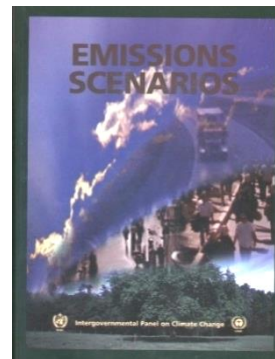
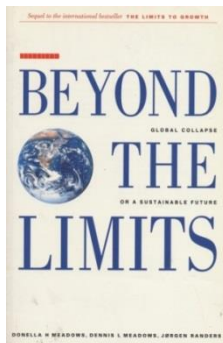
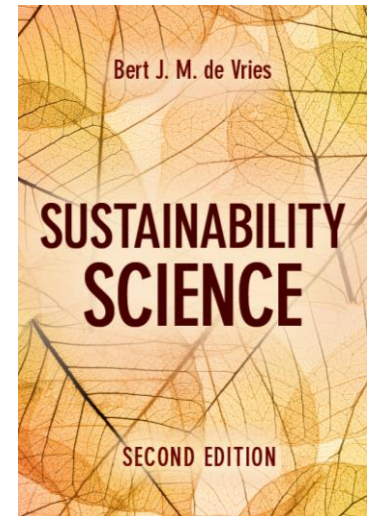
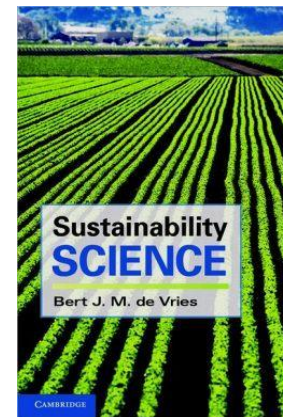
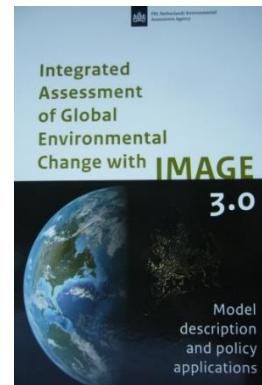
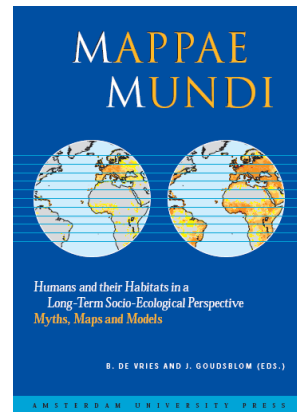
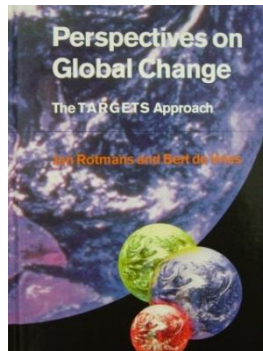
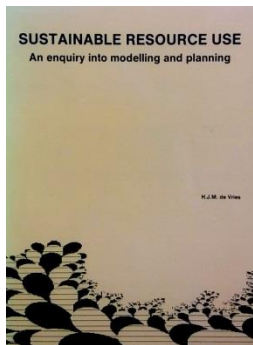


A critical perspective  
on contemporary economic concepts,  
theory and modelling

*Lecture at Maastricht University  
School of Business and Economics  
19 March 2025*

*Prof. em. dr. Bert de Vries  
Copernicus Institute of Sustainable Development, Utrecht University*

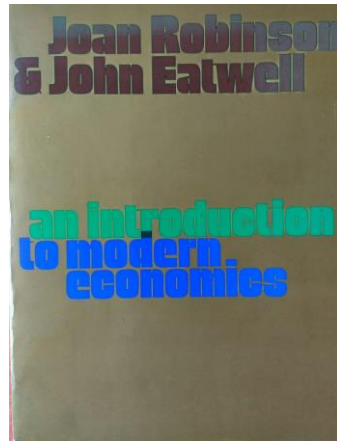
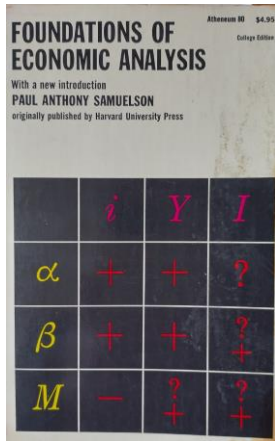
**My background:** natural science and philosophy, energy modelling and policy, global change and climate modelling and policy, teaching energy and sustainability science



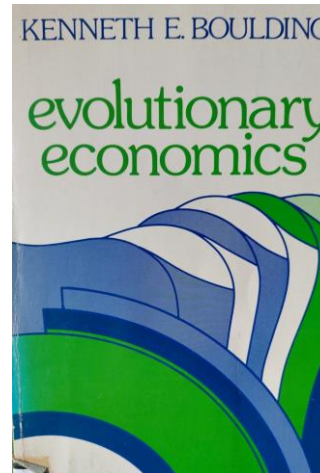
[www.sustainabilityscience.eu](http://www.sustainabilityscience.eu)

# Disclaimer:

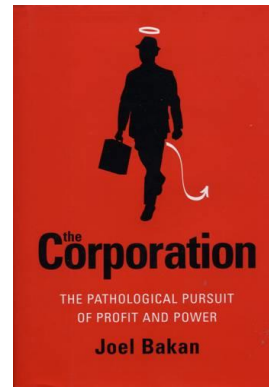
- I'm educated in physics and chemistry, not in economics
- My exposure to economic theory has been biased: Club of Rome Limits to Growth, Integrated Assessment Models of Global Change (IAMs), Climate Change modelling



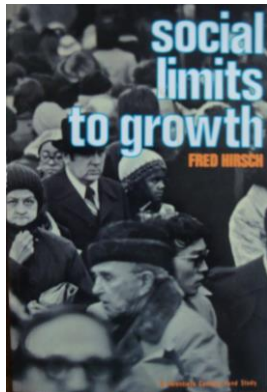
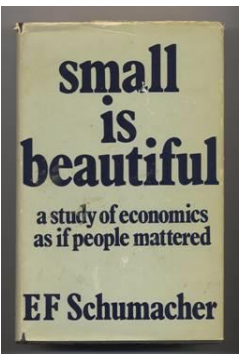
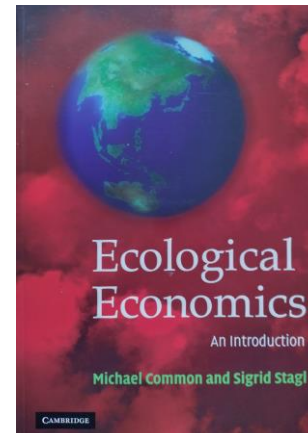
ecology



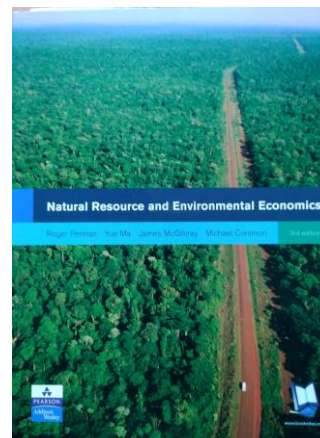
capitalism



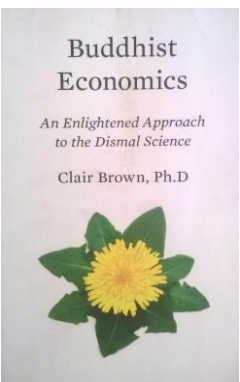
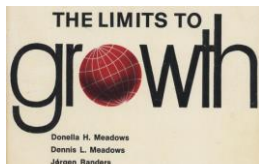
nature



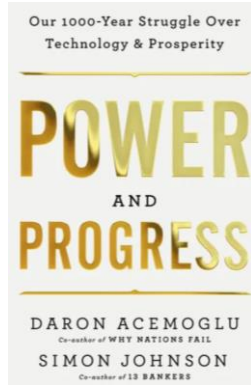
environment



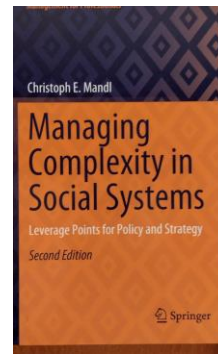
(resource) limits



history [of  
technology]



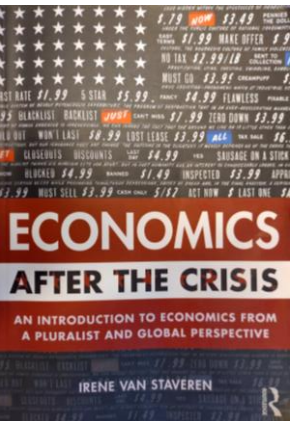
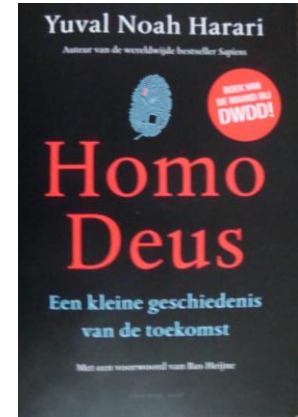
complex  
systems science



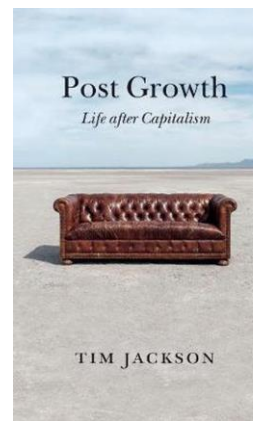
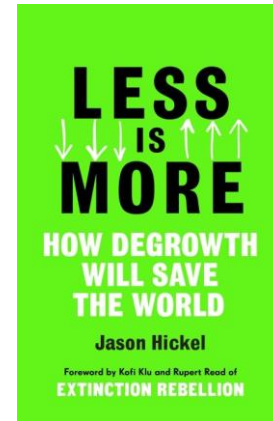
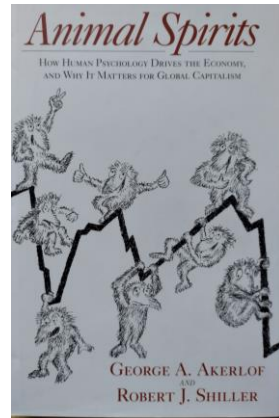
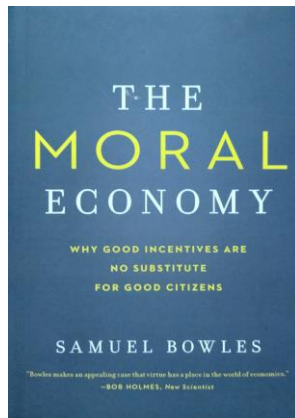
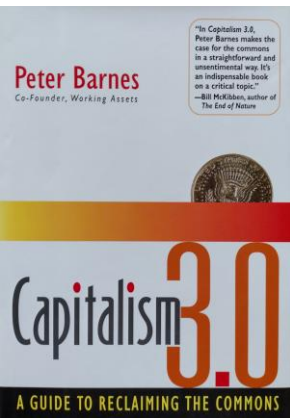
homo  
economicus?

finance and inequity

private equity  
(ir)rationality



degrowth  
post-growth



# Content of the lecture

1. **Background** to (macro-)economics
  - Boundaries of system considered
  - Time-space dimensions in human experience
  - Historical setting: economics as outcome of Modernity
  - Fruits and shadows of Modernity
2. **Modelling Global Change: Limits to Growth (1971-2022)**
3. What and how to **measure** about economic activity?
  - Indicators: GDP, income, wealth and well-being
  - Defining the economic system: what is [not] included?
4. The role of **state and government**
  - State, market, community – and ideology
  - Corporate power and ‘free’ global markets
  - Public vs. private: governing the commons
5. The role of the **financial sector**
  - What is money?
  - Financial institutions and money creation
6. Modelling **economic growth**

# 1.1 Boundaries of the system considered

## Solar energy flow

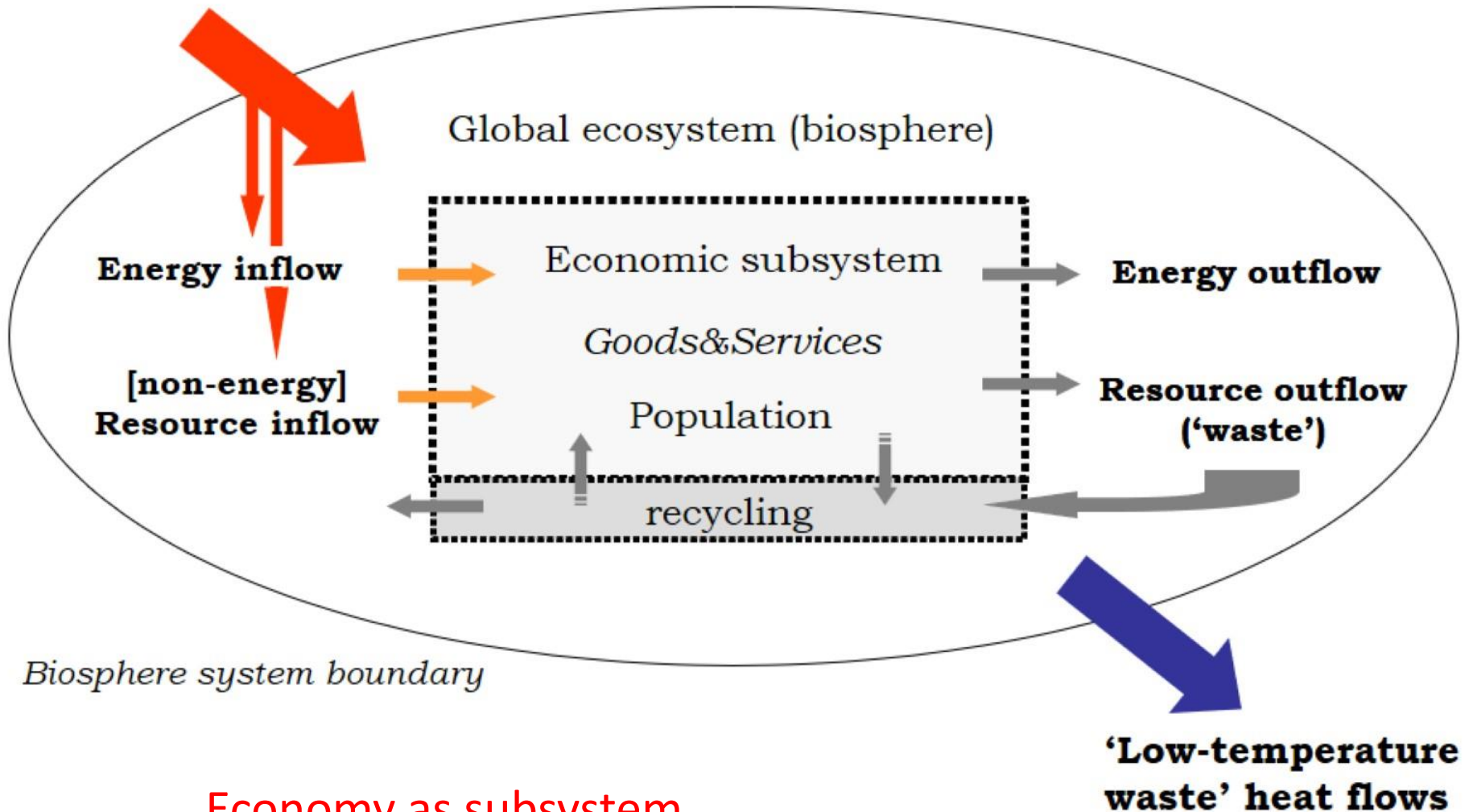
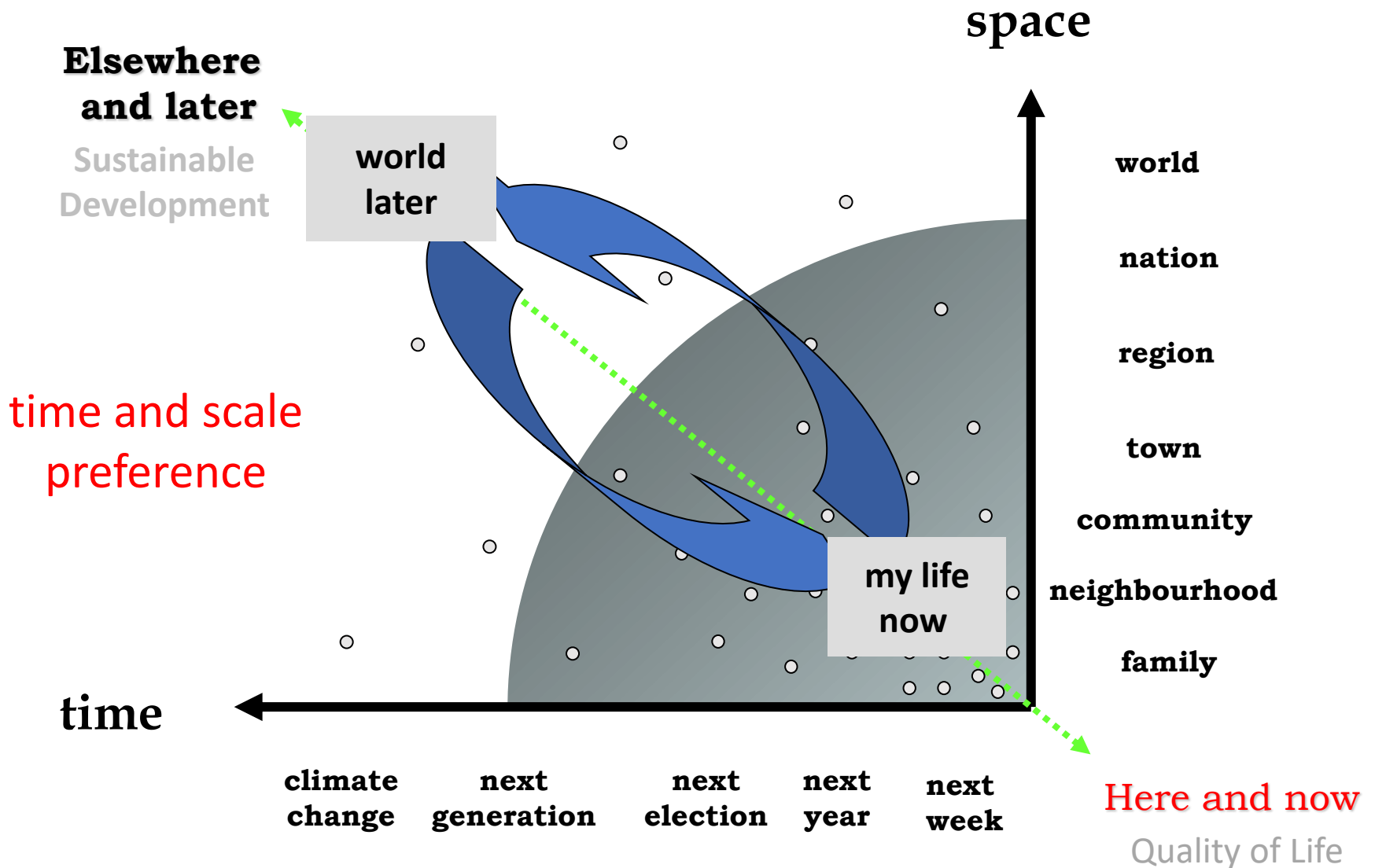
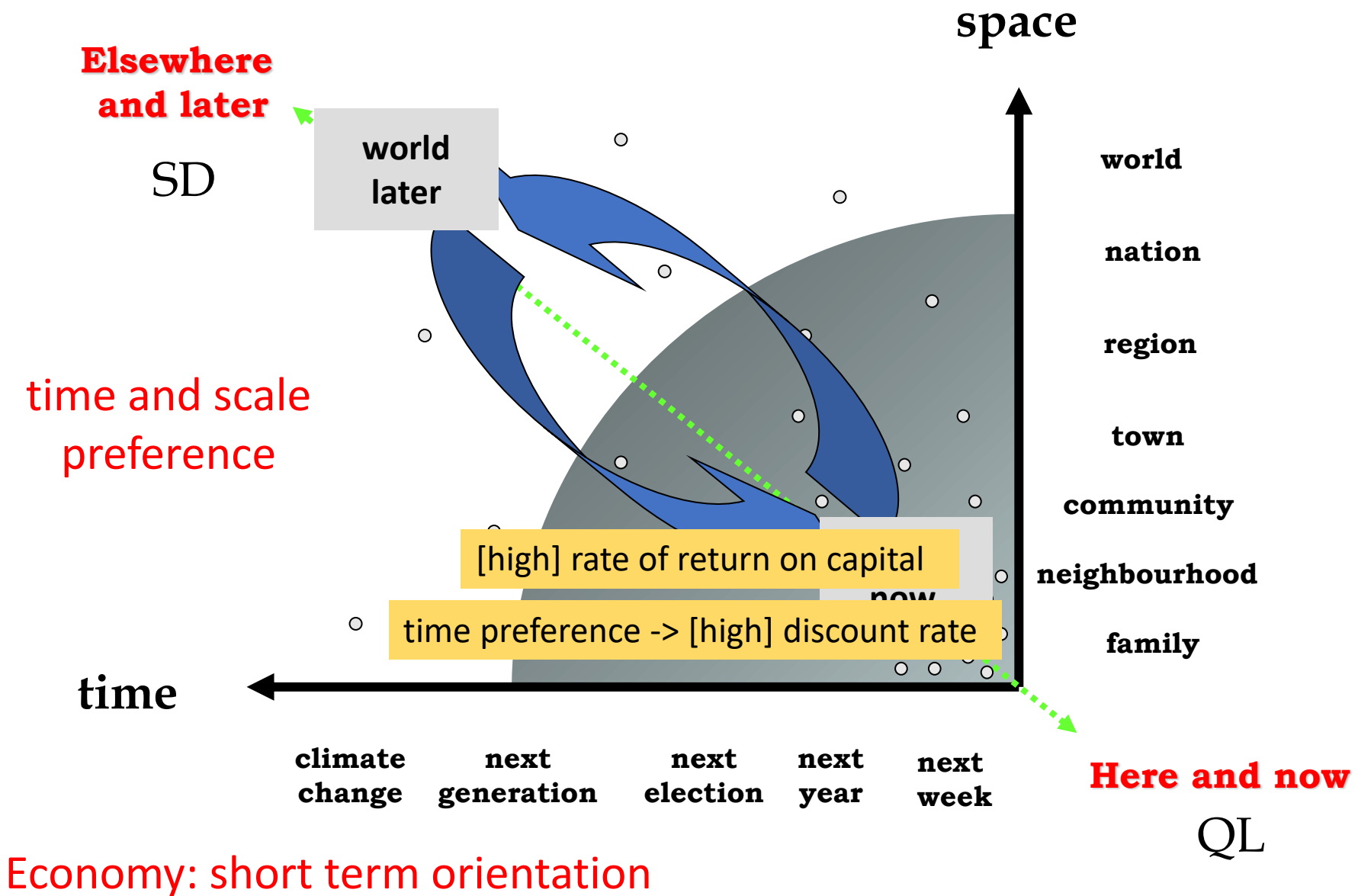


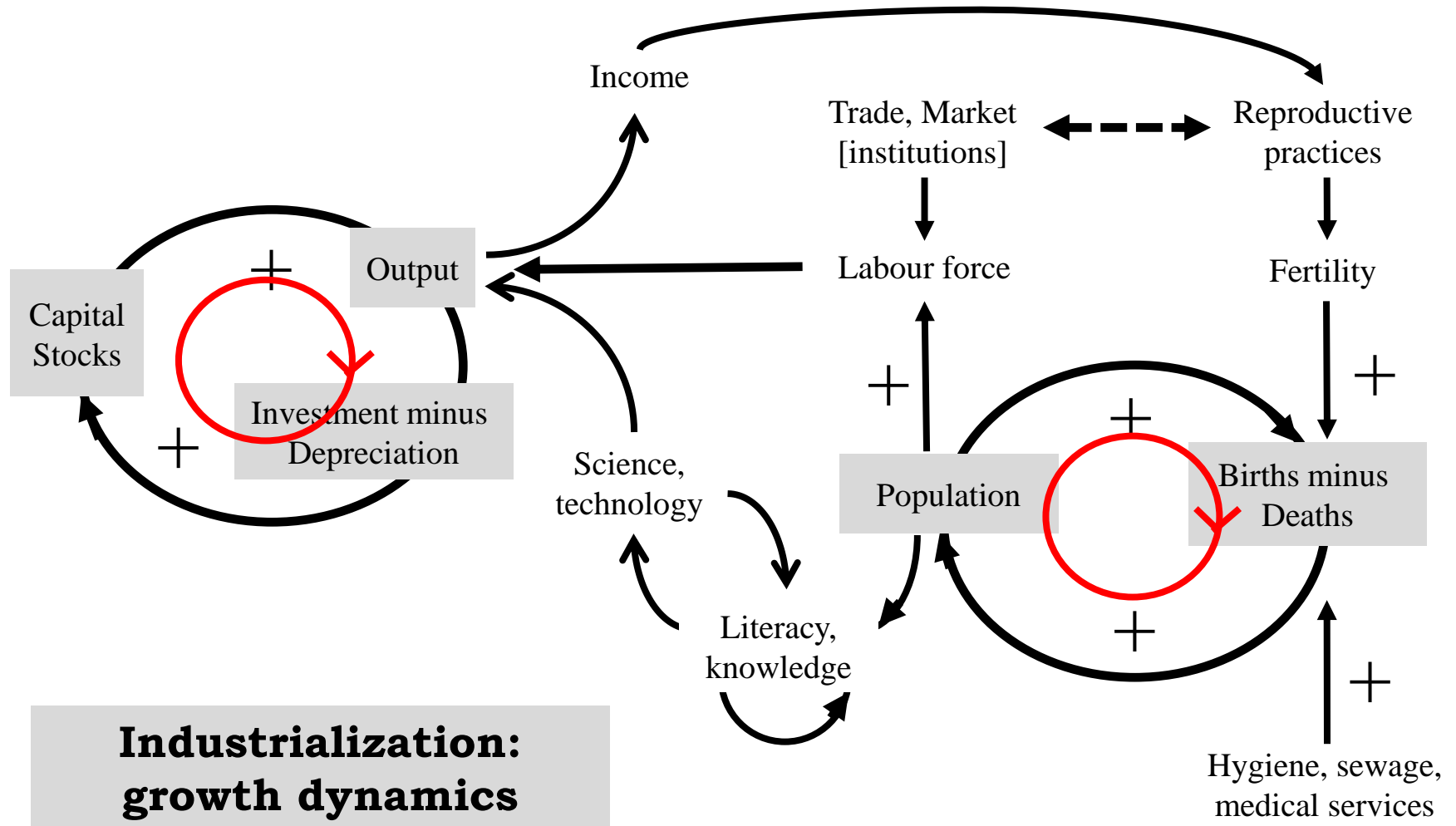
Figure 12.1 Conceptual scheme of human activities within the biosphere.

