choice other than to exercise the four sides of its original tetrad: extract value, squash local peer-to-peer markets, expand the empire, and seek personhood—all in order to grow pots of money, or capital. The most successful and most loathed corporations of the last century all work this way. Walmart, for one ready example, lives by the tetrad. It extracts value from local communities, replacing their peer-to-peer economies with a single, one-way distribution point for foreign goods. Workers are paid less

than they earned in their previous jobs or businesses and are often limited to part-time employment so the company can externalize the cost of health care and other benefits to local government (…) When it moves into a new region, it undercuts the prices of local merchants—often taking a loss on sales of locally available g oods simply to put smaller merchants out of business (…) Walmart retrieves the values of empire, where expansion is the primary aim. It has opened as many as one store a day in the United States alone.7 The company sometimes opens two stores, ten or twenty miles apart in a new region, and keeps them both open until local merchants go out of business and new consumer patterns are established. Then it closes the less popular store, forcing those consumers to travel to the other one (…) Finally, in its flip toward personhood, Walmart has attempted to accomplish all this with a human face—quite literally. The company adopted a version of the iconic 1970s yellow smiley face as a brand personality (…) Walmart's motto went from the utilitarian and immortal 'Always Low Prices' to the much more humanistic 'Save Money. Live Better.'"

Economy types	ARTISANAL 1000–1300	INDUSTRIAL 1300–1990	DIGITAL INDUSTRIALISM 1990–2015	DIGITAL DISTRIBUTISM 2015–
Direction	•	↗	⤴	↻
Purpose	Subsistence	Growth	Exponential growth	Sustainable prosperity
Company	Family business	Chartered monopoly/ corporation	Platform monopoly (Amazon, Uber)	Platform cooperative (Mondragon, La'Zooz)
Currency	Market money (support trade)	Central currency (support banks)	Derivative instruments (leverage debt)	Bitcoin and P2P (promote circulation)
Investment	Direct investment	Stock markets	Algorithms	Crowdfunding
Production	Handmade (manuscript)	Mass-produced (printed book)	Replicable (file)	Collaborative (wiki)
Marketing	Human face	Brand icon	Big data (prediction)	Utility, legacy (product attributes, company ethics)
Communications	Personal contact	Mass media	Apps	Networks
Land & resources	Church commons	Colonization	Privatization	Public commons
Wages	Paid for value (craftsperson)	Paid for time (employee)	Not paid/underpaid (independent contractor)	Value exchanged (community member)
Scale	Local	National	Global	Strategically bounded
Optimized for	Creation of value	Extraction of value	Destruction of value	Exchange of value

Rushkoff, Douglas (2016): *Throwing rocks at the Google bus: How growth became the enemy of prosperity*, Portfolio/Penguin.

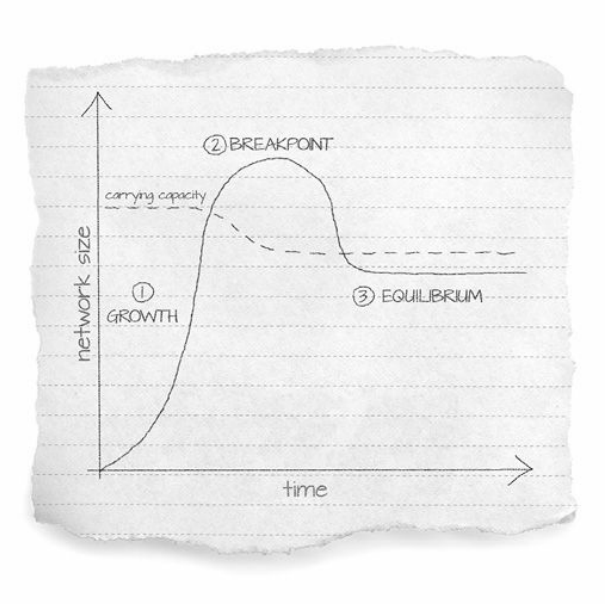
68. The two competing narratives of political economy (Capaldi and Lloyd, 2011)

- The liberty narrative. It originated with John Locke but became associated with Adam Smith. This narrative: (a) promotes personal autonomy and both economic and political liberty; (b) has a positive view of markets, technology and private property; and (c) encourages the pursuit of happiness (progress is improvement).