# 1.2. Time-space dimensions in human experience:

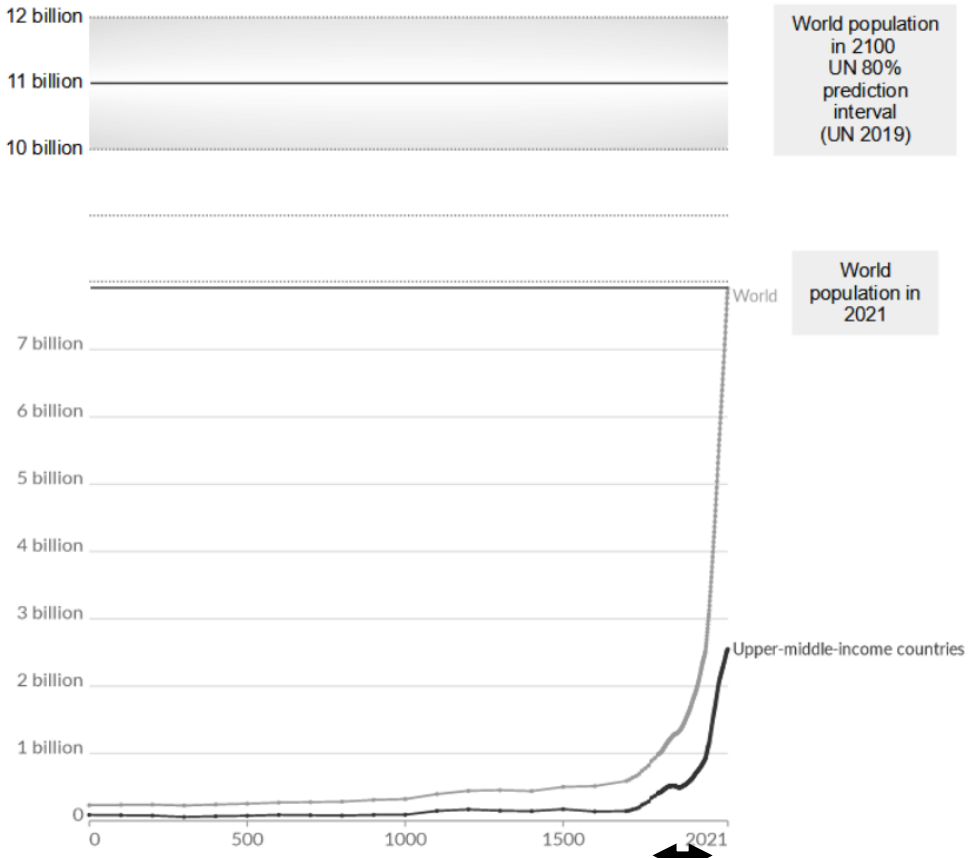




# 1.3 Historical setting: economics as outcome of Modernity



# 'the facts'

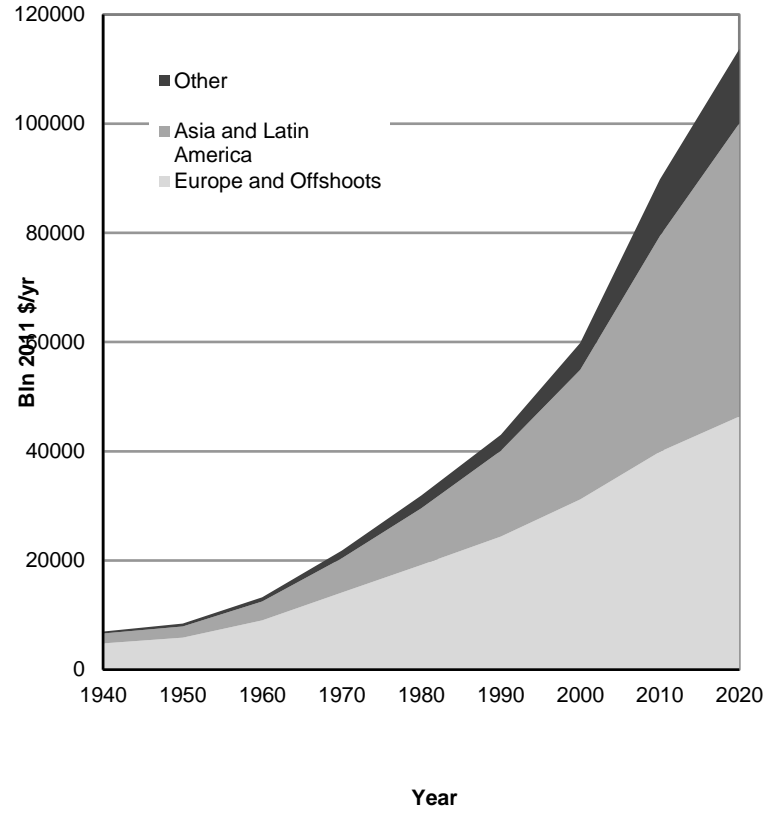


Source: Gapminder (v6); HYDE (v3.2); UN (2022)

Population (# of people)

Growth in population...

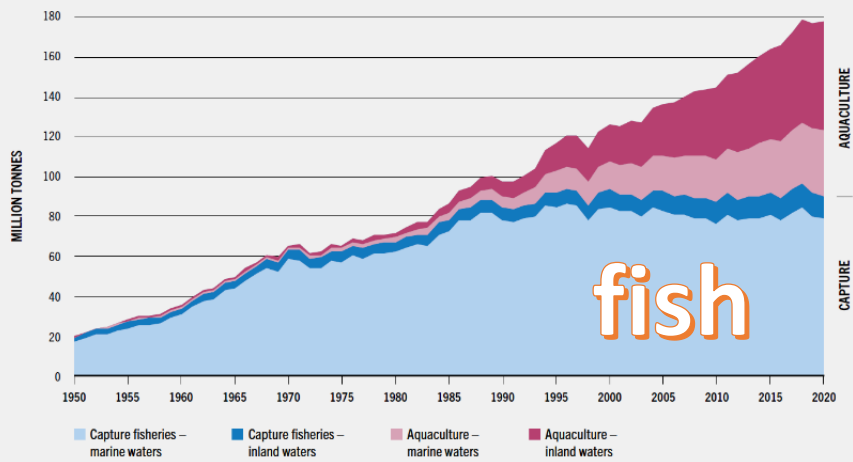
## Economic activity (bln US\$/yr)



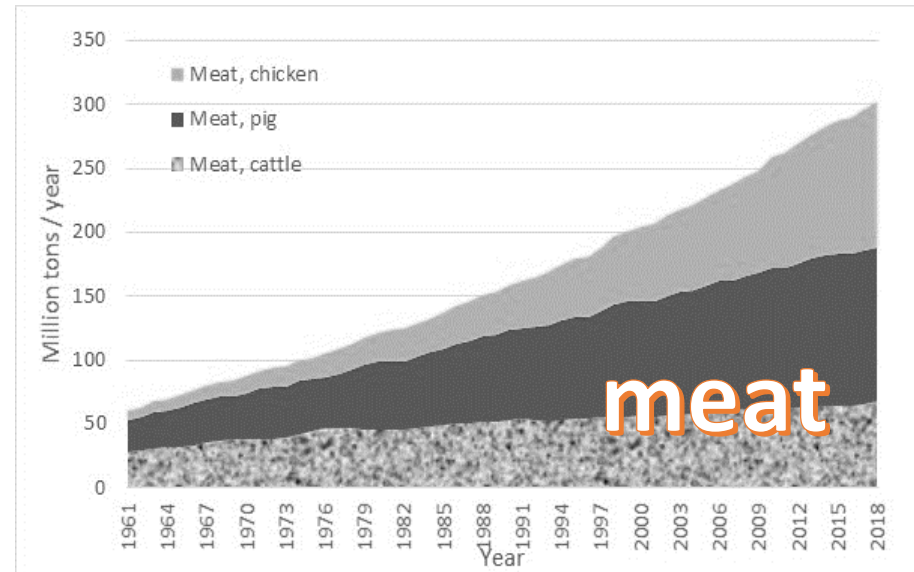
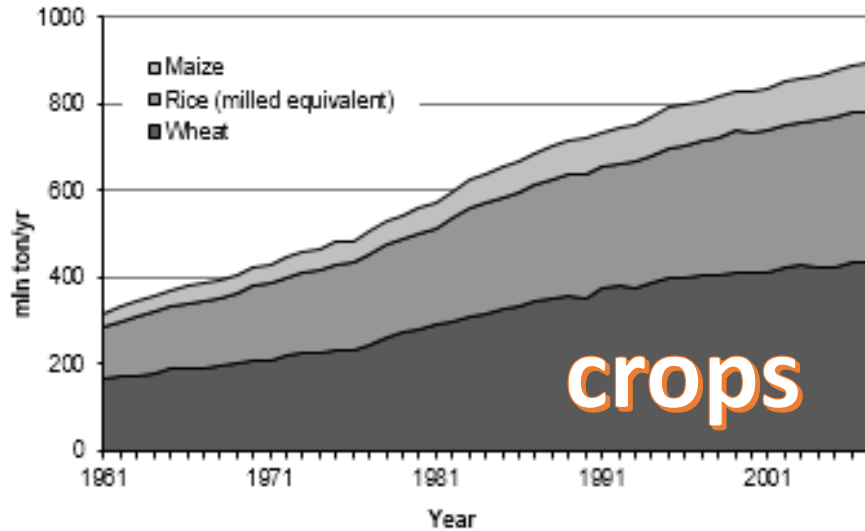
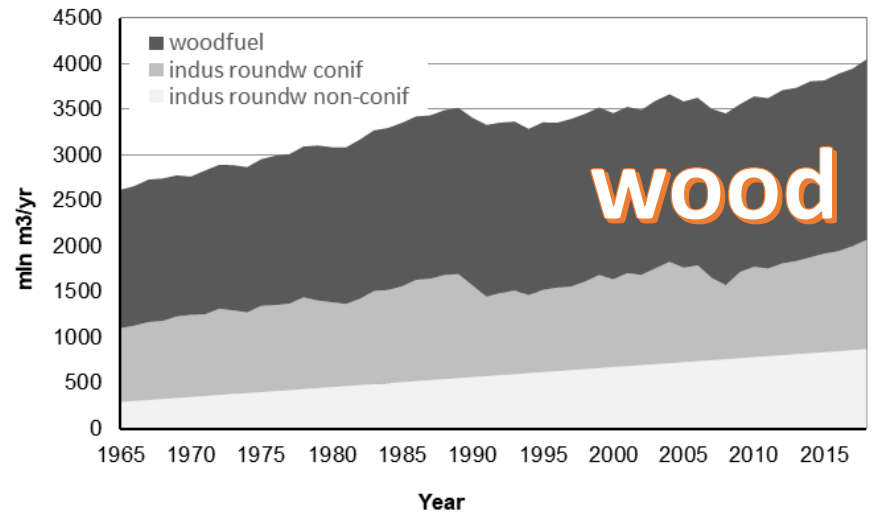
←—————→

...and economic activity...

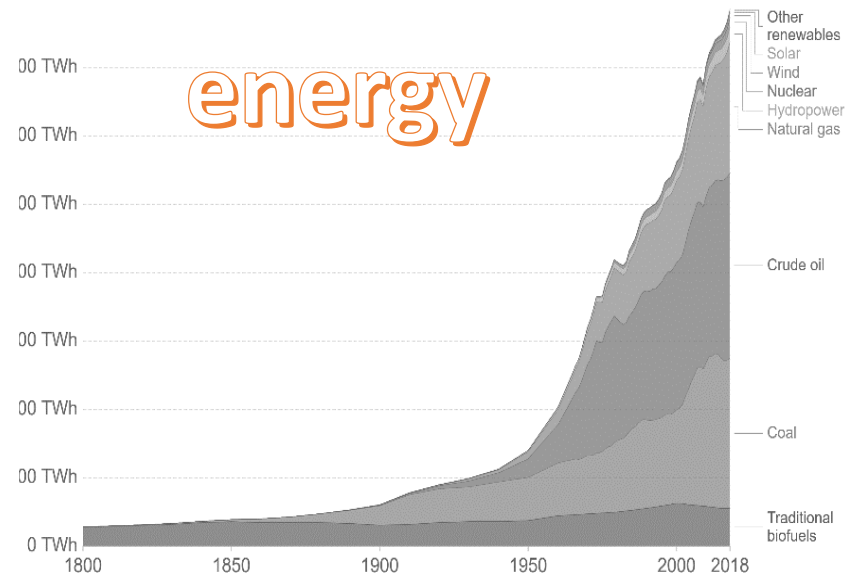
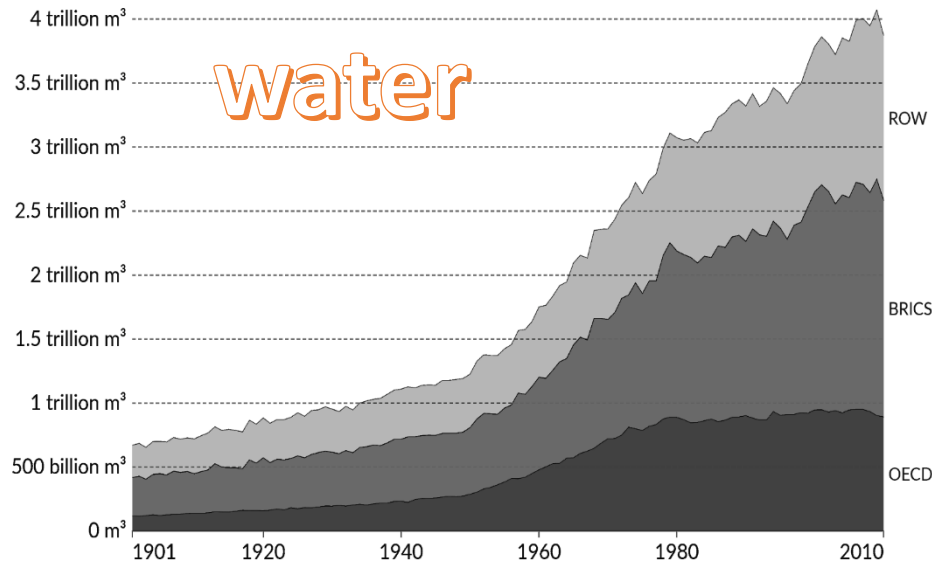
Positive (reinforcing) feedback loops: exponential growth



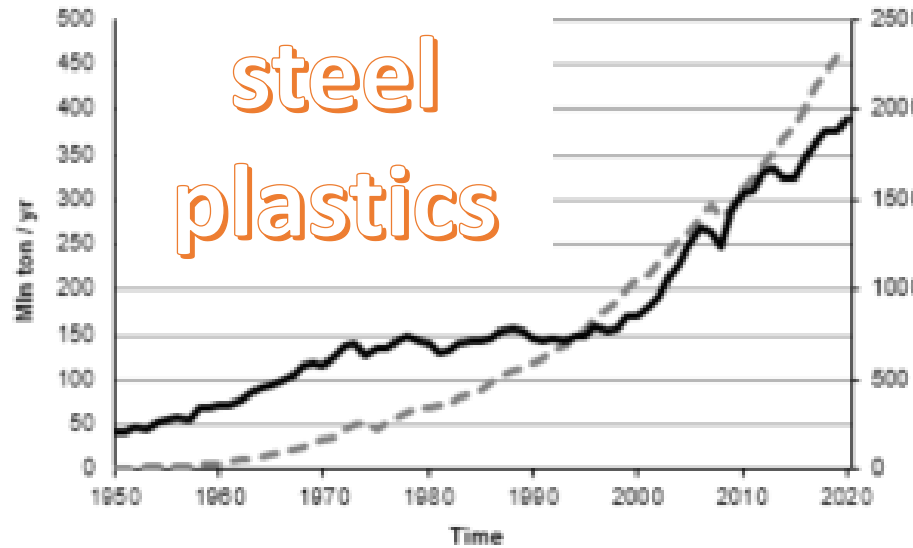
NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent. SOURCE: FAO.



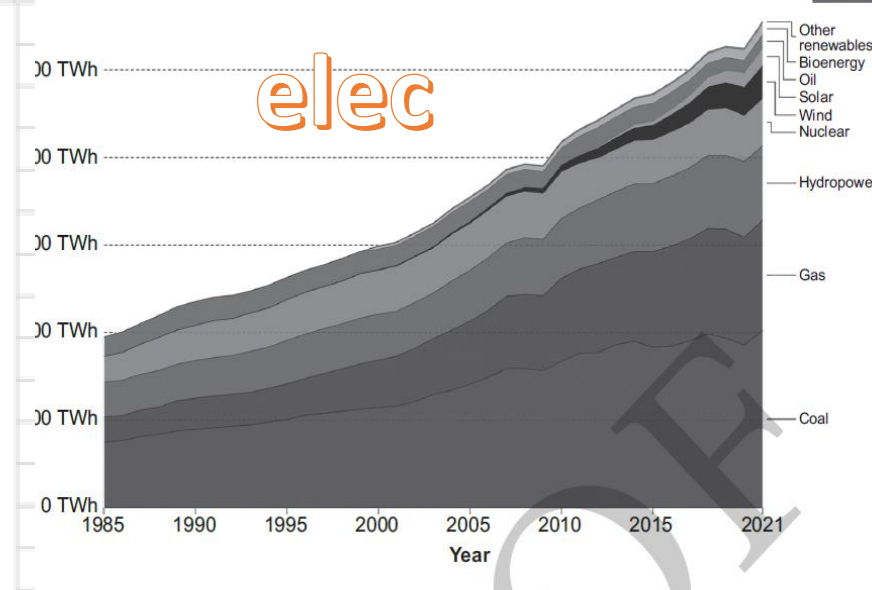
...and exploitation of natural resources since 1950...



Sc  
i)



Vaclav Smil (2017) and BP Statistical Review of World Energy  
CC BY



**...and of water, energy and materials**

# 1.4 Fruits and shadows of [High-] Modernity

High Modernity (1950-1980) Late Modernity (post-1980)

1. the *scientific method of empirical reductionism*, with
  - generate context-independent statements and abstractions;
  - elimination of religious superstition (*Entzauberung*);
  - distrust of personal knowledge; and
  - separation between object and subject, and between fact and value;
2. a continuous process of *rationalization, specialization and standardization* in a relentless quest for increasing efficiency and productivity.
3. a belief – legitimated by science and technology – in *predictability, planning and control of societal processes* by bureaucrat-manager-experts.
4. an *emancipatory ideal* of bringing progress and well-being to all people based on the imperatives of justice, equality and participation.

# 1.4 Fruits and shadows of [High-] Modernity

High Modernity (1950-1980) Late Modernity (post-1980)

1. the *scientific method of empirical*
  - generate context-independent
  - elimination of religious superstition
  - distrust of personal knowledge
  - separation between *instrumental rationality* and *value*;
    - The concept of 'Normalbaum' in 19th century forestry management in Germany; Taylorism in early 20th century; platform standards in early 21st century
2. a *concern for the realization and standardization* in a *reduction of constraints and productivity*.
  - "a generic outlook concerned above all with liberating individuals and groups from constraints which adversely affect their life chances", and the "release of underprivileged groups from their unhappy condition, or to eliminate the relative differences between them"* (Giddens 1991:210).
3. a *belief in technology – in predictability, planning and control by bureaucrat-manager-experts*.
4. an *emancipatory ideal* of bringing progress and well-being to all people based on the imperatives of justice, equality and participation.

## Human quality of life has benefited enormously from developments in (High) Modernity:

- satisfying and creating an *ever broader spectrum of needs*, including near-doubling of average life expectancy
- advancing *differentiation and complexification* of life's evolution (globalization-communication)

At the same time, **Modernism has generated (undesirable, unexpected) side-effects**, often shifted to elsewhere and later:

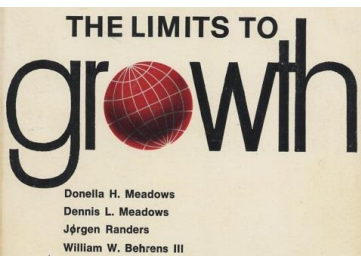
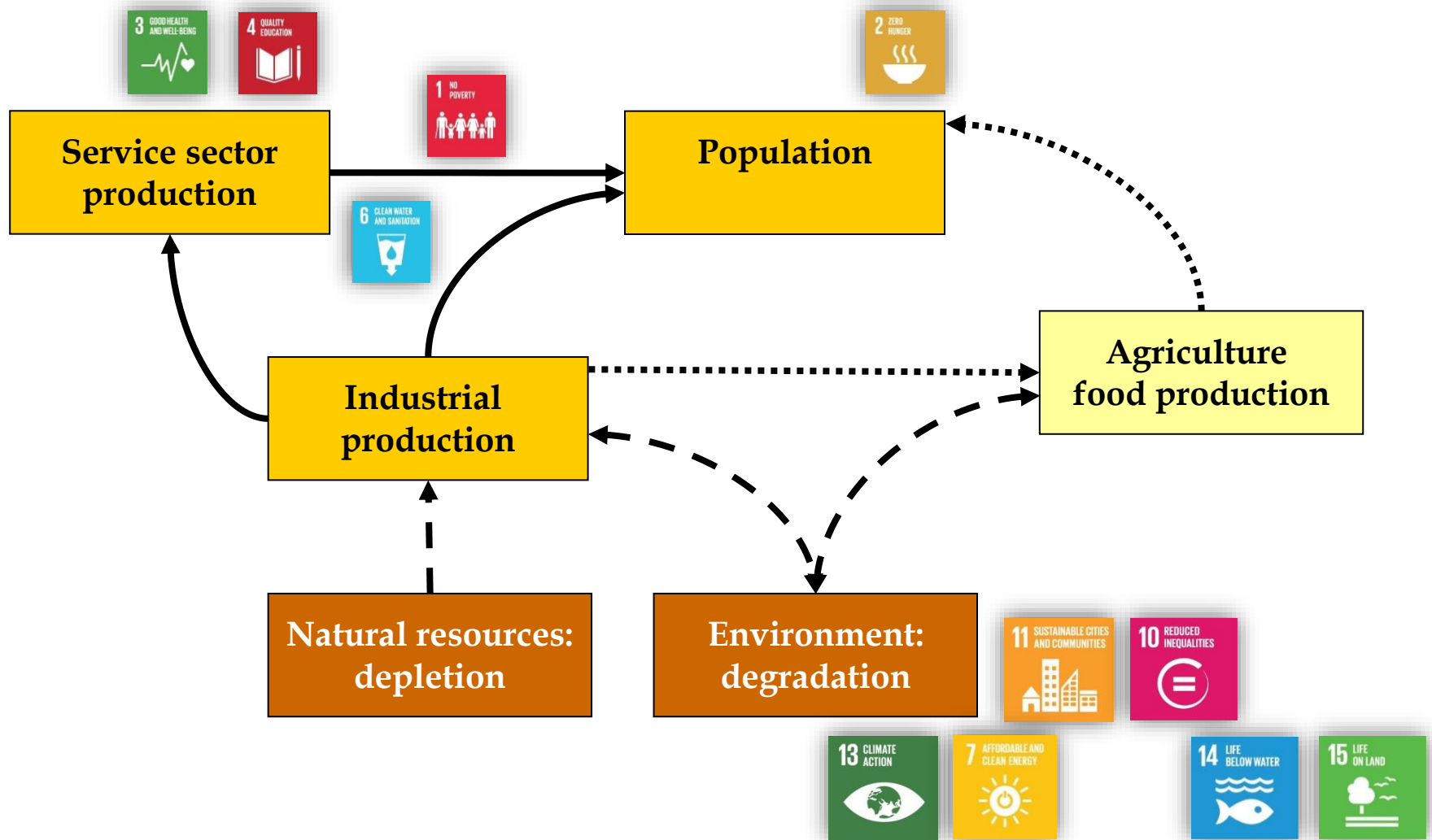
- more extensive and intensive *exploitation of humans and nature* (source depletion, sink pollution)
- *loss of diversity in nature and culture*, with concentration of power
- intractable *technological risks* (Goethe's *Zauberlehrling*)

The 'ruthless logic of modernity'

But is this Progress and (population and economic) growth sustainable?

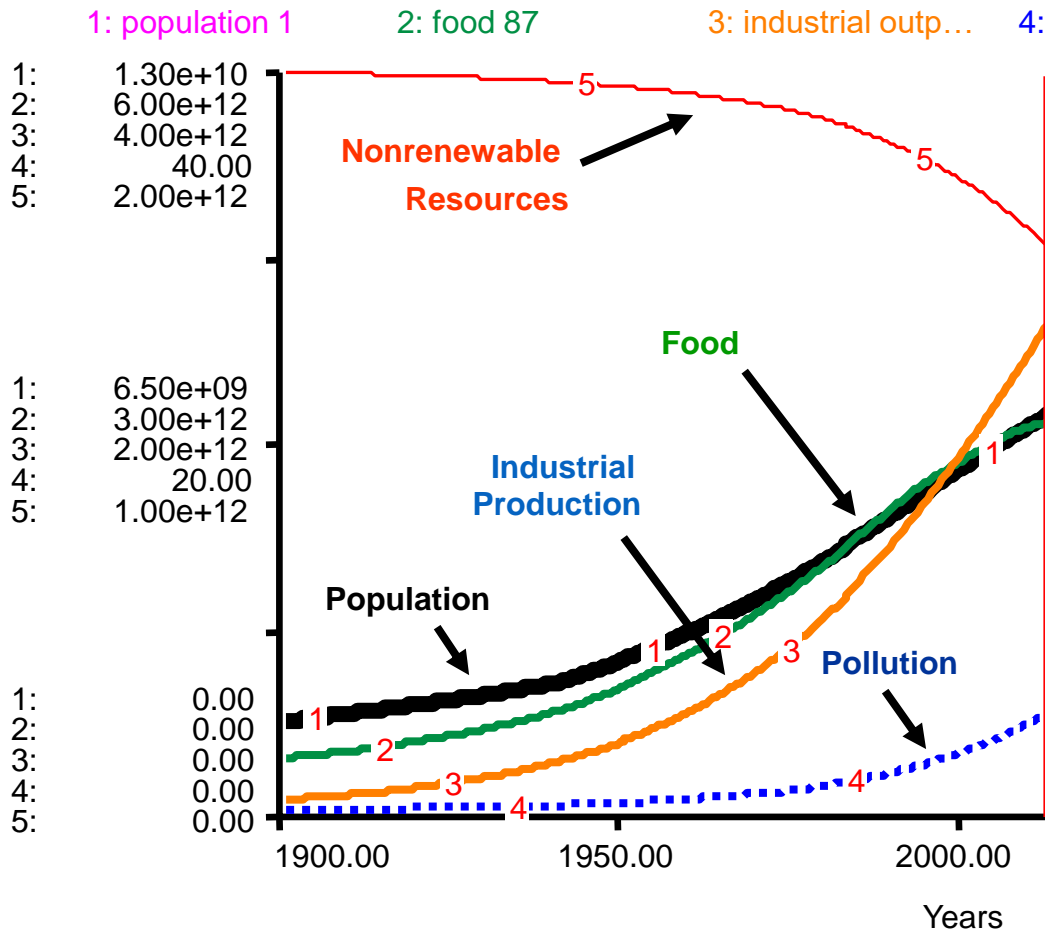


# 2 Modelling Global Change: Limits to Growth (1971-2022)

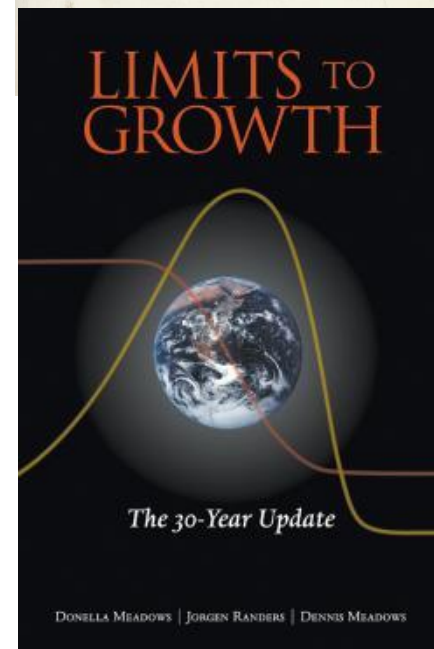
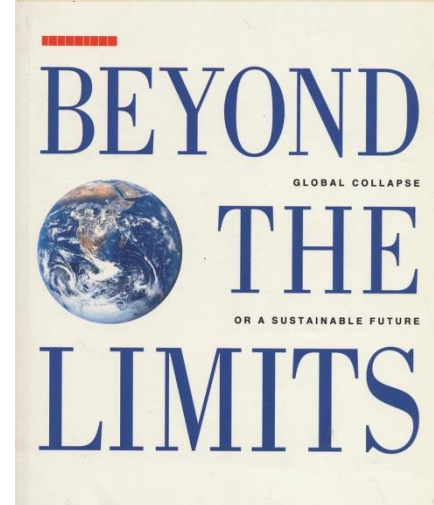
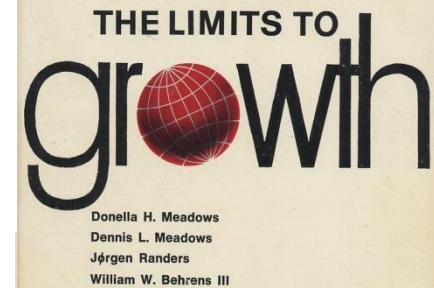


The World3-model: linked subsystems  
with limiting resource systems  
First version in 1971 in Dynamo, present version in STELLA

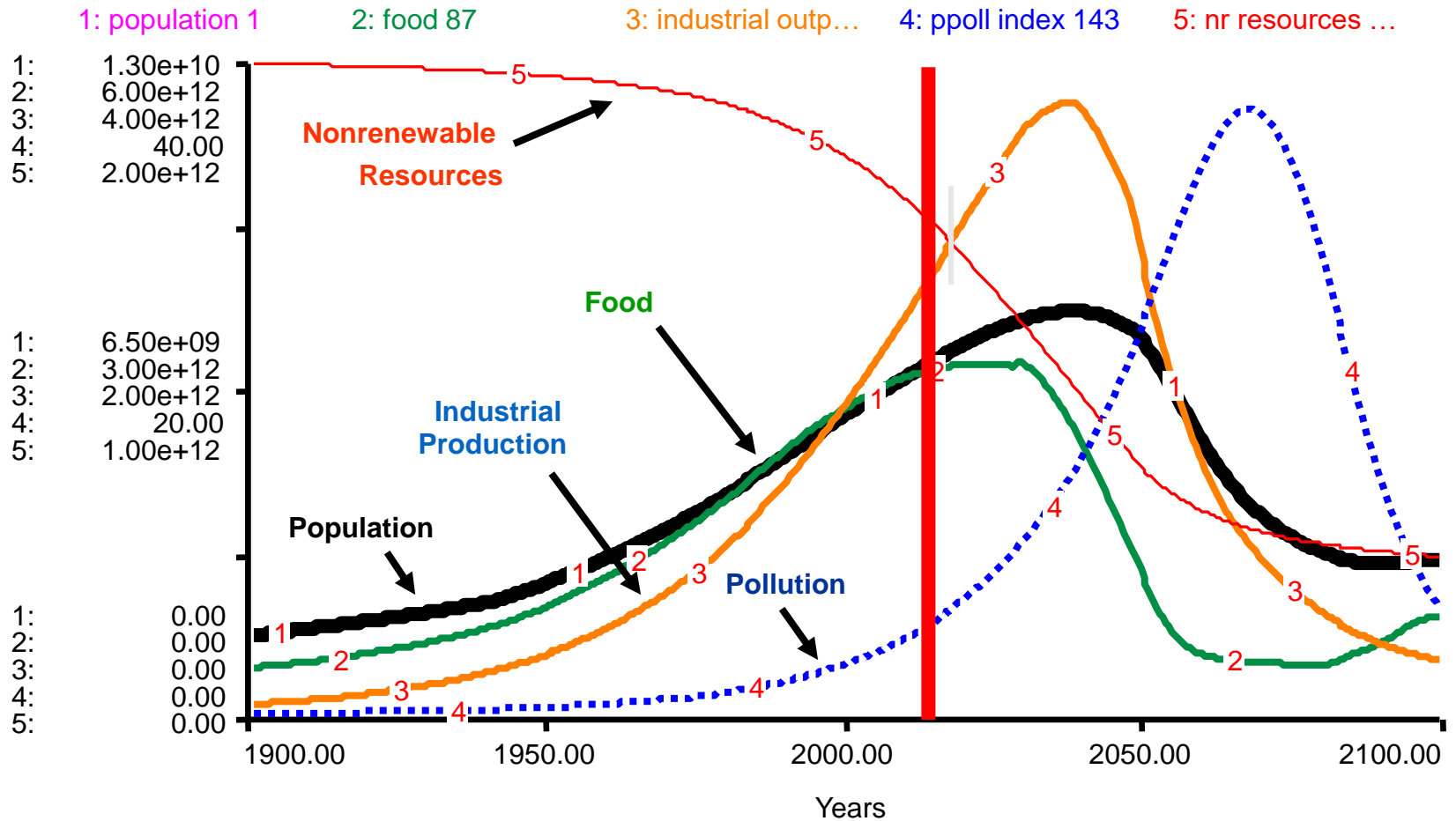
# World3: Trends as simulated in 1972, until 2020...



(Meadows et al. 1972, 1992, 2005)

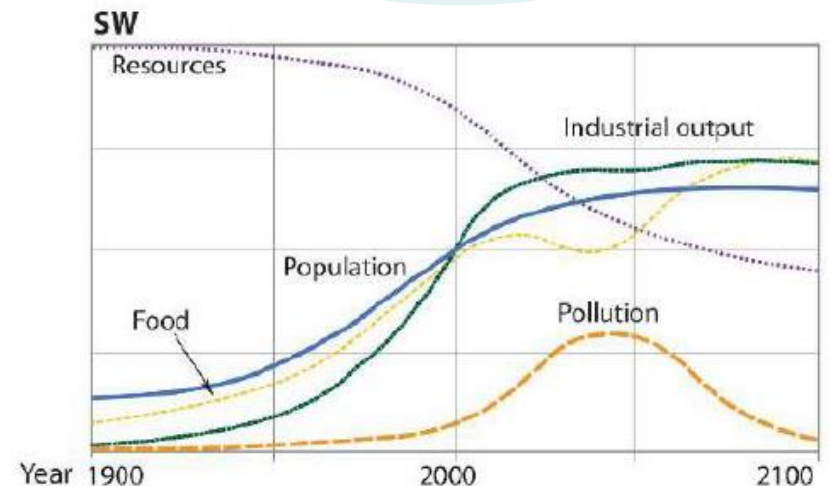
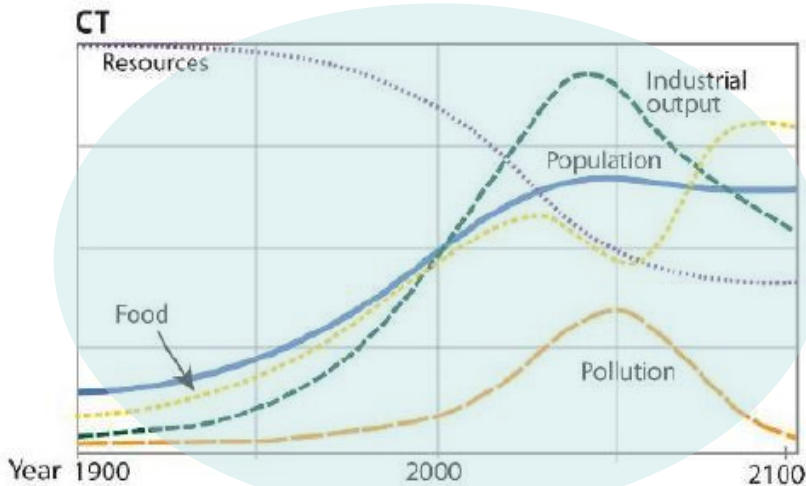
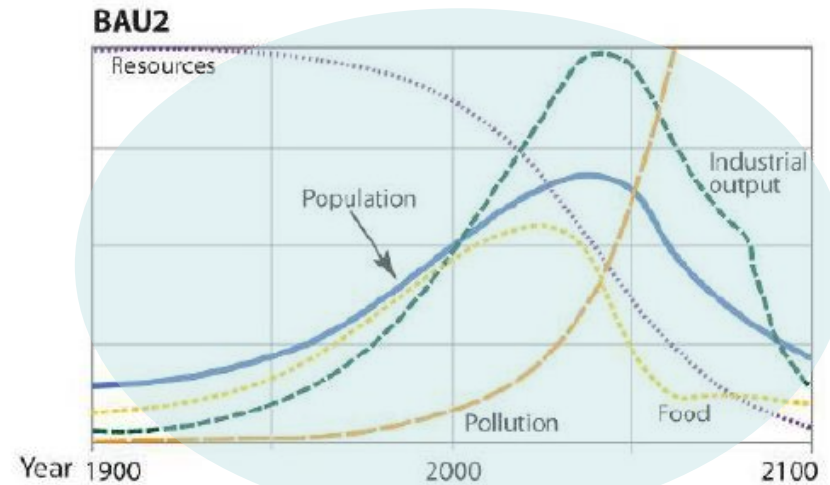
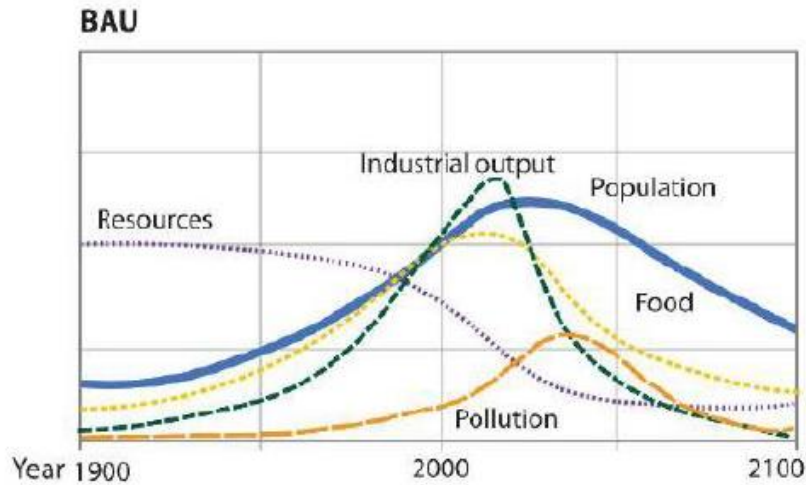


# ... and beyond in a Business-as-Usual scenario...



(Meadows et al. 1972, 1992, 2005)

# Model 'validation' in 2022...



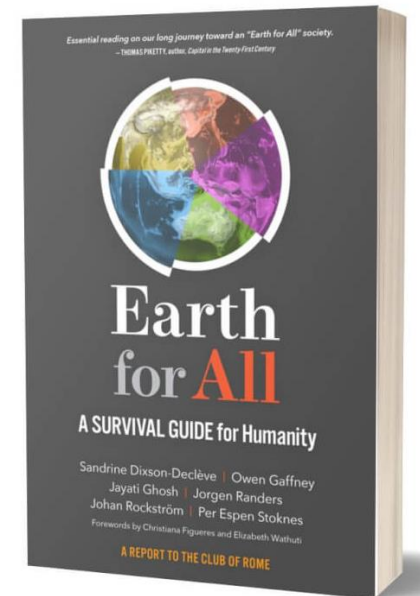
Four scenarios with the World3 model (Meadows et al. 2004)

BAU Business as Usual BAU2 as BAU with twice as many resources

CT Comprehensive Technologies SW Sustainable World (meadows 2005, Herrington 2021)

# Earth4All: latest Report to the Club of Rome (Dixson-Declève et al. 2022)

- expanded, regionalized *Limits to Growth* system dynamics model used to construct two scenarios: *Too little Too Late* and *Giant Leap*
- includes economic and finance mechanisms, (in)equ(al)ity, social tensions and environmental stresses
- outcomes are presented in two aggregate indicators: an **Inequality Index** and a **Social Tension Index**. The latter is derived from the **change** in the Average Well-being Index
- **deep transformative policies** with respect to poverty, education, food, energy, trade and financing can make a significant difference in the quality of life of billions of people in the second half of the 21<sup>st</sup> century.
- unlike previous reports to the Club of Rome, the report is **explicit in its political-economic analysis**: the title of the last chapter is *'From 'Winner Take All' Capitalism to Earth4All Economies'*.



# 1. Main trends

## Too Little Too Late scenario

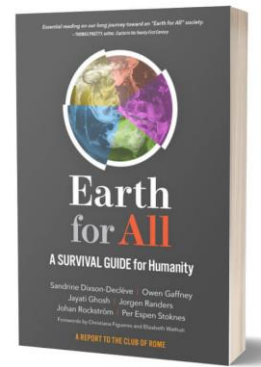
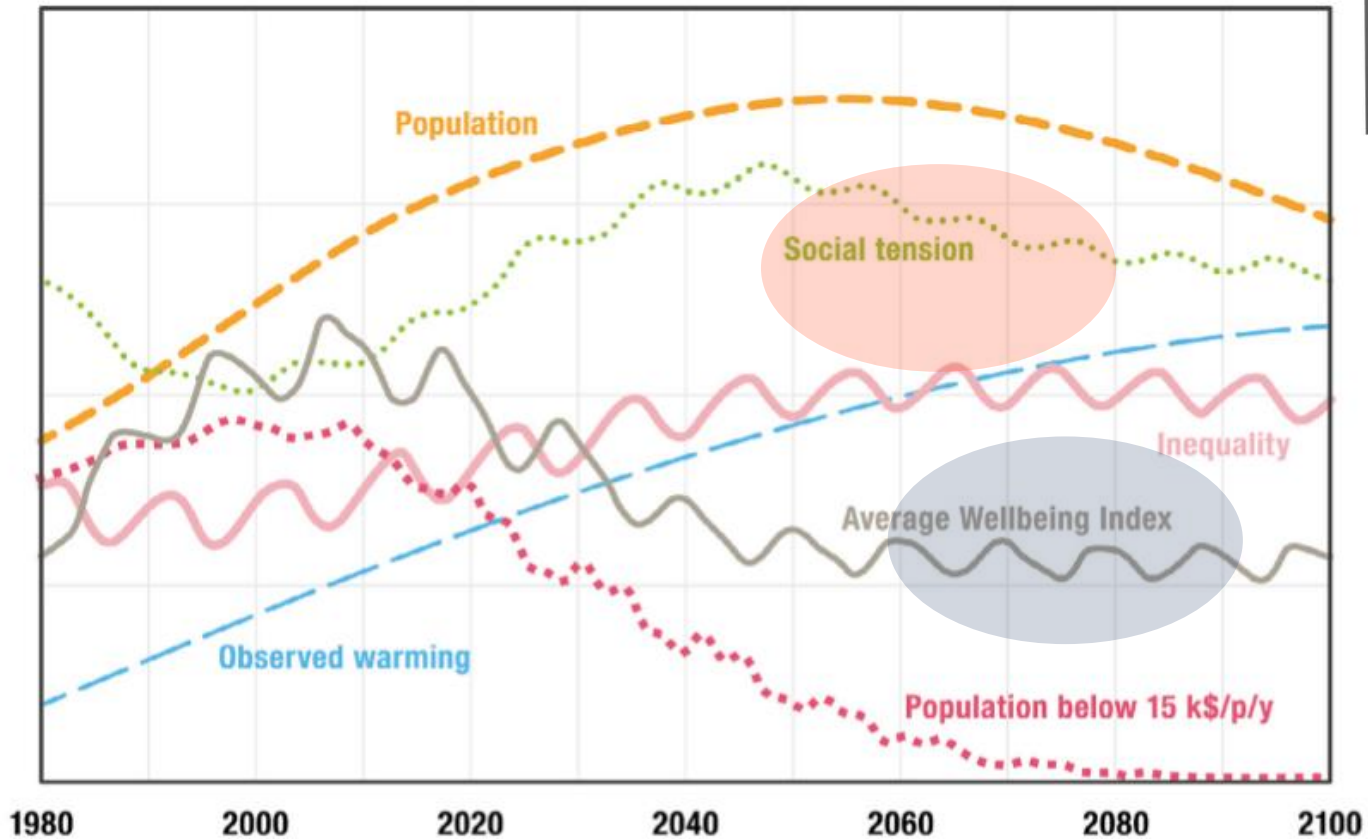


Figure 1. Main trends in the Too Little Too Late Scenario of the Earth4All model – World 1980 to 2100.

**Latest Report to the Club of Rome (Dixson-Declève et al. 2022)**  
**Earth4All**

# 1. Main trends

## Giant Leap scenario

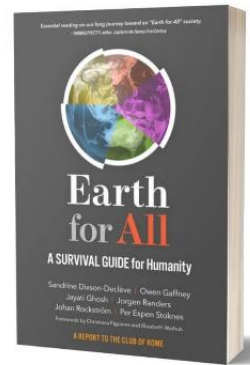
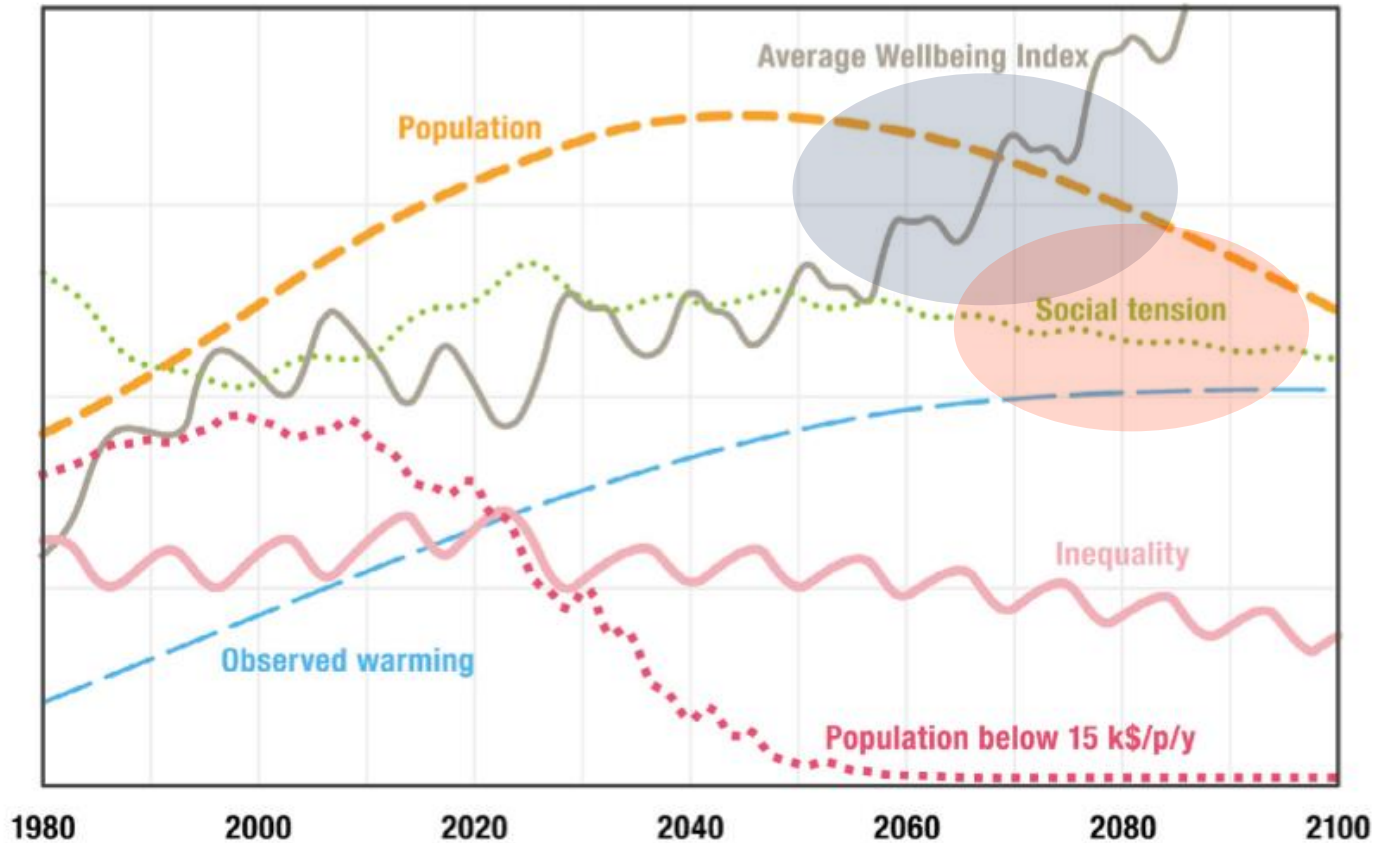
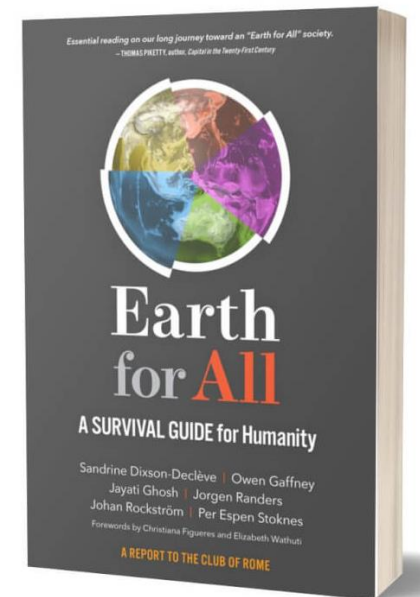


Figure 2. Main trends in the Giant Leap Scenario of the Earth4All model – World 1980 to 2100.