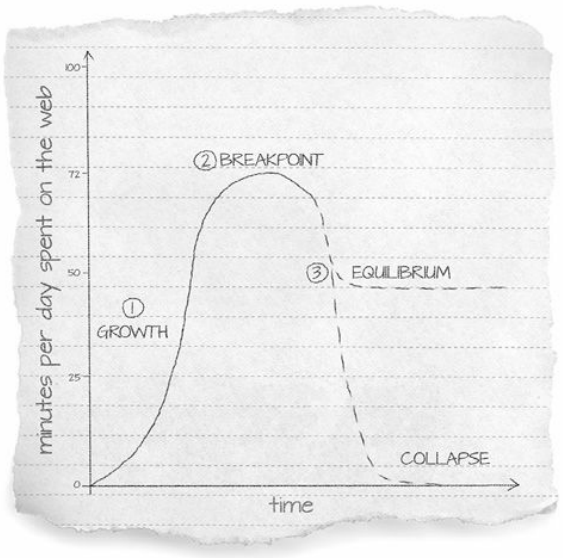
- The equality narrative. It originated with Jean-Jacques Rousseau but became associated with Karl Marx. This narrative: (a) promotes the social good, restrictions of individual autonomy and both economic and political equality; (b) emphasizes the problems caused by markets, technology and private property; and (c) encourages the securing of happiness (progress is perfection).

69. The three phases of networks (Jeff Stibel, 2013)

"There are three phases to any successful network: first, the network grows and grows and grows exponentially; second, the network hits a breakpoint, where it overshoots itself and overgrows to a point where it must decline, either slightly or substantially; finally, the network hits equilibrium and grows only in the cerebral sense, in quality rather than in quantity."



"Internets, ant colonies, and brains all start small, grow steadily, and then explode into hypergrowth. In nature, all species multiply as much as resources allow. This expansion may start linearly, but it quickly becomes exponential. Populations of plants, animals, yeast, and brain cells grow unencumbered until they reach the maximum quantity that the environment can sustain, the carrying capacity of an ecosystem."



"Ant colonies, various other animal species, brains, and internets are all networks, and as such they follow the same pattern of growth, breakpoint, and equilibrium. They start out small and grow explosively to the point where they overshoot and collapse. A successful network has only a small collapse, out of which a stronger network emerges wherein it reaches equilibrium, oscillating around an ideal size (…) At the phase of equilibrium, networks continue to grow, but in terms of quality instead of quantity. When the size of a network slows, other things speed up—like communication, intelligence, and consciousness. At this point, the real magic begins. This last network phase is poorly understood, even by biologists. We are just beginning to learn about equilibriums in biological systems, let alone in technology."

Stibel, Jeff (2013): ***Breakpoint: Why the web will implode, search will be obsolete, and everything else you need to know about technology is in your brain.***

70. Matt Ridley (2010) on the modern global economy

"To explain the modern global economy, then, you have to explain where this perpetual innovation machine came from. What kick-started the increasing returns? They were not planned, directed or ordered: they emerged, evolved, bottom-up, from specialisation and exchange. The accelerated exchange of ideas and people made possible by technology fuelled the accelerating growth of wealth that has characterised the past century."

"Innovation is like a bush fire that burns brightly for a short time, then dies down before flaring up somewhere else. At 50,000 years ago, the hottest hot-spot was west Asia (ovens, bows-and-arrows), at 10,000 the Fertile Crescent (farming, pottery), at 5,000 Mesopotamia (metal, cities), at 2,000 India (textiles, zero), at 1,000 China (porcelain, printing), at 500 Italy (double-entry book-keeping, Leonardo), at 400 the Low Countries (the Amsterdam Exchange Bank), at 300 France (Canal du Midi), at 200 England (steam), at 100 Germany (fertiliser); at 75 America (mass production), at 50 California (credit card), at 25 Japan (Walkman). No country remains for long the leader in knowledge creation (…) Why must the torch be passed elsewhere at all? (…) The answer lies in two phenomena: institutions and population. In the past, when societies gorged on innovation, they soon allowed their babies to grow too numerous (…) or they allowed their bureaucrats to write too many rules, their chiefs to wage too many wars, or their priests to build too many monasteries (…) or they sank into finance and became parasitic rentiers."