Latest Report to the Club of Rome (Dixson-Declève et al. 2022)  
Earth4All

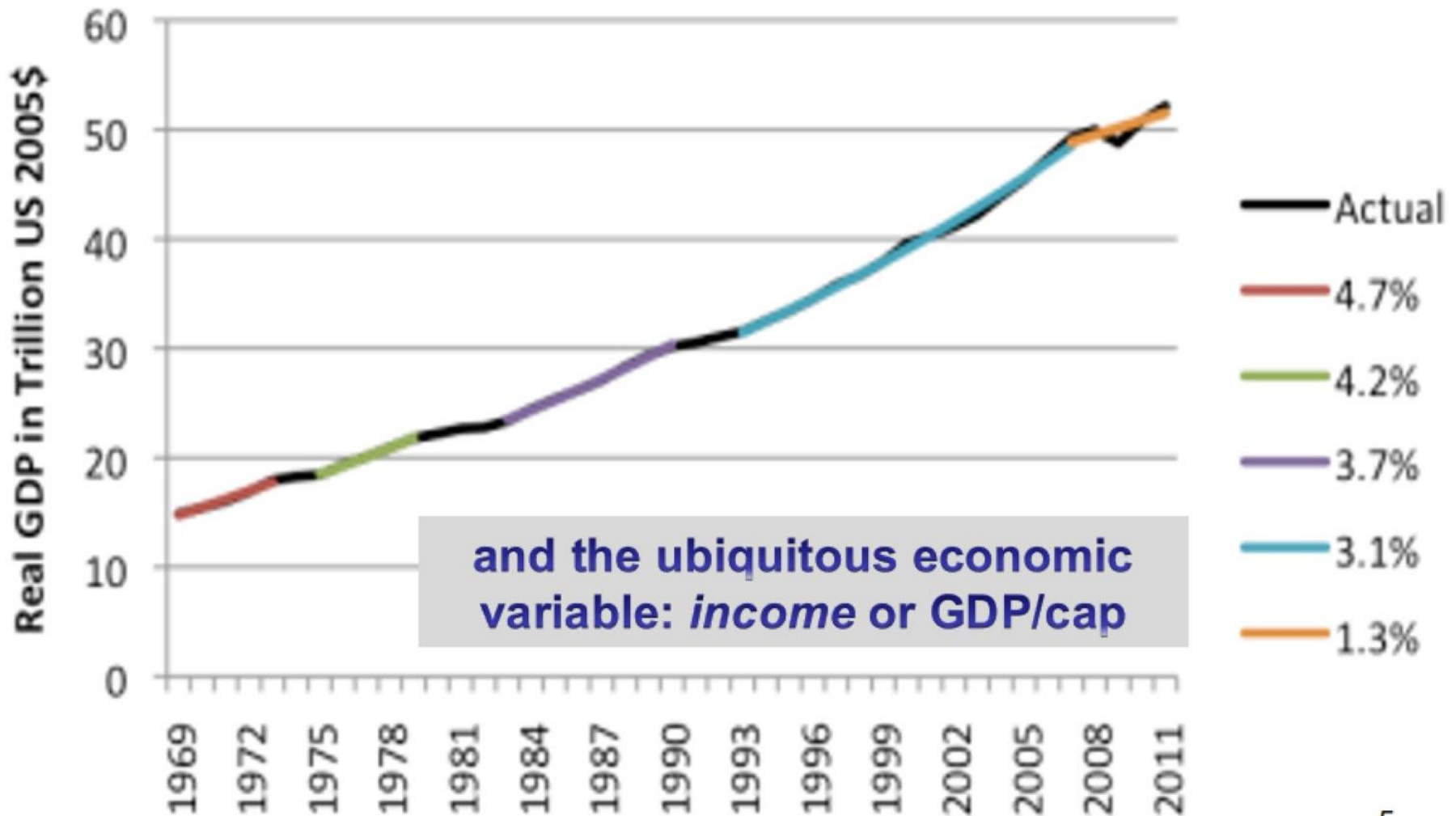
# Latest Report to the Club of Rome (Dixson-Declève et al. 2022) Earth4All

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- unlike previous reports to the Club of Rome, the report is **explicit in its political-economic analysis**: the title of the last chapter is *'From 'Winner Take All' Capitalism to Earth4All Economies'*.



# 3.1 Indicators: GDP, income, wealth and well-being

## World GDP with Fitted Exponential Trend Lines



# How Was Life?

## GLOBAL WELL-BEING SINCE 1820

Well-being and progress:  
how measured  
and for whom?

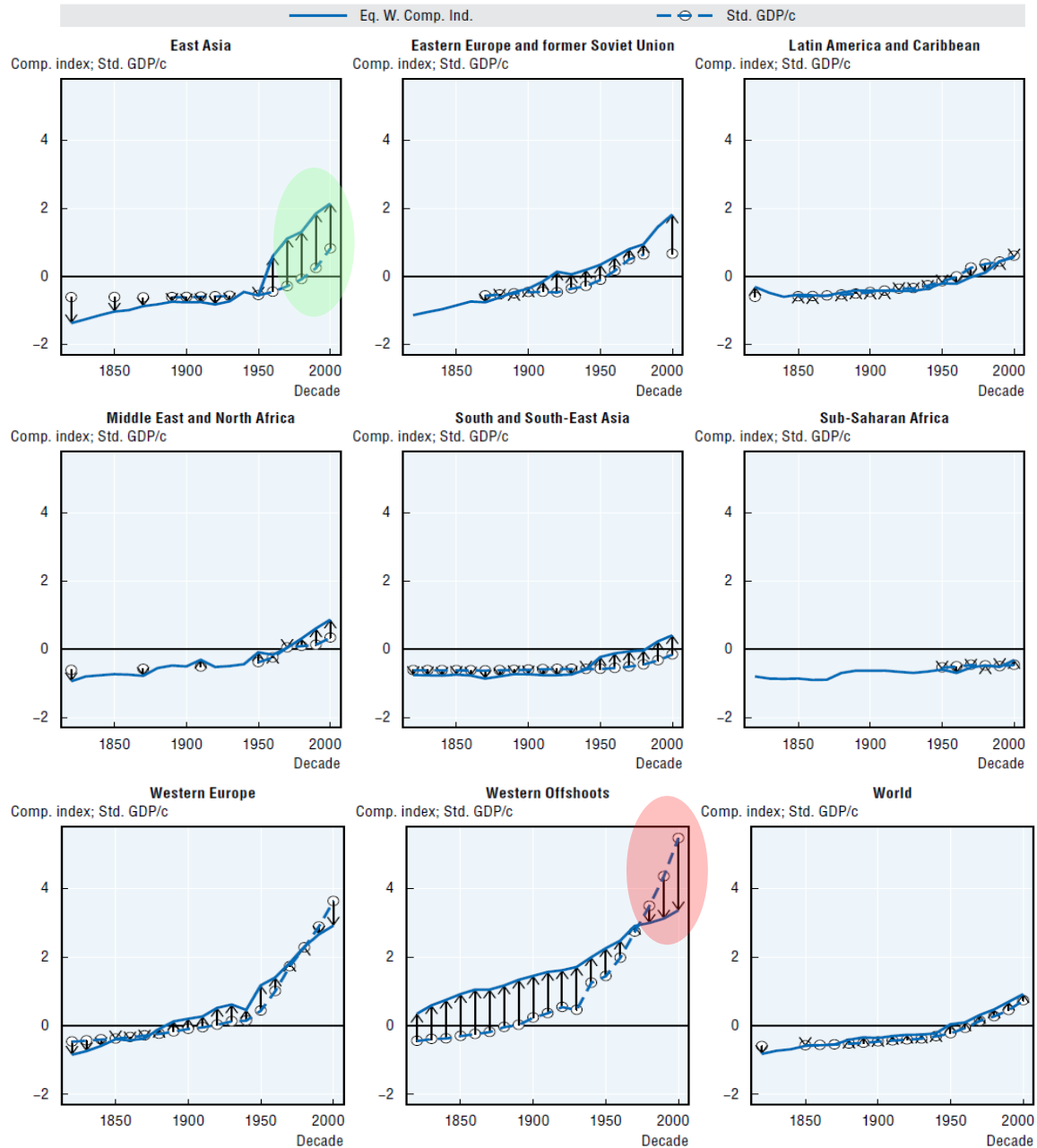
GDP per capita

Real wages

Height

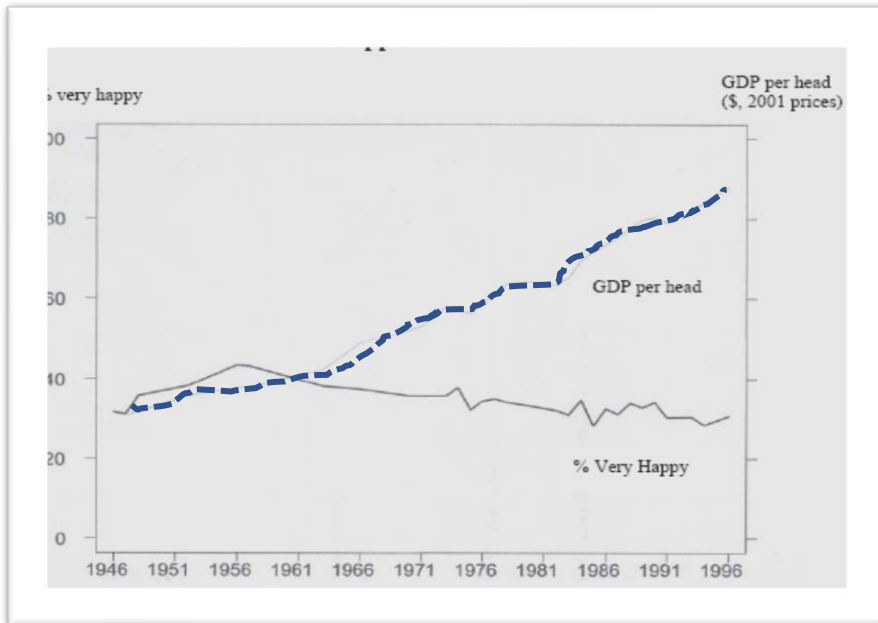
Life expectancy

Well-being is increasingly **decoupled** from income, notably because of (consumer) technology and the role of positional goods.



Seven factors really matter for an individual's experience of 'being happy' in order of importance, according to scientific investigations of happiness (Layard (2004, 2005):

- *family ties*
- *financial situation*
- *work*
- *social environment*
- *health –*
- *and also personal freedom and philosophy of life*



Important in one's experience of happiness:

- *Comparison with others (reference drift)*
- *Getting used (preference drift)*

**Well-being** is not well represented by income (GDP/cap); there is a need for a more comprehensive measure

A variety of 'beyond-GDP' indicators have been proposed: Human Development Index (HDI), Genuine Progress Indicator (GPI), Ecological Footprint (EF) and others

But in official (gov'ts, corporations) documents, GDP- and income growth remain key indicators – and they [are assumed to] keep growing:

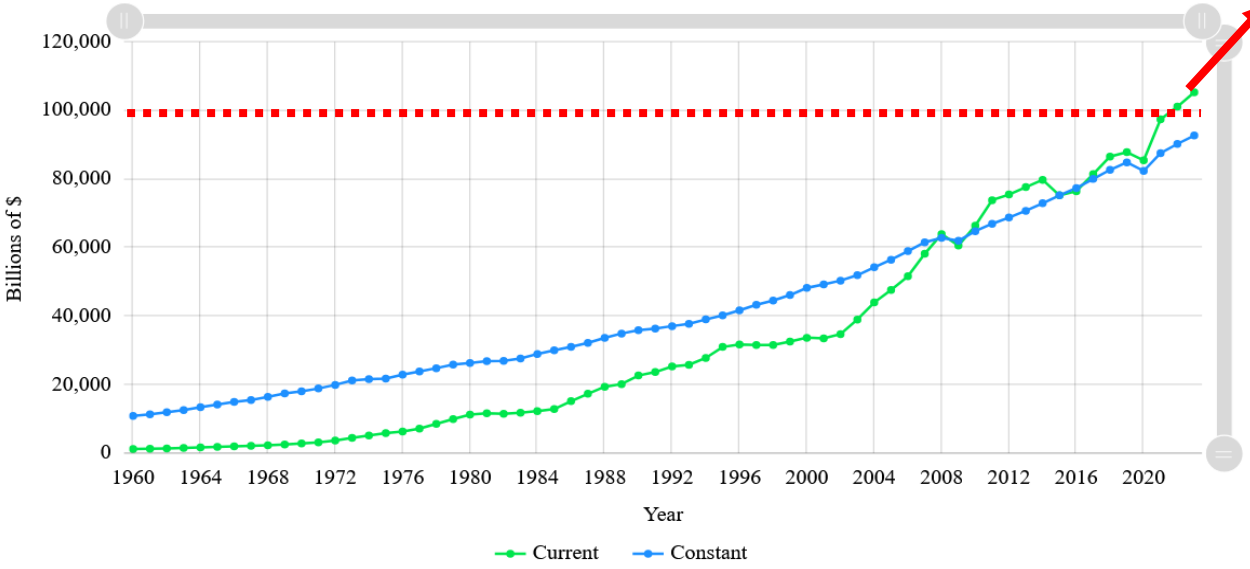
Country/region	Period	Factor increase	Source
Japan, EU	2014-2050	2,5-3,5	The Economist 2015
USA, China	2014-2050	6-7	The Economist 2015
India	2014-2050	31	The Economist 2015
World	2016-2050	>2	McKinsey 2016
World (middle scenarios)	2014-2050	2,9-6	IPCC Riahi et al. 2017

Nominal

PPP

Growth (%)

Gross World Product (Nominal)



Gross World Product (GWP) [world average]

*Nominal*  
*1960-2023*

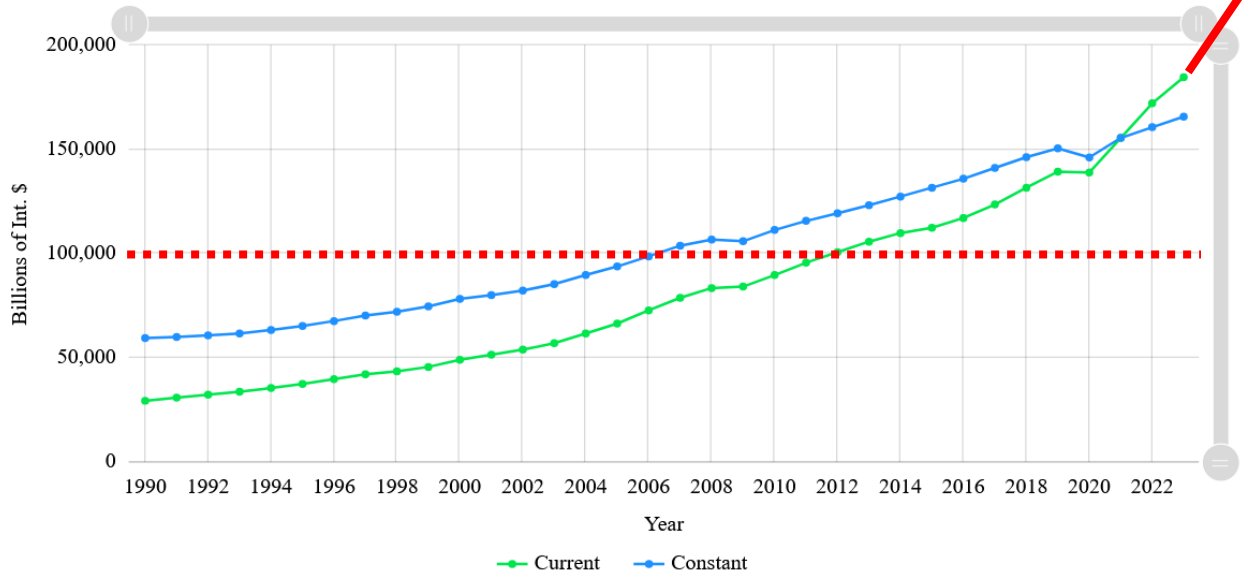
..... Nominal 100 Trillion of \$

Nominal

PPP

Growth (%)

Gross World Product (PPP)

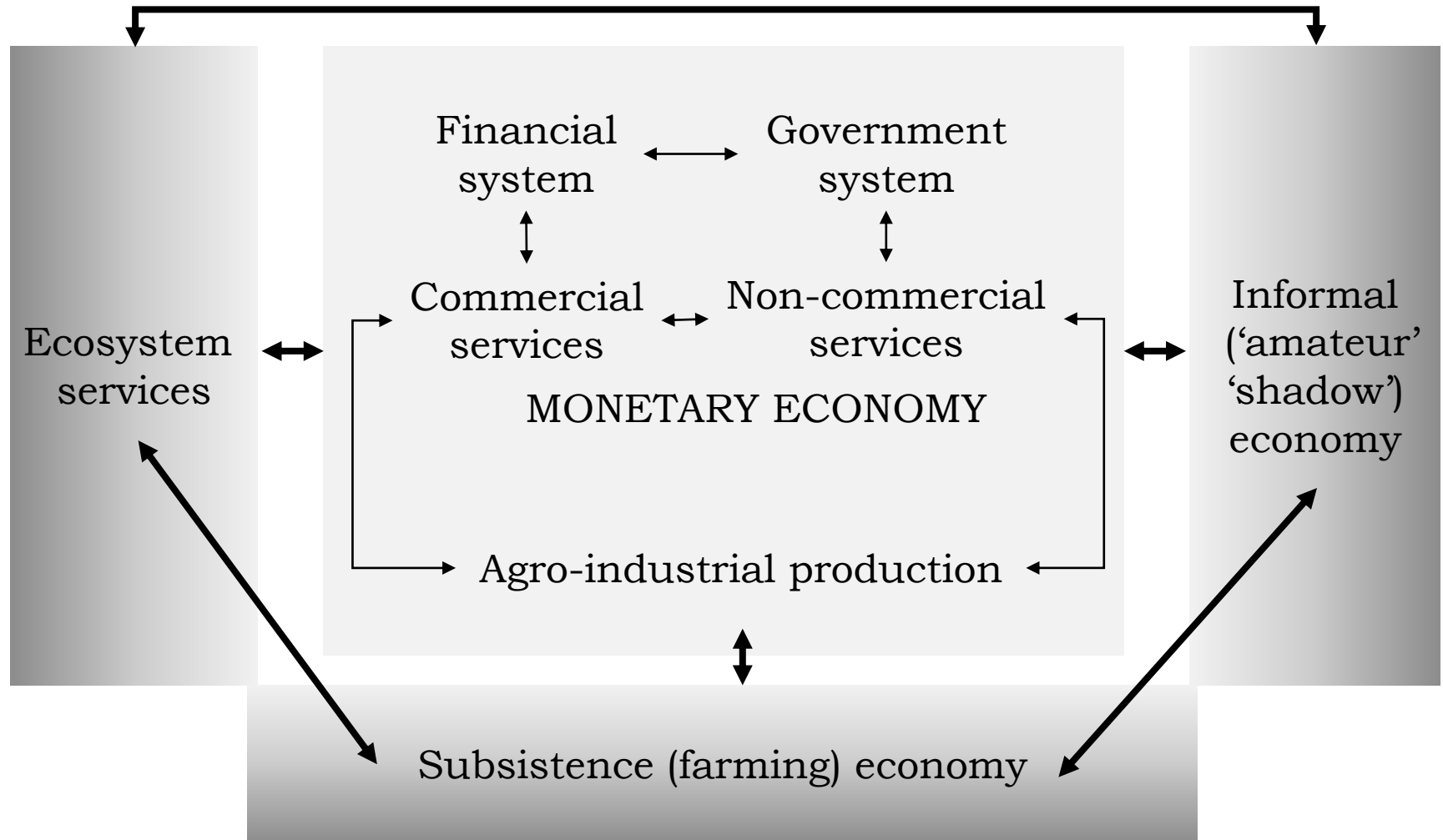


*PPP-corrected*  
*1990-2023*

..... Purchasing Power Parity (PPP) corrected 100 Trillion of \$

(IMF 2024)

## 3.2 Defining the economic system: what is [not] included?



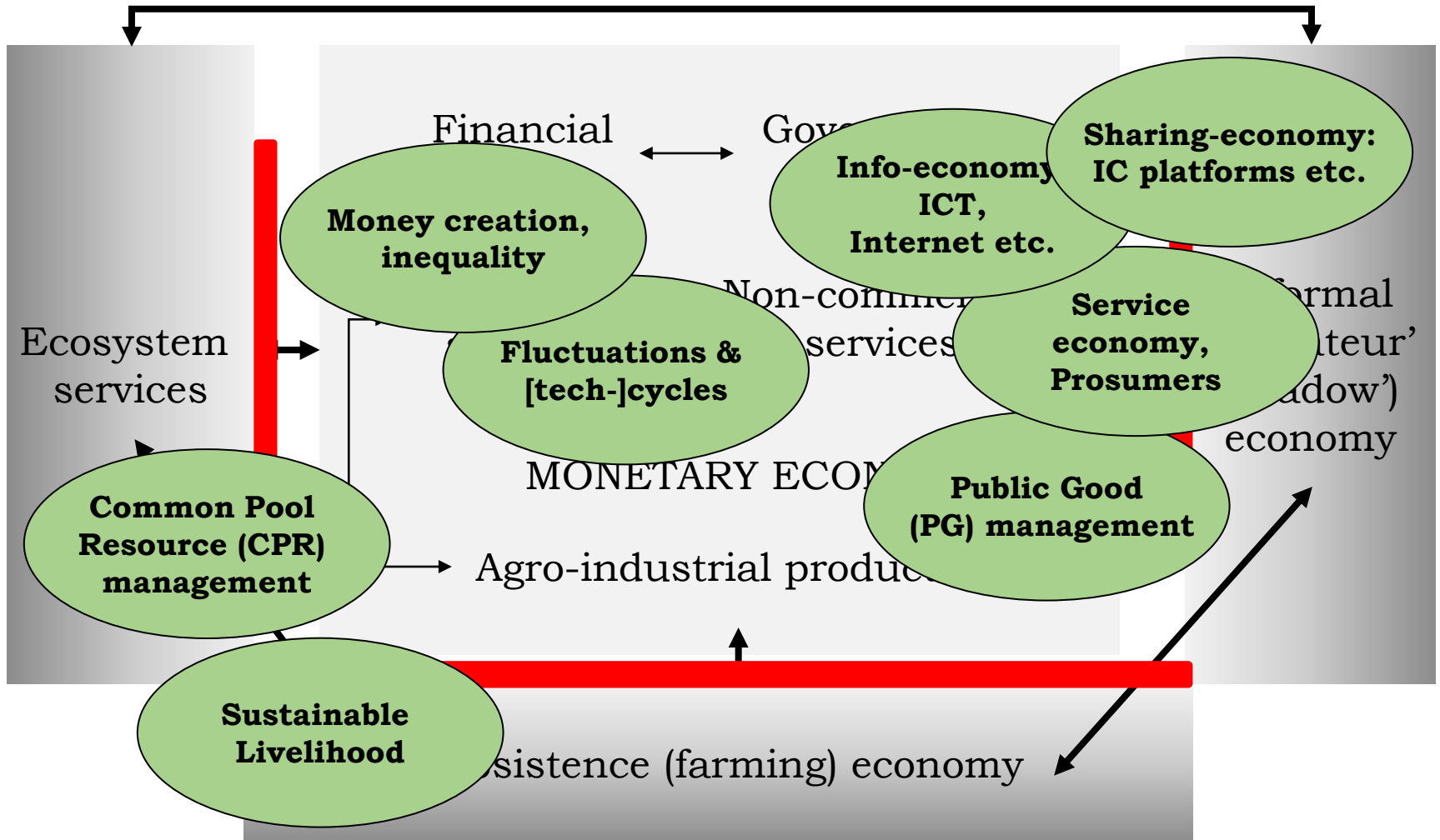
**What is counted? What are definitions and rules?  
Which system boundaries are chosen?**

Many **negative externalities** are (usually) not (explicitly) included, such as:

- **Loss of ecosystem services** is in the same order as annual additions to GWP
- activities dealing with negative externalities (medical care for traffic accidents, cleaning the environment etc.); they are counted as *contribution* to GDP

Many social and political aspects of well-being are not included:

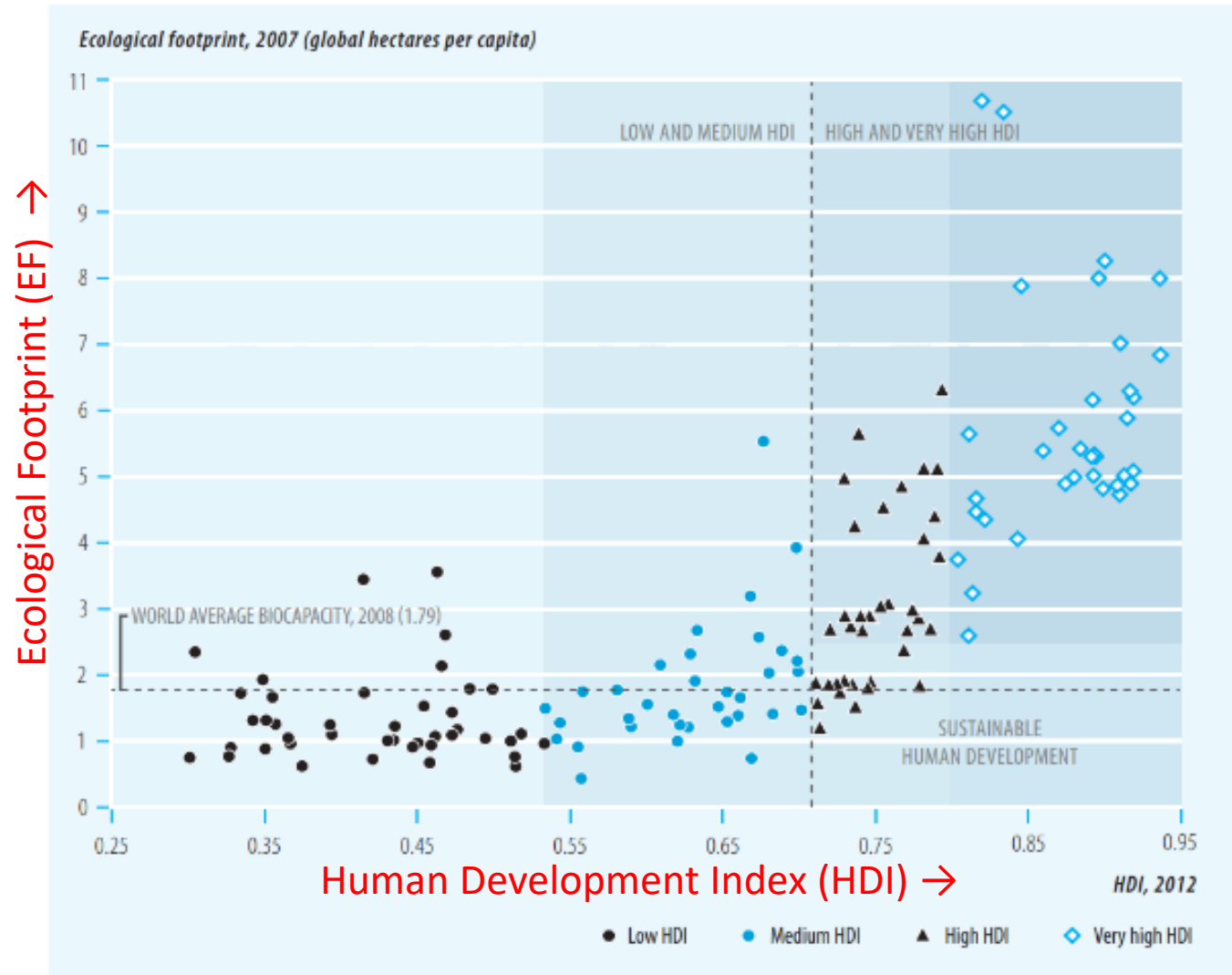
- **Income** and **wealth inequality** are (usually) not (explicitly) considered
- **Basic needs** (food, water, housing...) and **public goods provision** (safety, clean air...) are (usually) not (explicitly) considered
- The **shadow (informal) economy** of household work, volunteer work and illegal (e.g. crime) is not accounted; it may amount to 5-20% of GDP
- **Subsistence farming** (outside formal markets) is not included; it can amount up to 20% of GDP in some countries



**What is counted? What are definitions and rules?  
Which system boundaries are chosen?**

# Loss of ecosystem services

Environmental Footprint (EF) vs. Human Development Index (HDI)

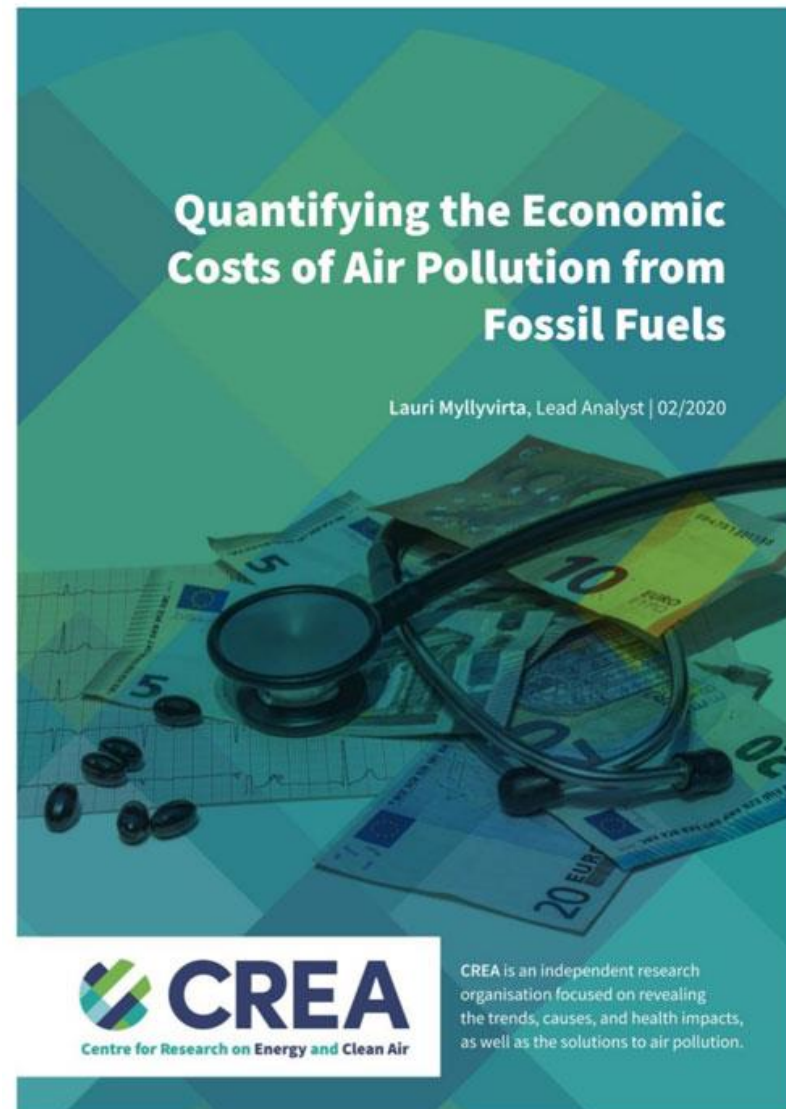


Note: Ecological footprint is a measure of the biocapacity of the earth and the demand on biocapacity. It depends on the average productivity of biologically productive land and water in a given year.

Source: HDRO calculations and Global Footprint Network (2011).

**Reference:** UNDP (United Nations Development Programme). 2013. Human Development Report 2013: The Rise of the South: Human Progress in a Diverse World. New York.

One example: see <https://www.eea.europa.eu/en/analysis/indicators/environmental-protection-expenditure-8th-eap>  
Data on expenditures for environmental protection



The economic costs of air pollution from fossil fuels are estimated at US\$2.9 trillion in 2018, or 3.3% of global GDP, far exceeding the likely costs of rapid reductions in fossil fuel use (CREA 2018)

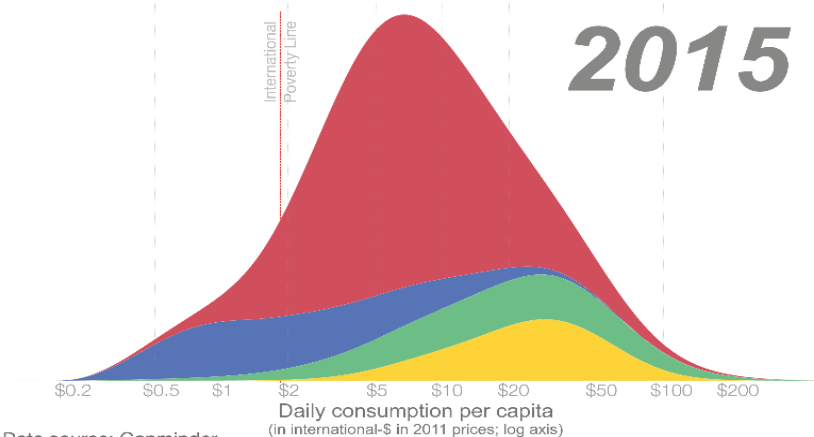
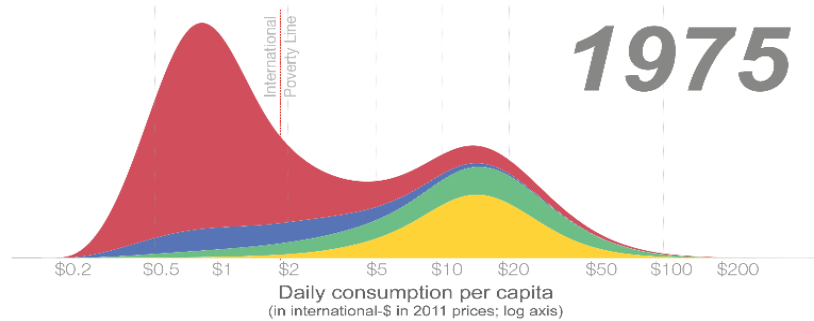
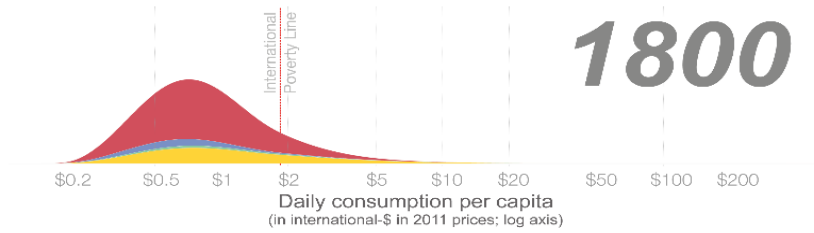
# Income and wealth inequality

## Global income distribution in 1800, 1975, and 2010



Income is measured by adjusting for price changes over time and for price differences between countries (purchasing power parity (PPP) adjustment). These estimates are based on reconstructed National Accounts and within-country inequality measures. Non-market income (e.g. through home production such as subsistence farming) is taken into account.

Europe Asia and Pacific Africa North- and South America



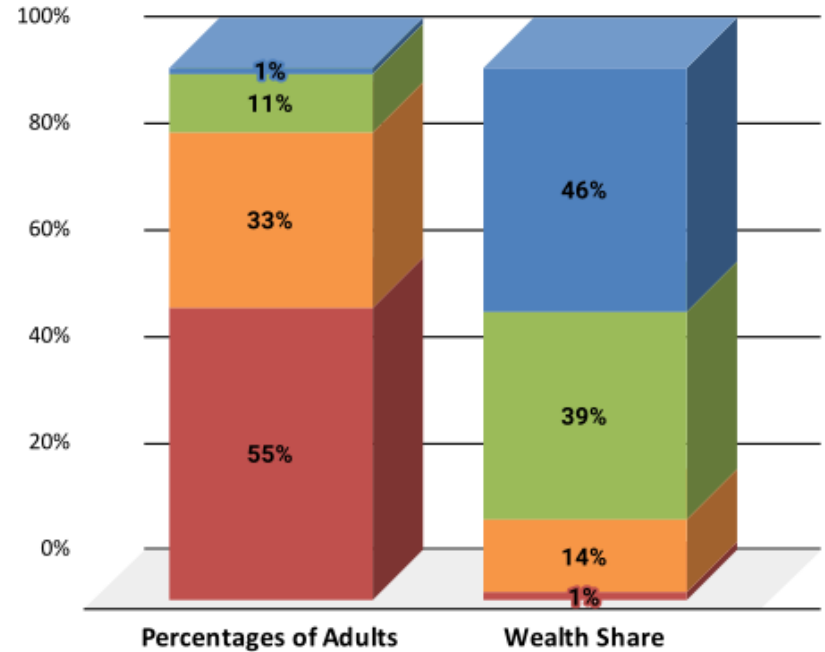
Data source: Gapminder

The visualization is available at OurWorldInData.org where you find more visualizations and research on global development.

Licensed under CC-BY-SA by the author Max Roser.

## Global Wealth Distribution 2020 (Property)

Millionaires (> US\$ 1M) Middle class (US\$ 100K–1M)  
 Poor (US\$ 10K–100K) Miserable (< US\$ 10K)



(IARIW/Wikipedia and OurWorldInData)

# 4.1 State, market, community – and ideology

Activist

Wealth Redistribution  
Industrial Policy

Intermediate

Social Insurance  
Insurance, Financial Regulation  
Overcoming Imperfect Information  
Regulating Monopoly  
Education, Environment  
Addressing Externalities

Minimal

Protecting the Poor  
Improving Equity  
Public Health  
Macroeconomic Management  
Property Rights  
Defense, Law, and Order  
Providing Pure Public Goods



Scope for the State – can it deliver what it is expected to deliver?



# The Scope of State Functions

Activist

Wealth Redistribution  
Industrial Policy

Intermediate

Social Insurance  
Insurance, Financial Regulation  
Overcoming Imperfect Information  
Regulating Monopolies money creation  
Education Environment  
Addressing environmental externalities

Minimal

infrastructure: water, energy...

Improving Equity  
Public Health social security

Maximal

infrastructure: health, education, mobility  
Property Rights  
Defense, Law, and Order  
Providing security: defense goods



Scope for the State – can it deliver what it is expected to deliver?

# The Scope of State Functions

50 %

Activist

Wealth Redistribution  
Industrial Policy

Intermediate

Social Insurance  
Insurance, Financial Regulation  
Overcoming Imperfect Info  
Regulating Monopoly

Tax revenues as percentage of GDP as proxy of Scope

25 %

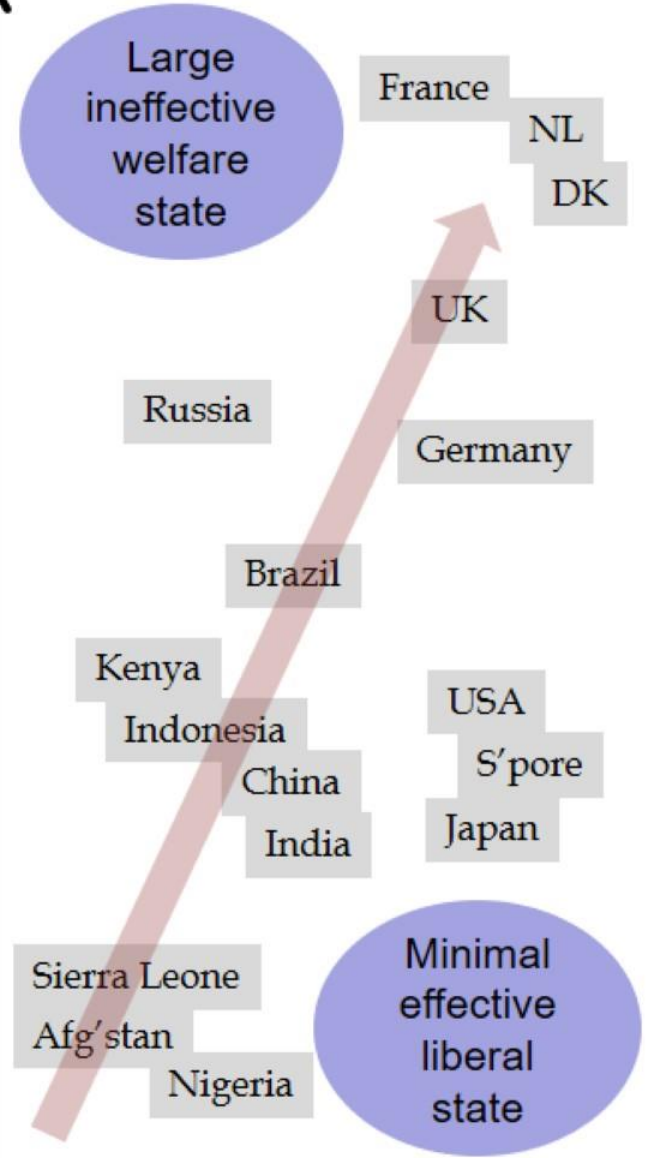
Minimal

Protecting the Poor  
Improving Equity  
Public Health  
Macroeconomic Management  
Property Rights  
Defense, Law, and Order  
Providing Pure Public Goods

0 %

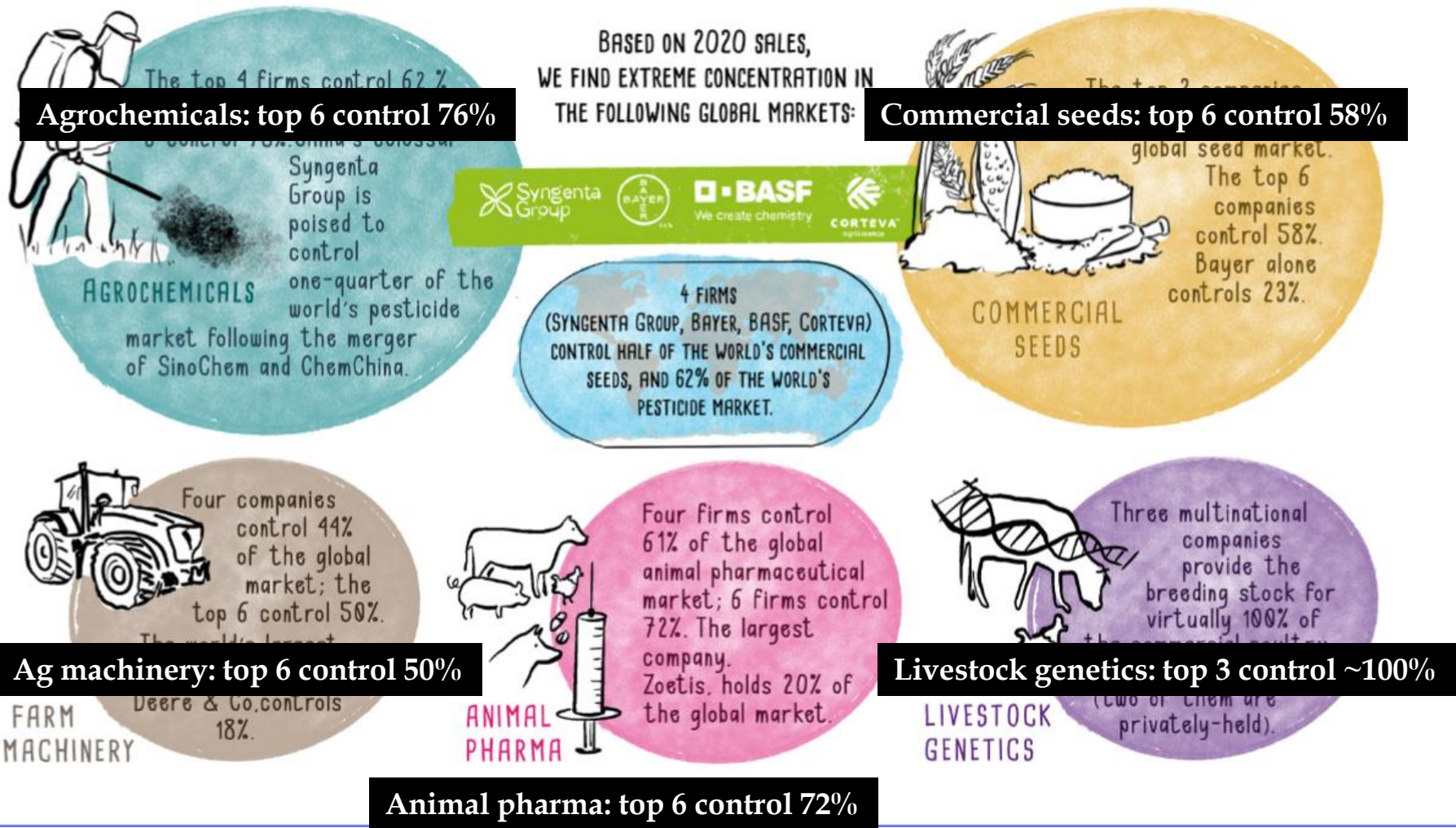
Gov' tax revenues as % of GDP

Gov't Effectiveness



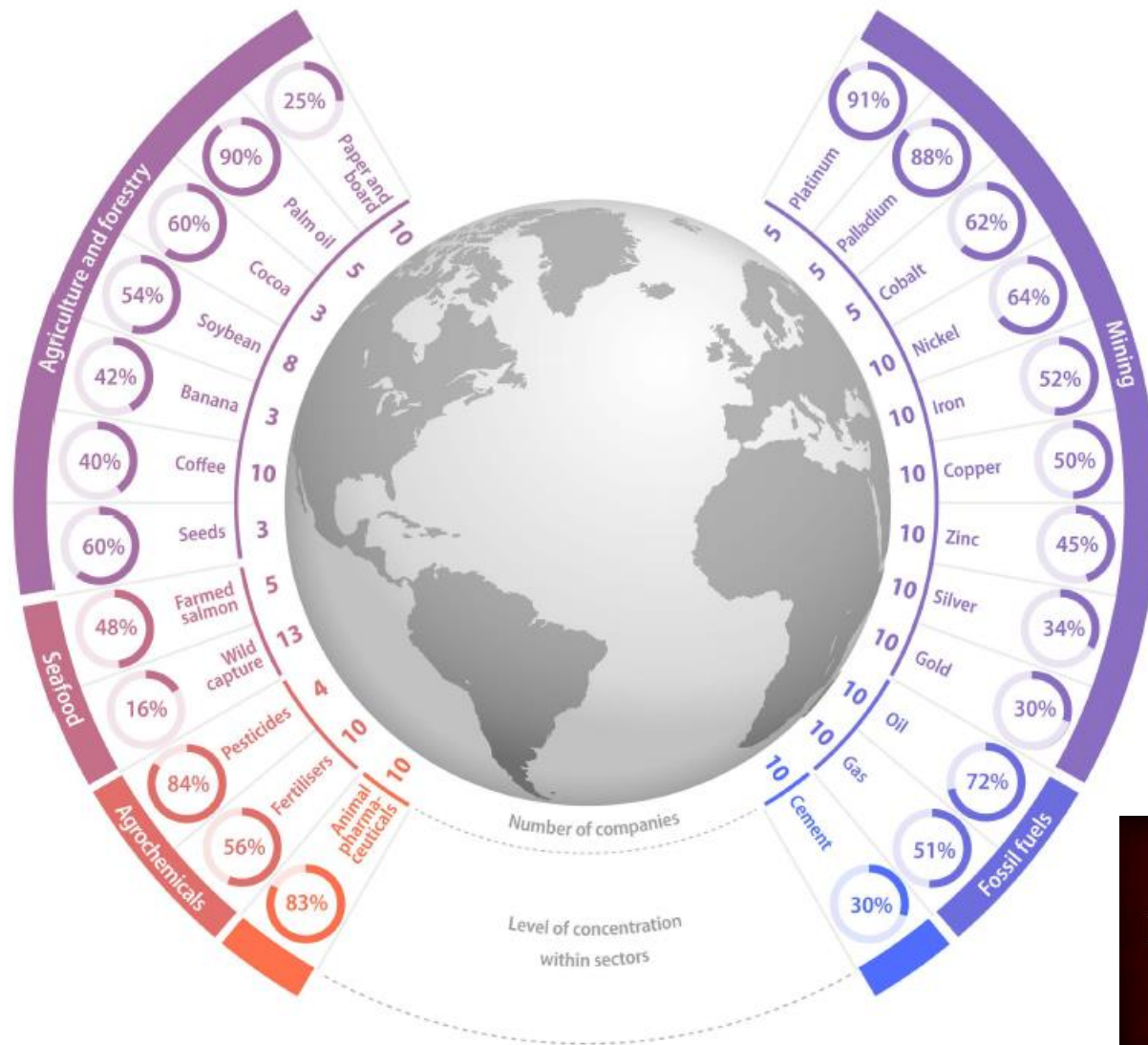
Universiteit Utrecht

# 4.2 Corporate power and 'free' [global] markets

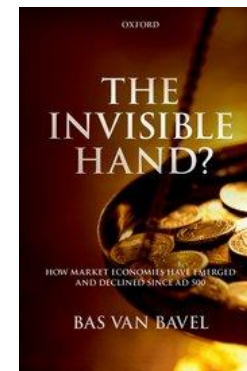
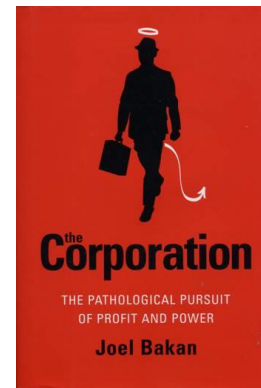


Source: ETC Group (2022). *Mapping corporate power in Big Food: Food Baron 2022 - Crisis Profiteering, Digitalization and Shifting Power*

The **Biosphere**  
in the hands of  
a few:  
corporate  
power  
(and what  
about  
**Cybersphere?**)



**Figure 13 | The biosphere in the hands of a few.** The figure illustrates levels of concentration for industries shaping the biosphere through their activities on land- and seascapes. Concentration is measured as, for example, percentage of profits or sales, market share, exports, production, trade volumes or access to resource reserves. Source: Folke et al., 2019.