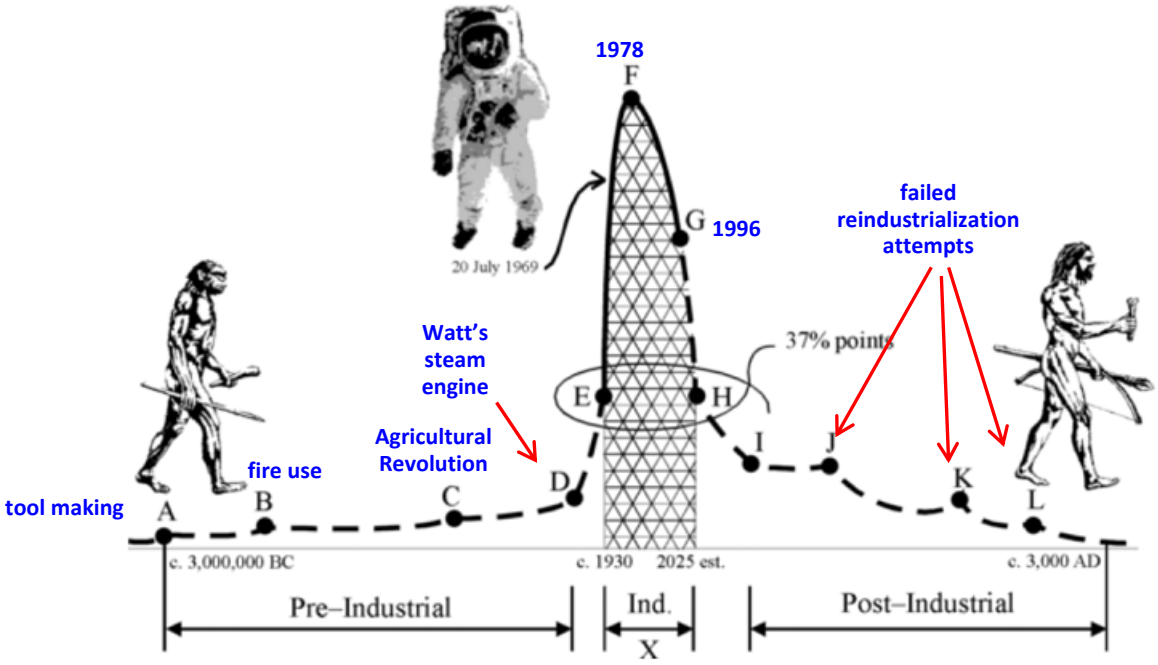
Ridley, Matt (2010): ***The rational optimist: How prosperity evolves*****, HarperCollins, New York.**

71. The Olduvai theory of industrial civilization (http://www.hubbertpeak.com/duncan/olduvai.htm)

The Olduvai theory of industrial civilization holds that industrial civilizations last around one century. The variable that determines the rise and fall of an industrial civilization is energy production per capita.

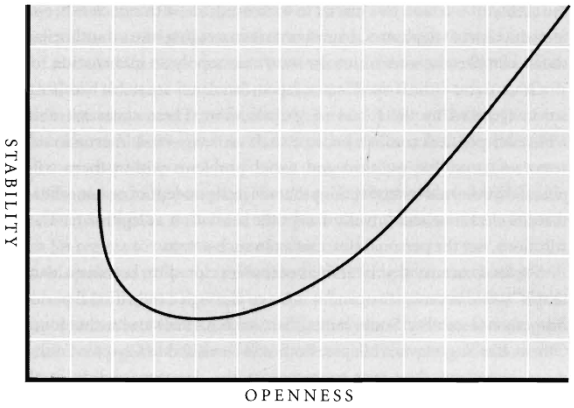
"The Olduvai Theory states that the life expectancy of industrial civilization is approximately 100 years: circa 1930-2030. Energy production per capita (e) defines it. The exponential growth of world energy production ended in 1970... Average e will show no growth from 1979 through circa 2008... The rate of change of ewill go steeply negative circa 2008... World population will decline to about two billion circa 2050... A growing number of independent studies concur..."

Richard C. Duncan (2005-2006): "The Olduvai Theory. Energy, population, and industrial civilization", The Social Contract, Winter 2005-2006.



72. Ian Bremmer's (2006) J curve between stability and openness

"Each nation whose level of stability and openness we want to measure appears as a data point on the graph. These data points, taken together, produce a J shape. Nations to the left of the dip in the J are less open; nations to the right are more open. Nations higher on the graph are more stable; those that are lower are less stable." (Bremmer, 2006, p. 6)



Bremmer, Ian (2006): *The J curve: A new way to understand why nations rise and fall*, Simon & Schuster, New York.

73. Laws of capitalist economies (Michael Hudson)

- "The inexorable tendency of debt to grow beyond the ability to be paid."
- "There is no way to sustain the rise in debt without killing the economy."

"Neoliberals say they're against government, but what they're really against is democratic government. (...) As Germany's Wolfgang Schäuble said, 'democracy doesn't count.' Neoliberals want the kind of government that will create gains for the banks, not necessarily for the economy at large. Such governments basically are oligarchic. Once high finance takes over governments as a means of exploiting the 99%, it's all for active government policy – for itself."

Hudson, Michael (2017): *J is for junk economics: A guide to reality in an age of deception*, ISLET-Verlag.