## 4.3 Public vs. private: governing the commons

In late 19<sup>th</sup> and early 20<sup>th</sup> century, economists started to emphasize the consumption: the value of a good or a service depends on the **utility to the consumer** and is reflected in the price on the market (Mazzucato 2018).

Thus, 'conventional' economic theory focuses on the individual and her **preferences** in consuming goods and services. In modelling, the formal concept of **utility** is used.

Economists have proposed **excludability** and **rivalry** to distinguish different classes of goods and services.

The concept of the individual consumer (rational, deciding in isolation, perfect knowledge) is positioned in the lower right corner of this framework (*homo economicus*).

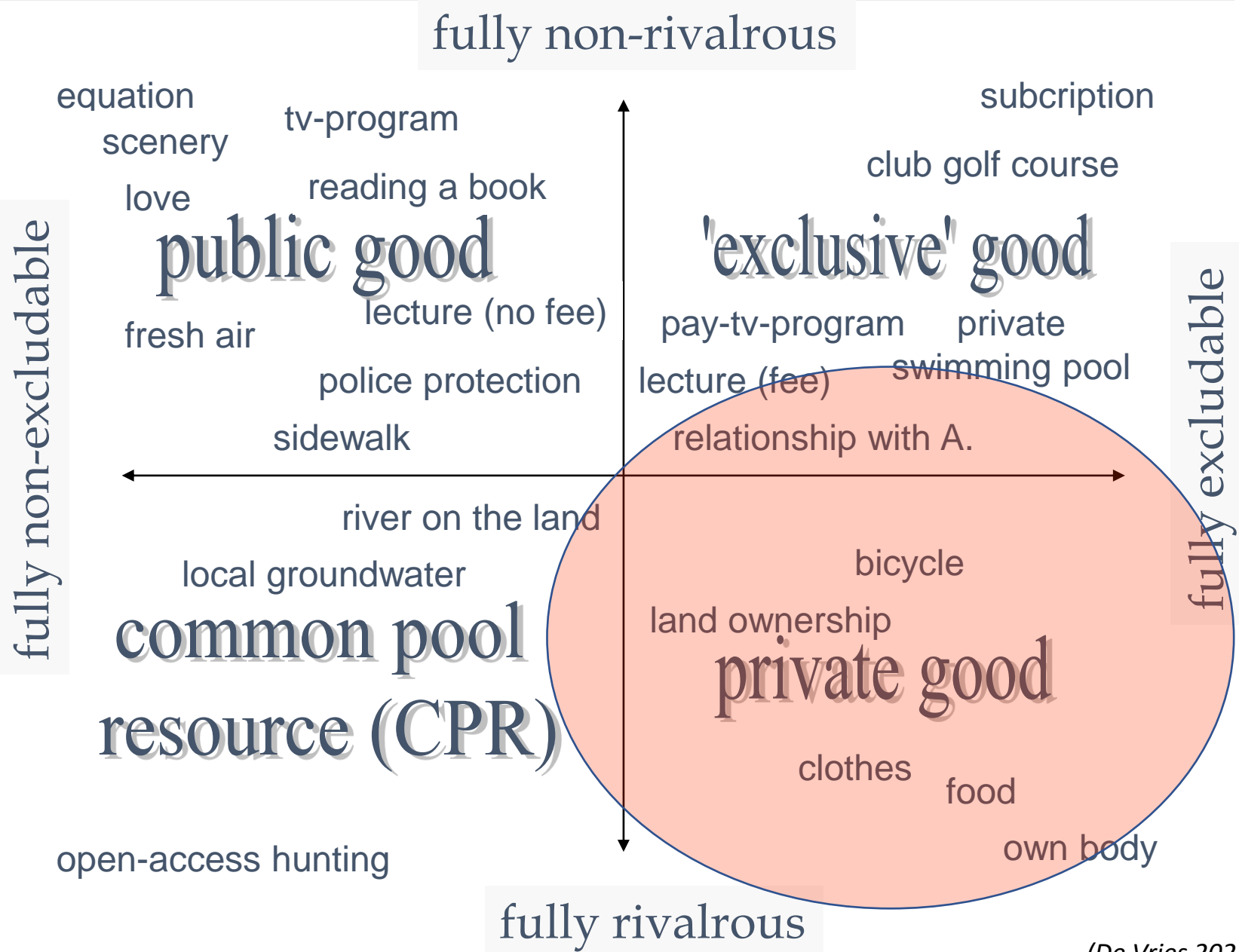
This is a serious reductionism, at the expense of consideration of Common Pool Resources (**CPR** – rivalrous and non-excludable) and Public Goods (**PG** – non-rivalrous and non-excludable).

**Rivalry: does my use affect yours?**  
**YES/NEGATIVE** **NO/POSITIVE**

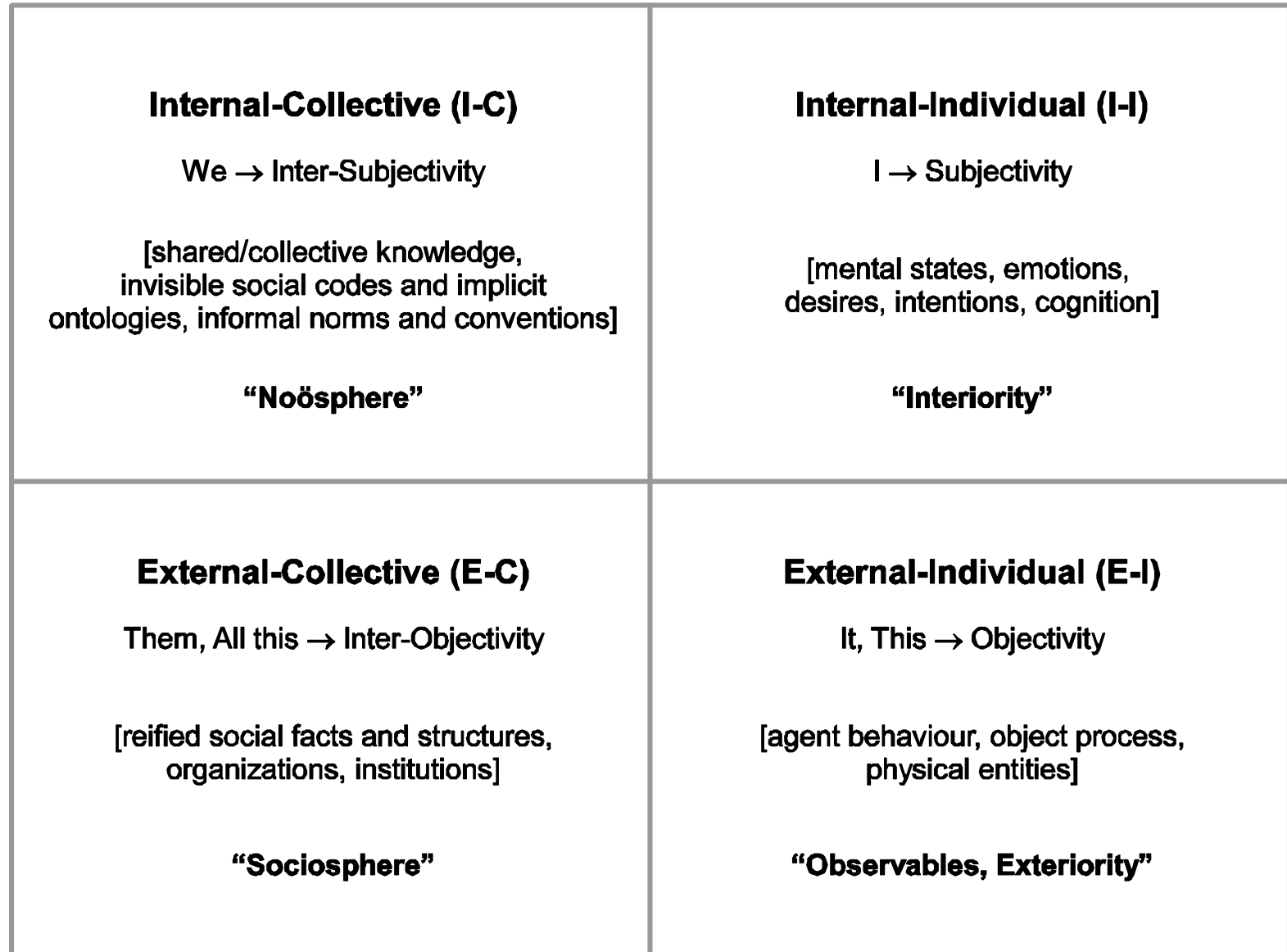
**Excludability: can I forbid you to use it?**

**NO**

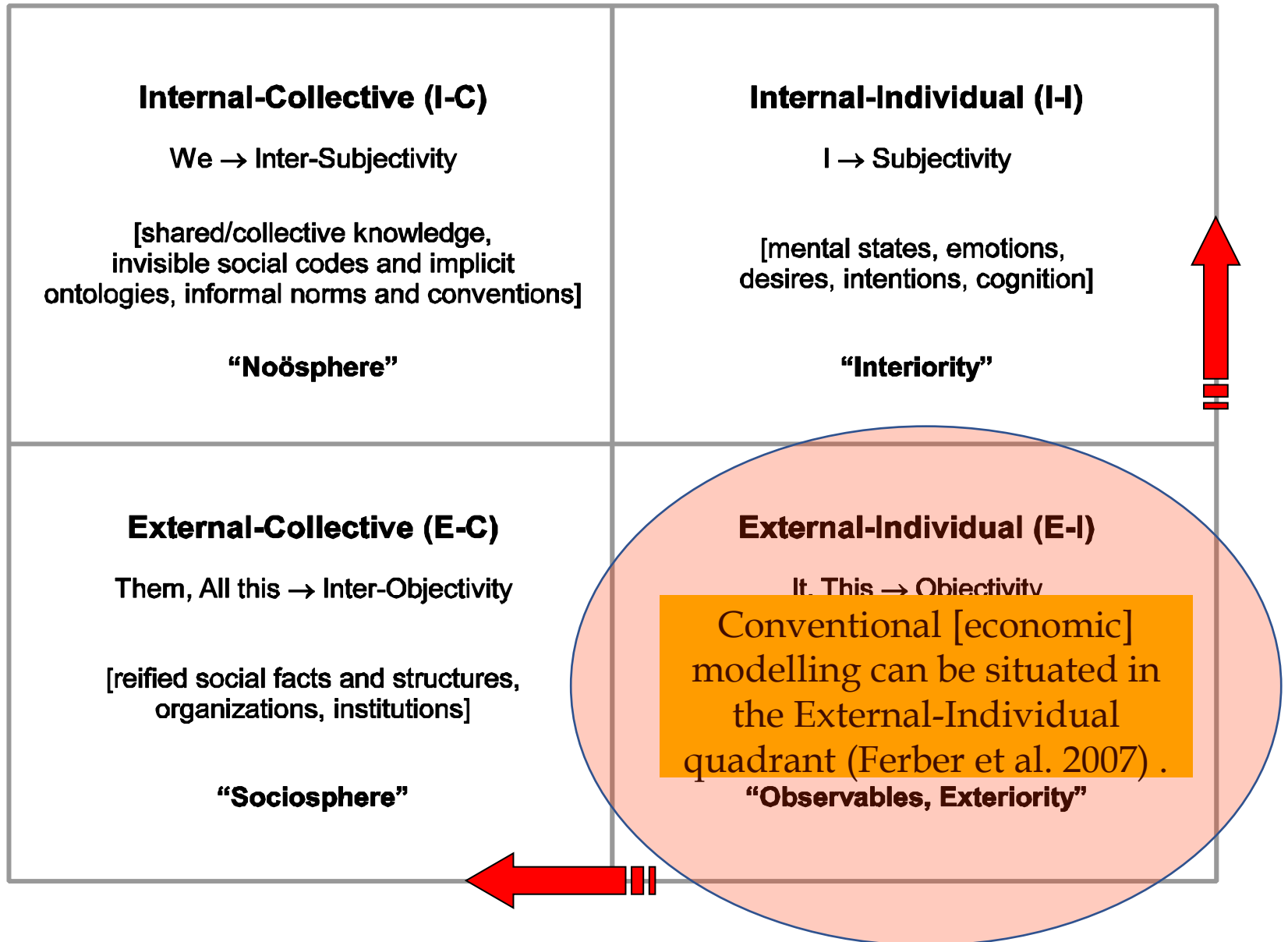
**YES**



# Epistemology and modelling of a more refined concept of human agents



Modelling human behaviour in society: the four quadrant view (Ferber et al.)



Modelling human behaviour in society: the four quadrant view (Ferber et al.)

# 5.1 What is money?

In general, money has three functions:

- a medium of exchange
- a unit of account
- a storage of wealth

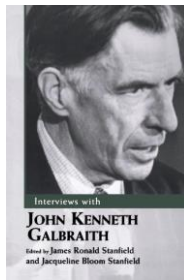


## Ideas about money creation and finance

“The Government should create, issue, and circulate all the currency and credits needed to satisfy the spending power of the Government and the buying power of consumers. By the adoption of these principles, the taxpayers will be saved immense sums of interest. **Money will cease to be master** and become the servant of humanity.”  
(Abraham Lincoln, 1809-1865)

“The process by which banks create money is so simple that the mind is repelled.” (J.K. Galbraith, 1975)

“The study of money, above all other fields in economics, is one in which complexity is used to **disguise truth or to evade truth**, not to reveal it.” (J.K. Galbraith, circa 1990)



# 5.1 What is money?

Until the 2008 financial crisis, a common (mis)understanding was that 'money is neutral': doubling the amount does not influence the economy. In 2015 the Bank of England stated otherwise:

---

In the modern economy, most money takes the form of bank deposits. But how those bank deposits are created is often misunderstood: the principal way is through commercial banks making loans. **Whenever a bank makes a loan, it simultaneously creates a matching deposit in the borrower's bank account, thereby creating new money.**

BankOfEngland.co.uk

*Money is non-neutral in both short-run and long-run because it is bank debt, limiting the capacity of price adjustments to restore the economy to its natural equilibrium and giving money a pro-cyclical role in the business cycle and economic growth.*

This reappraisal of (parts of) Keynesian macro-economic theory had and has important consequences for the financing of long-term projects (such as infrastructure) by governments.

## 5.2 Financial institutions and money creation



The 'classical' economists 'shared two basic ideas: that value derived from the cost of production, principally labour; and that therefore activity subsequent to value created by labour, such as **finance, did not in itself create value.**' (Mazzucato 2018:34).

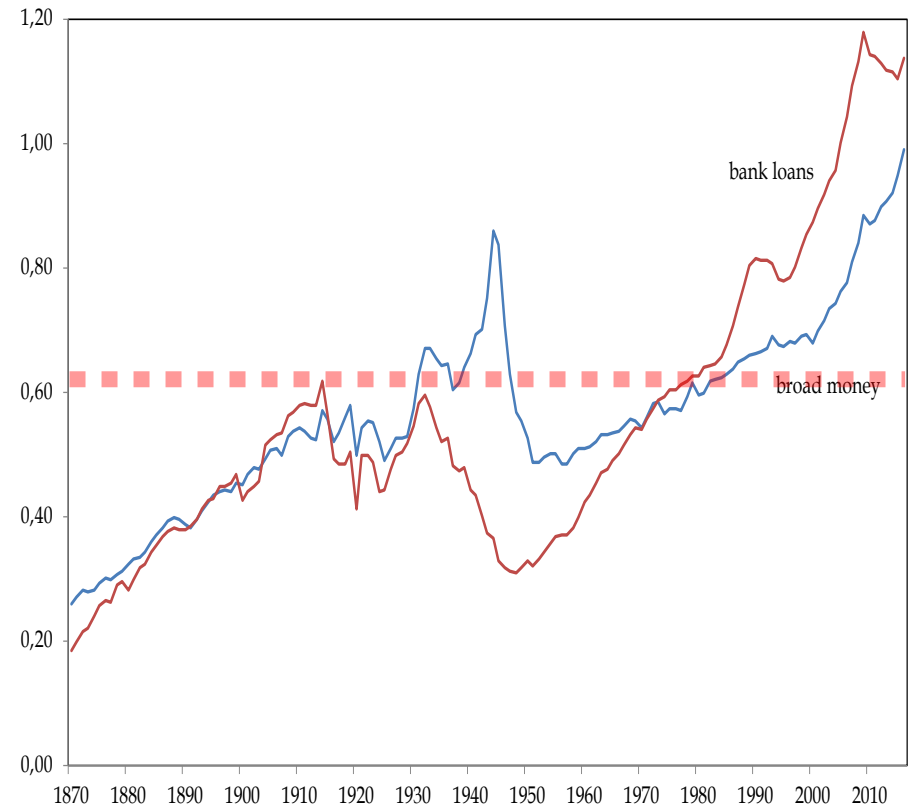
# Money and debt growth: increasing indebtedness as business model of banks

**Long upward trend in the ratio of debt to income since the 1870s.**

Since WWII, trend has resumed, surpassing previous levels from the 1980s.

The driving mechanism is the **rising role of private debt as the source of money creation**

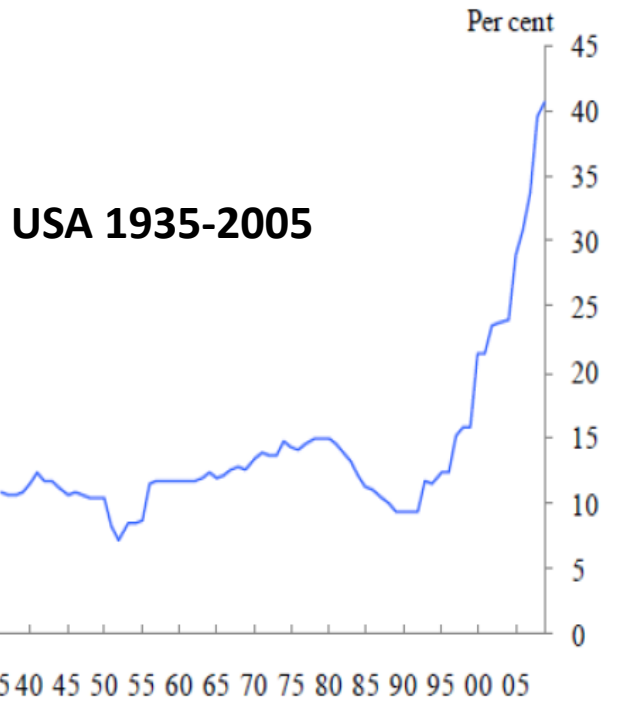
Higher levels of debt have been **driven by the dominance of bank money based on fractional reserves**



The ratio of bank loans and broad money (M2) to GDP in 17 OECD countries, 1870-2016

# Concentration in US banking

# Mortgage and non-mortgage credit

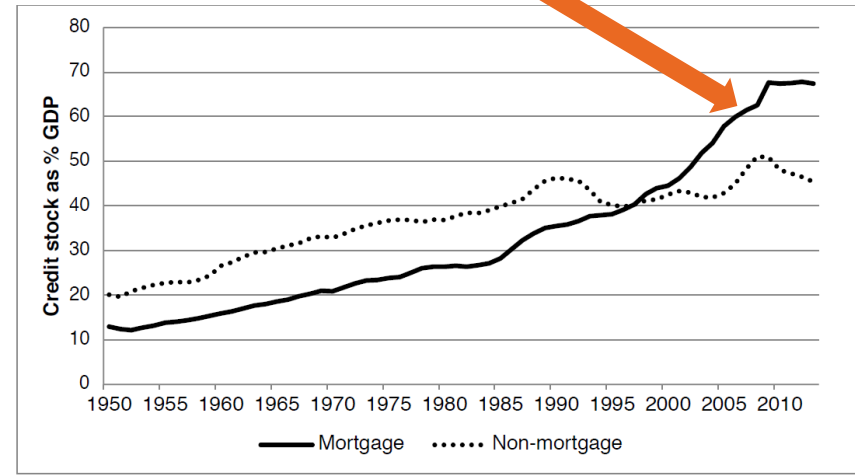


Sources: FDIC and Bank calculations.

(a) Top 3 banks by total assets, as percentage of total banking sector assets. Data include only insured depository subsidiaries of banks.

Concentration of US Banks From 1935-2008 (Haldane et al., 2010).

Figure 1: Stocks of outstanding mortgage credit and non-mortgage credit in 17 advanced economies, 1950-2013



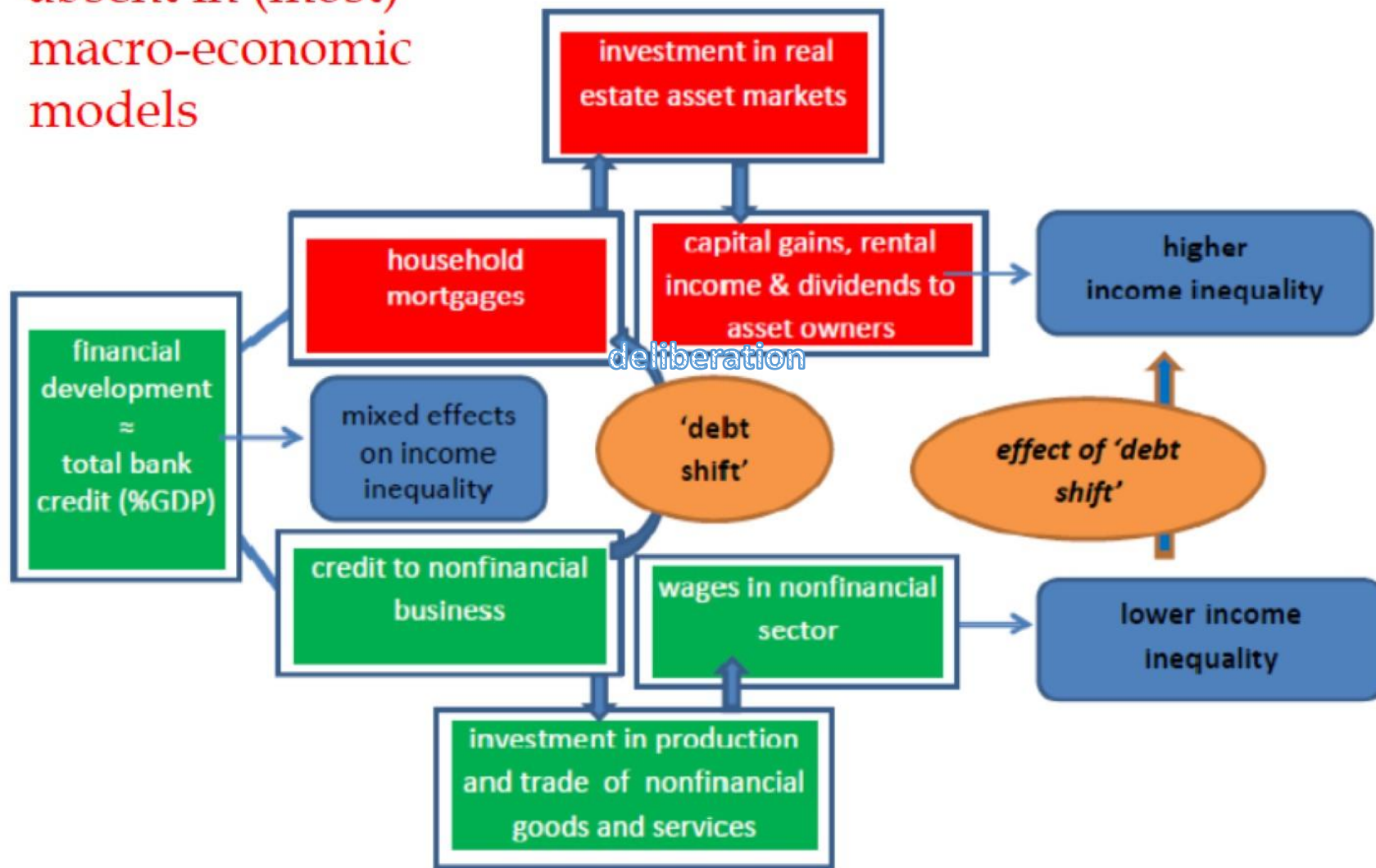
Source: Jordà et al (2017). Data downloaded from Jordà-Schularick-Taylor macro history database (accessed December 2017): [www.macrohistory.net/data/](http://www.macrohistory.net/data/). NB: Non-mortgage variable is lending to non-financial firms and to households for consumption; mortgage variable includes household and commercial real estate lending.

(Bezemer, Ryan-Collins, Lerven and Zhang 2018)

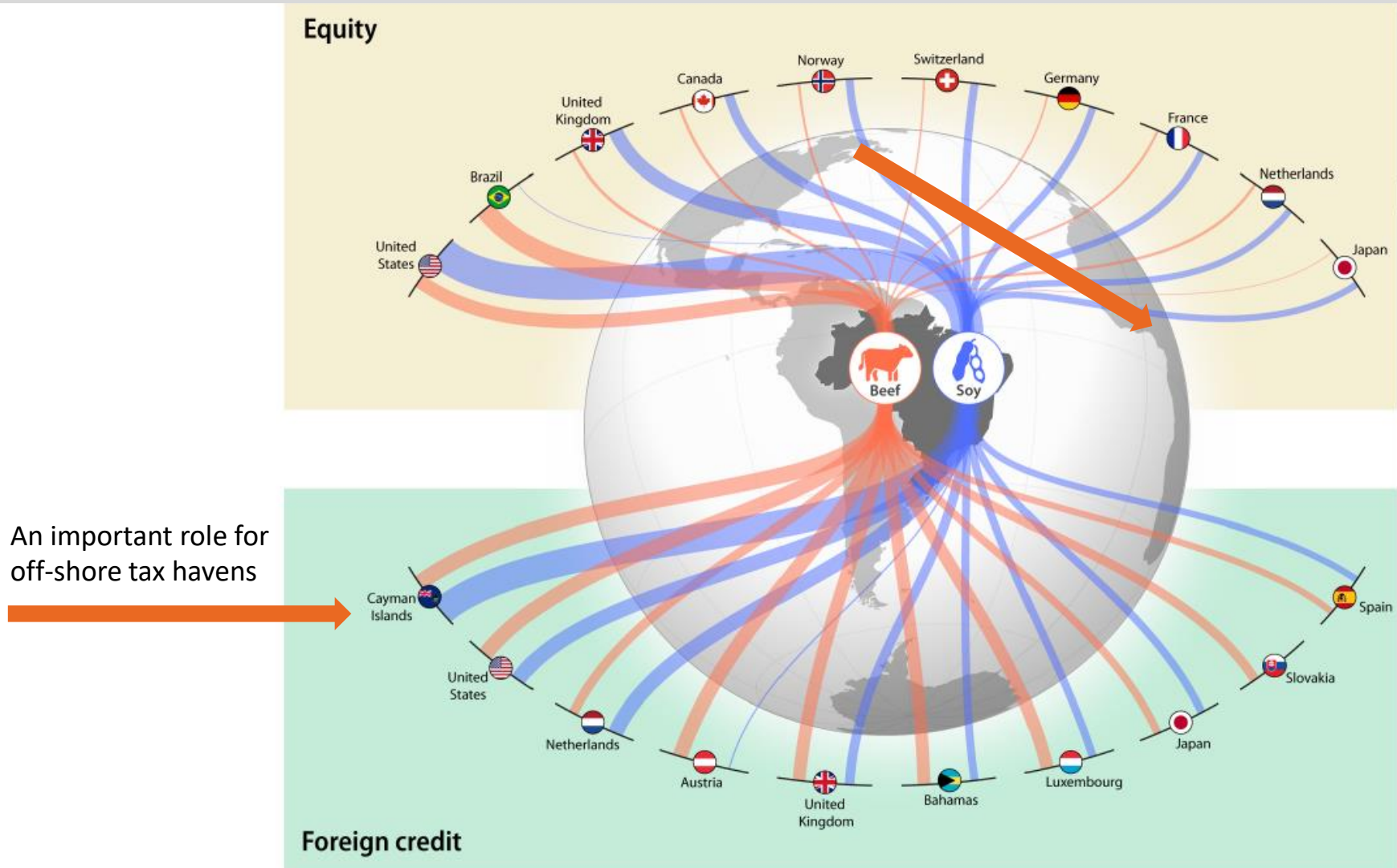
Higher levels of debt have coincided with a large concentration in banking and an increasing share of mortgages in credit provision

# The **debt shift**: credit supply from real economy (firms) to mortgages (consumers) - and its impact on income inequality

absent in (most) macro-economic models



# Globalization, financialization – and the destruction of the Amazon



**Figure 3 | Equity, and foreign credit to deforestation-risk economic industries in the Brazilian Amazon.** The data from this image is based on the methods and analysis presented in (Galaz et al., 2018a and Galaz et al., 2018b). Updated data from these cases have been provided by Ami Golland (equity, based on data from Orbis values for year 2018) and by Alice Dauriach (foreign credit, based on data from the Brazilian Central Bank, 2000–2018).

## 6.1 Modelling economic growth

# The Mystery of Economic Growth

ELHANAN HELPMAN

Economic growth:

- Supply-side: production functions in  $K$  and  $L$ , but what are these?
- Other production factors (land, resources)?
- Role of science and technology?
- Mechanisms of trade and finance?
- Assumption of equilibrium in supply-demand and investment-savings?
- Formulation of simplistic, stylized producers and consumers?

## The neoclassical economic growth model (supply-side)

$$\frac{dK}{dt} = Y(K, L) - mK - C$$

Per labourer, using  $k=K/L$  and  $dL/dt=nL$ :

$$\frac{dk}{dt} = y(K, L) - (m + n)k - c$$

Sustainable [per person] consumption as indefinite constant consumption per person,  $c$ , is possible in this formulation.

A sustainable economy in the sense of a constant producing capital stock implies that [per person] consumption equals [per person] output minus depreciation.

capital dep=reciation rate

population growth rate

$$\frac{dK}{dt} = y(K, L) - mK - C$$

Per labourer, using  $k=K/L$  and  $dL/dt=nL$

$$\frac{dk}{dt} = y(K, L) - (m + n)k - c$$

consumption of goods and services of average person

production of goods and services of average labourer

But how does THIS (the production function) look like? And how does technology a.o. influence it?

Sustainable [per person] consumption as indefinite constant consumption per person,  $c$ , is possible in this formulation.

A sustainable economy in the sense of a constant producing capital stock implies that [per person] consumption equals [per person] output minus depreciation.

Table 14.X Structure of capital stocks

**Switzerland 2006**

**Finland 2006**

**Australia 1993/94**

Capital stock structure, at prices of preceding year, base year = 2000

Switzerland 2006		Finland 2006		Australia 1993/94	
	%				
Construction, building	55,8%	<b>Tangible fixed assets</b>		<b>Private</b>	
Construction, civil engineering	15,2%	- residential buildings	40,0%	Dwellings	32,5%
part of construction: Machinery and	27,6%	- non-residential buildings	26,7%	construction	17,2%
Fabricated metal products and machinery	14,4%	- other structures	12,6%	Equipment	15,5%
Office machinery and computers	1,2%	- transport equipment	3,1%		
Electrical machinery and apparatus n.e.c.	2,3%	- other machinery and equipment	15,0%	<b>Public</b>	
Radio, television and communication equ	2,1%			Dwellings	1,9%
Medical, precision and optical instrument	3,8%	<b>Intangible fixed assets</b>		construction	23,6%
Motor vehicles, trailers and semi-trailers	0,8%	software, knowledge, entertainment, art...	1,5%	Equipment	4,8%
Other transport equipment	2,9%				
Cultivated assets	0,2%	<b>Major improvements to land, etc.</b>	1,1%		
Computer and related services	1,3%				

**Sources:**

[http://www.bfs.admin.ch/bfs/portal/en/index/themen/04/02/04/key/Stock\\_cap.html](http://www.bfs.admin.ch/bfs/portal/en/index/themen/04/02/04/key/Stock_cap.html)

[http://www.stat.fi/til/pka/tau\\_en.html](http://www.stat.fi/til/pka/tau_en.html)

[http://www.rba.gov.au/statistics/op8\\_index.html](http://www.rba.gov.au/statistics/op8_index.html)

Crucial role for capital[ists], but...

what IS aggregate capital K?

And what should be counted:

physical, social, environmental – or financial capital?

## Annual working hours in EU countries 1955-2005

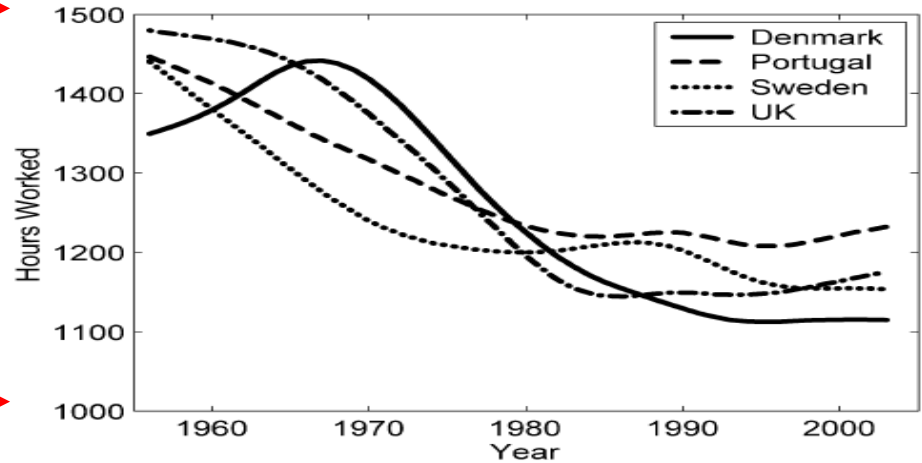
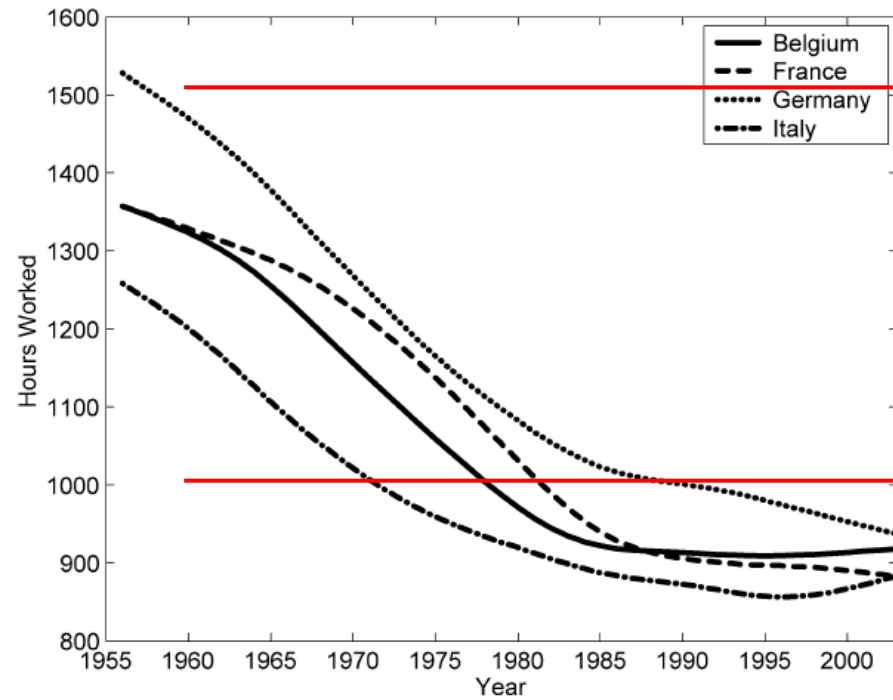


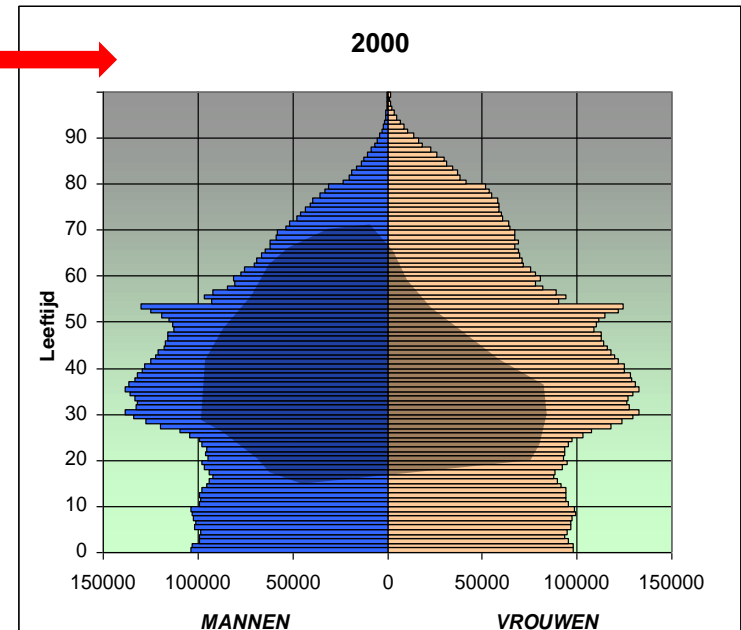
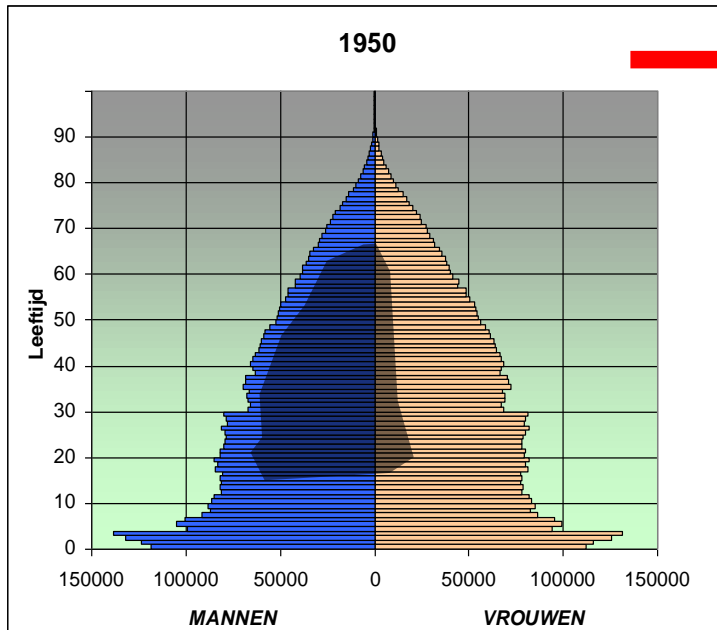
Fig. 5. Hours worked in group 3.

With K-L substitution and technology, capital and labour productivity go up (specialization, mechanization, automation, robotization → **less working hours and more time** (and obligation) **to consume**)

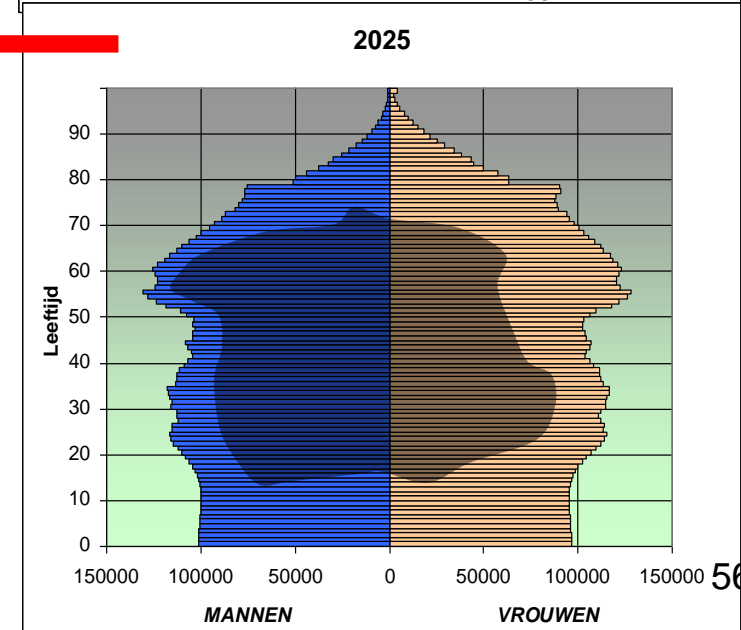
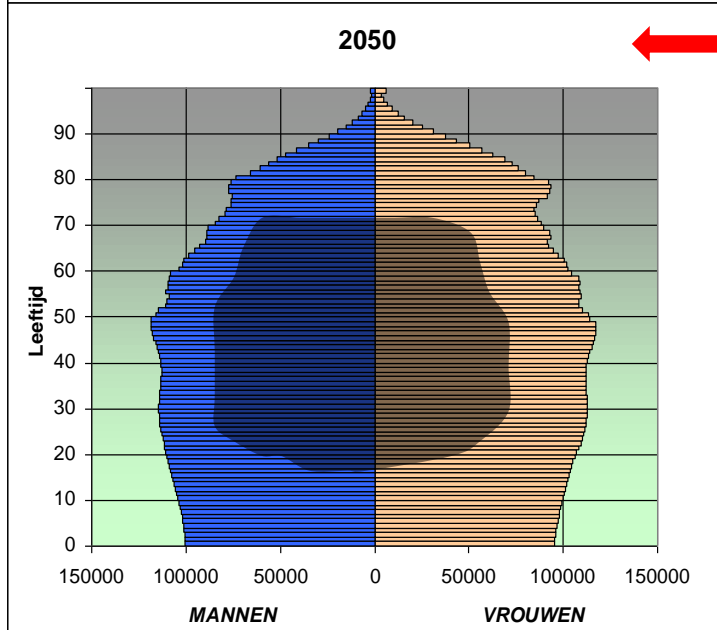
Aggregate labour force  $L$ , but...  
how much can people work?  
And how much they wish to work?  
Is there an 'optimal' employment rate?

# Changing patterns of employment: aging, female participation

## The Netherlands 1950-2000



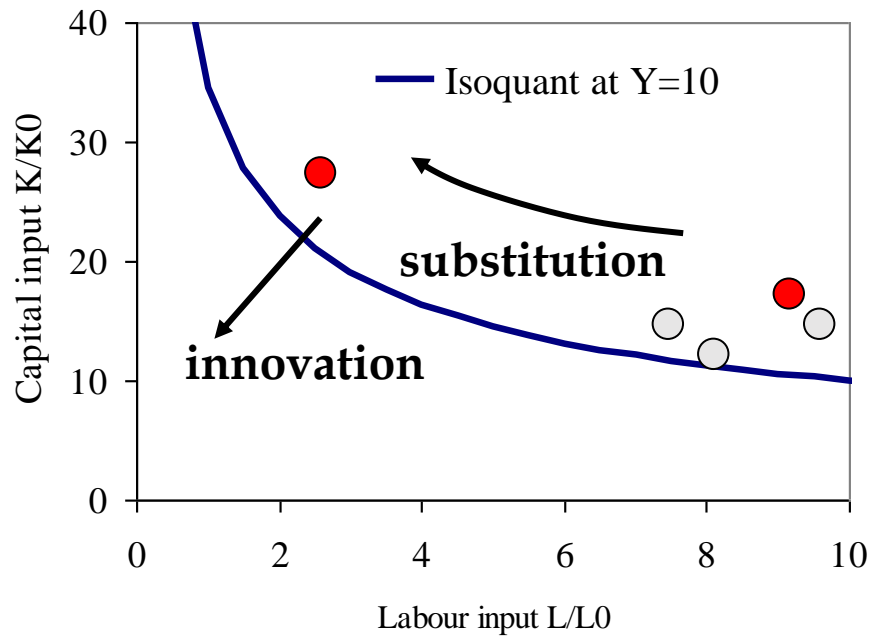
?



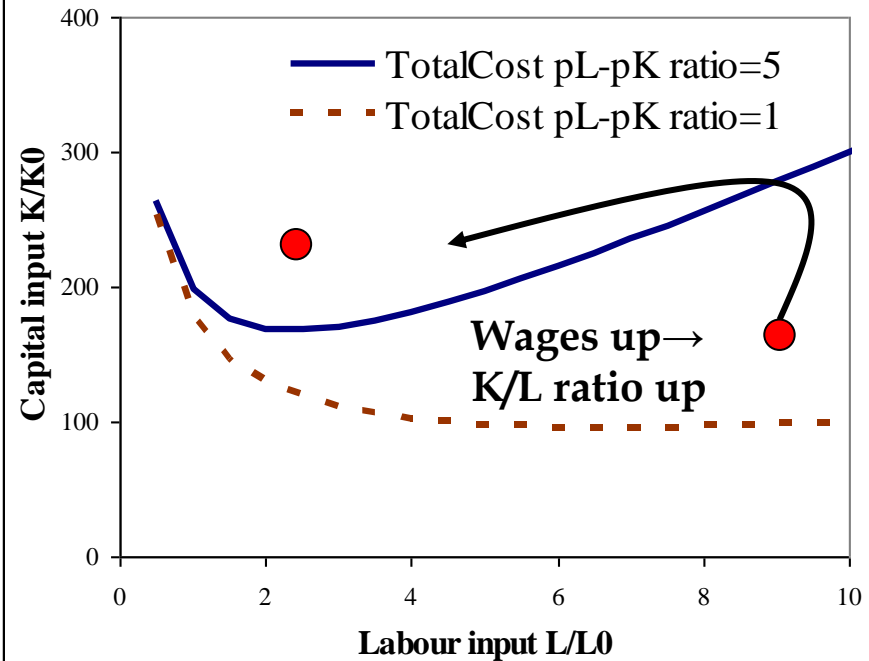
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# Technology: factor substitution and exogenous

Cobb-Douglas production function: capital (K) - labour (L) substitution



Cobb-Douglas production function: cost minimization

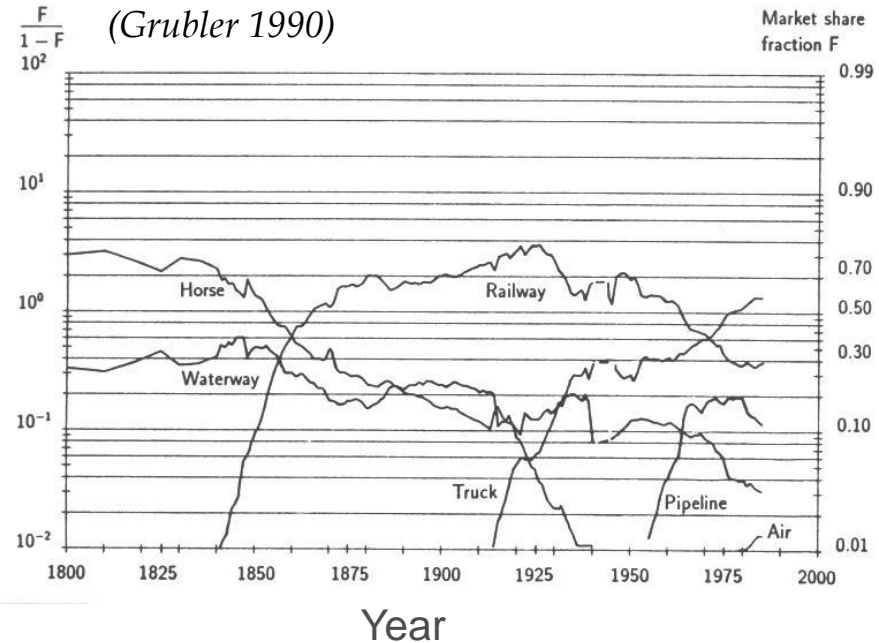
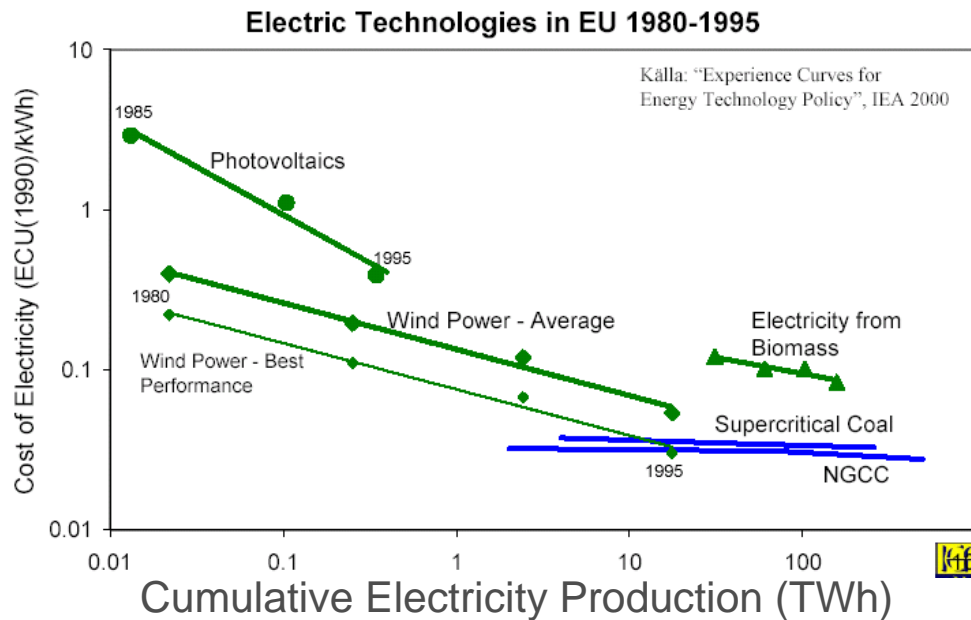


Economic growth model of industrial economy (Solow):

- Existence of **production frontier** with capital K and labour L as production factors
- **Substitution** between K and L (driven by changes in relative factor prices)
- **Innovation** (factor-specific or factor-neutral) **exogenous** in production function
- Similar dynamics for other production factors (energy, materials)

eat

# The quasi-autonomous endogenous forces of technology



Other dynamics in industrial economy:

- **Science-based technology** determines most of productivity (and macro-economic) growth
- **[endogenous] learning-by-doing** (see left figure); openness to trade, patenting and intellectual property laws, state competition...
- Attempts at **generalized mechanisms**: logistic substitution in technology (see right figure), creative destruction (Schumpeter), long waves (Kondratiev), evolution, winner-takes-all dynamic, first mover advantage...

# Economic growth and the financial system

revisiting neoclassical economic growth modelling after the 2008 financial crisis

*'planned investment need not equal planned saving' - a central feature of the Keynesian position' - Jones 1976:22)*

Non-equilibrium dynamics with stock-flow formulation:

- demand  $D$  is not equal to supply  $Y \rightarrow$  adaptive price fluctuations
- savings  $S$  are not equal to investment  $I \rightarrow$  behavioural equations about investment
- savings  $S$  and consumption  $C$  depend on income and wealth of households

$$D \neq Y$$

$$I \neq S$$

$$C \neq Y - S$$

Entrepreneurs use profits for replacement and expansion investments; additional credit comes from bank loans and/or shares. Consumers spent part of income and wealth on real estate; banks provide mortgages.

$$I \leftrightarrow [\text{financial system}] \leftrightarrow S$$

# Modelling physical and financial dynamics

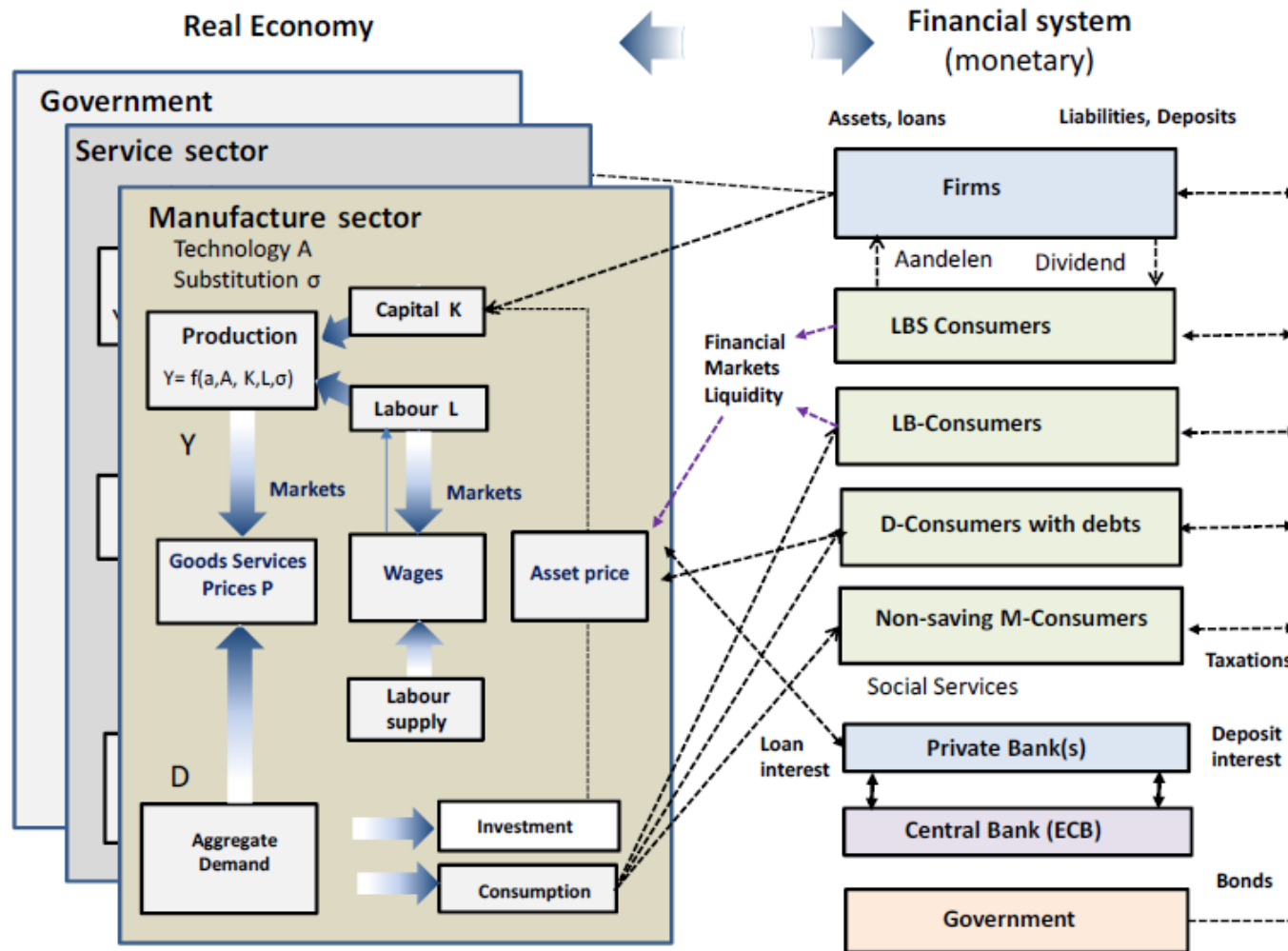
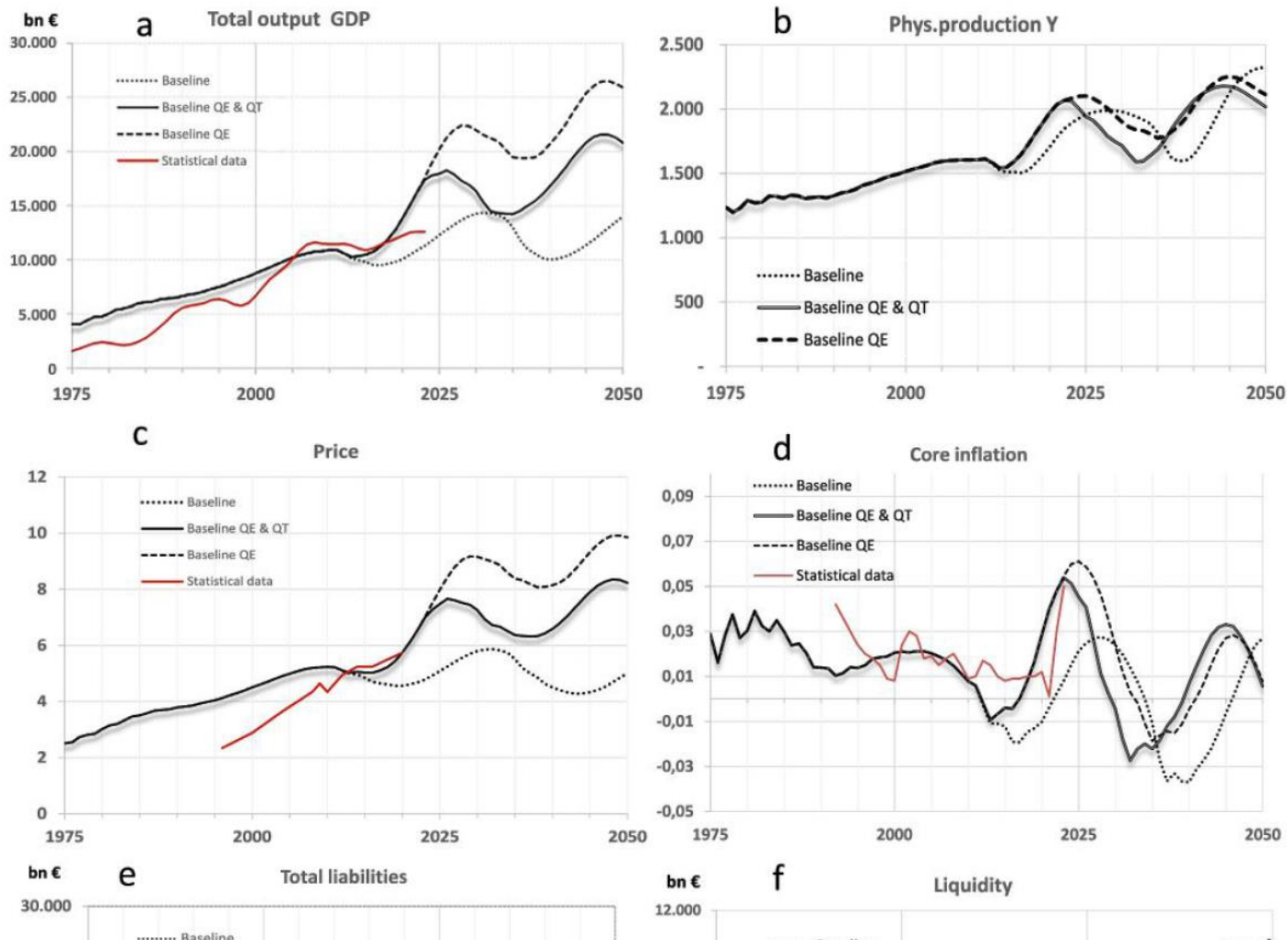


Figure A1. Schematic representation of the Eurozone Sustainable Finance Model: the 'real', physical three-sector economy on the left hand side, the financial monetary system on the right hand side and their mutual interconnections.



Model-based narratives about money creation: money creation by private banks is procyclical and causes instabilities (Minsky); money creation should be in public hands, providing credit for societal needs.

# Economic growth and sustainability (demand-side)

*“It is only in the backward countries of the world that increased production is still an important object; in those most advanced, what is needed is a better distribution”. (J. S. Mill 1857)*

Hypotheses:

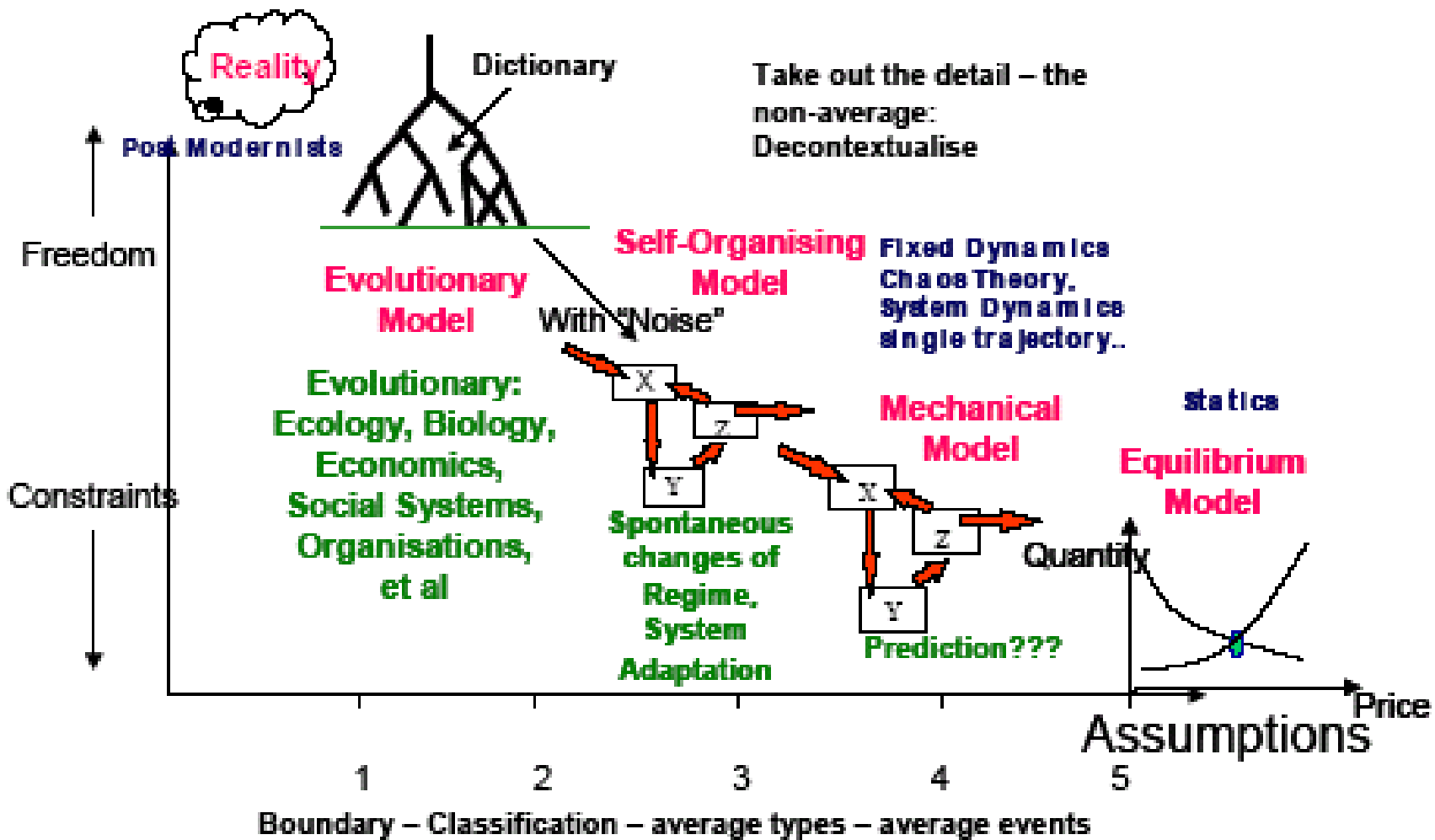
- stagnating growth in income and wealth causes social and political unrest
- capitalists want to make profits and a good return on capital
- governments prefer expanding budgets, which enhances political power and status
- the labour market is the conventional way of distributing the rewards of rising productivity among workers (‘labour’) and others
- most ideological battle in economics is about the organization and fairness of this distribution (acemoglu and johnson 2024)
- economic growth mitigates the tensions of inequality and environmental deterioration; hence a needs creation orientation and industry

*The compelling attraction of economic growth in its institutionalized modern form has been a superior substitute for redistribution (Hirsch 1977)*

## Which ways to go?

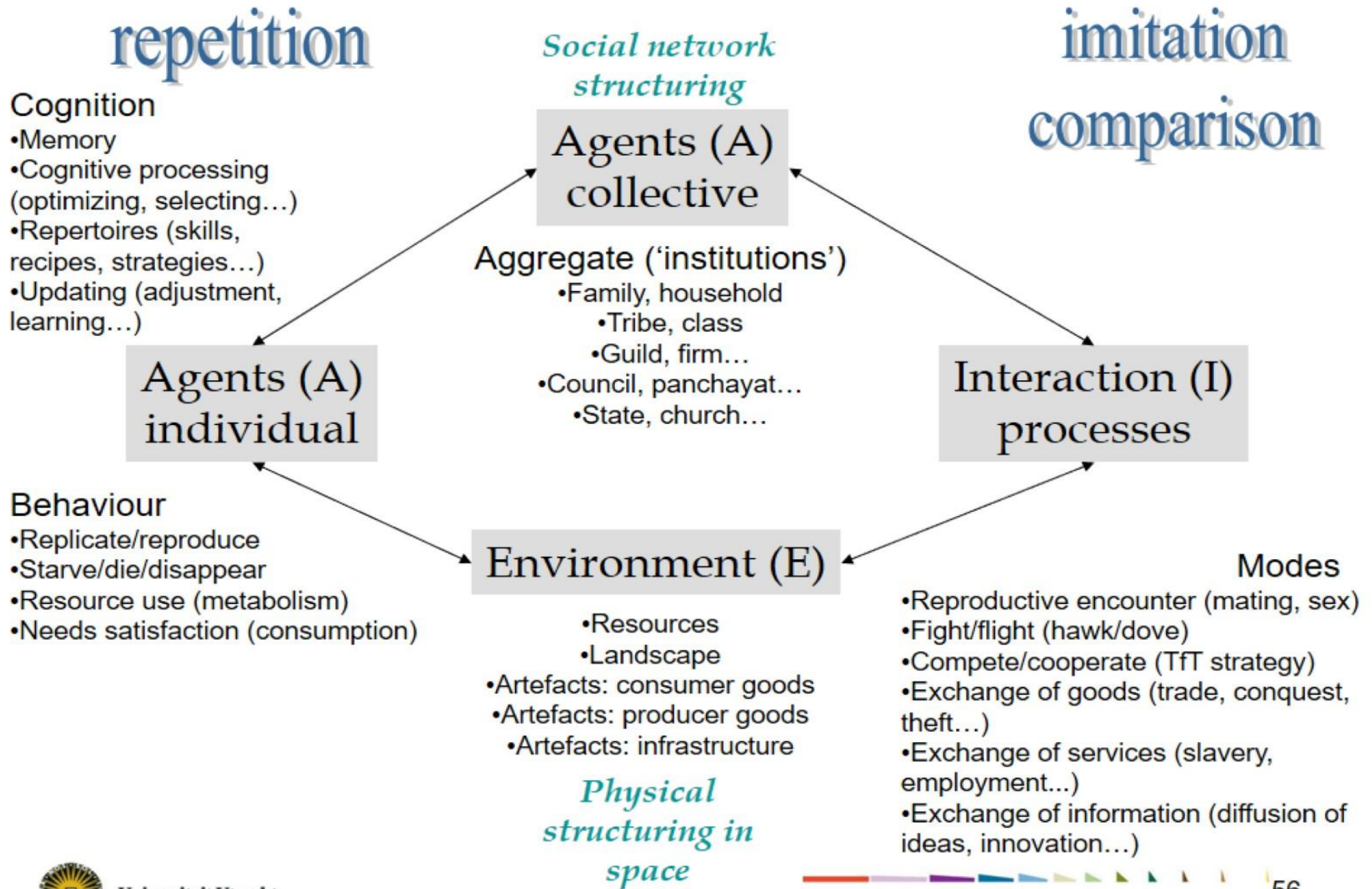
- Recognition of (extreme) simplification and aggregation (epistemology)
- Focus on subsectors of the economy and interconnections (structural economics, Input-Output analysis)
- Broaden the formulation of (economic) agents (evolutionary and institutional economics, behavioral economics, agent-based simulation)
- Consider explicitly the relations with resources and technology (resource and environmental economics)

# Modelling: simple but not too simple... the economy is a self-organizing complex system

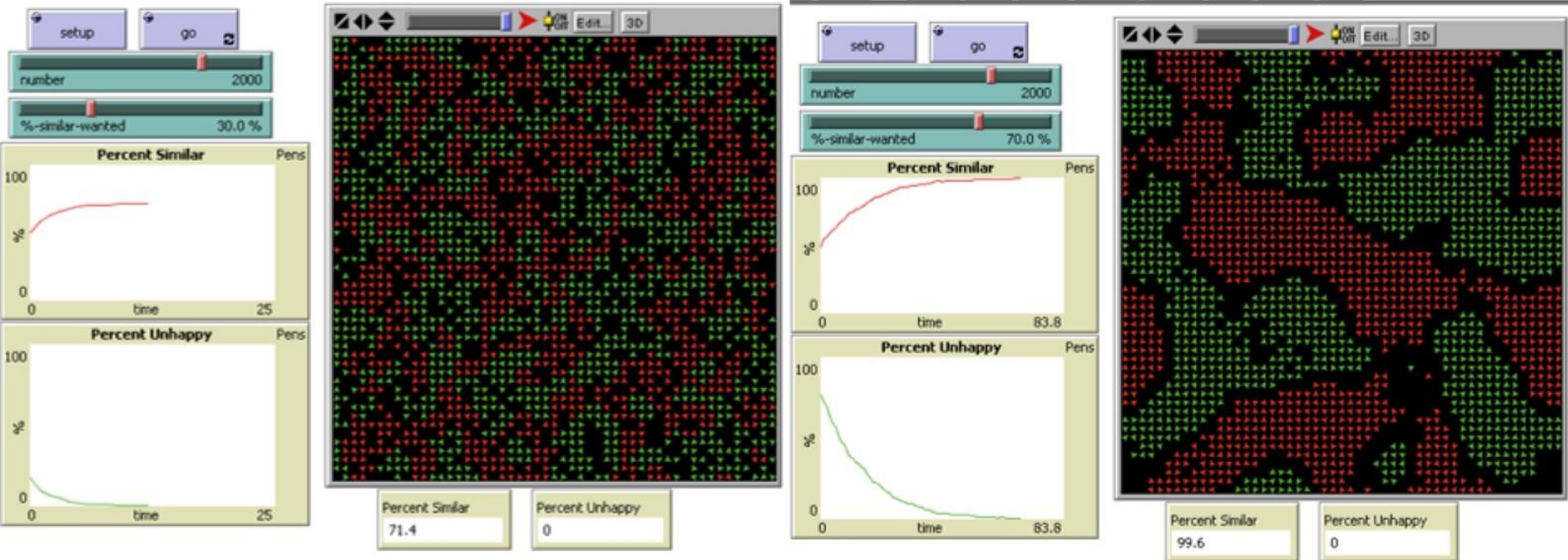


Assumptions made in trading off realism and complexity against simplification and hence ease of understanding (Allen et al. 2004)

# Agents instead of stylized homo economicus



Economic agents: more than rational deliberation...



## NETLOGO SEGREGATION MODEL

- \*two types of turtles in a mythical pond.
- \*red turtles and green turtles get along with one another, but each turtle wants to make sure that it lives near some of "its own."
- each red turtle wants to live near at least some red turtles, and the same for green ones.

Based on Schelling's *Micromotives and macrobehaviour*.

See <http://ccl.northwestern.edu/netlogo/models/Ethnocentrism> for a more recent model, that is included in the NetLogo Library.

# Resource Abundance and Strategy

- Distributed resource, minority game, Tragedy of Commons: fishing in different areas



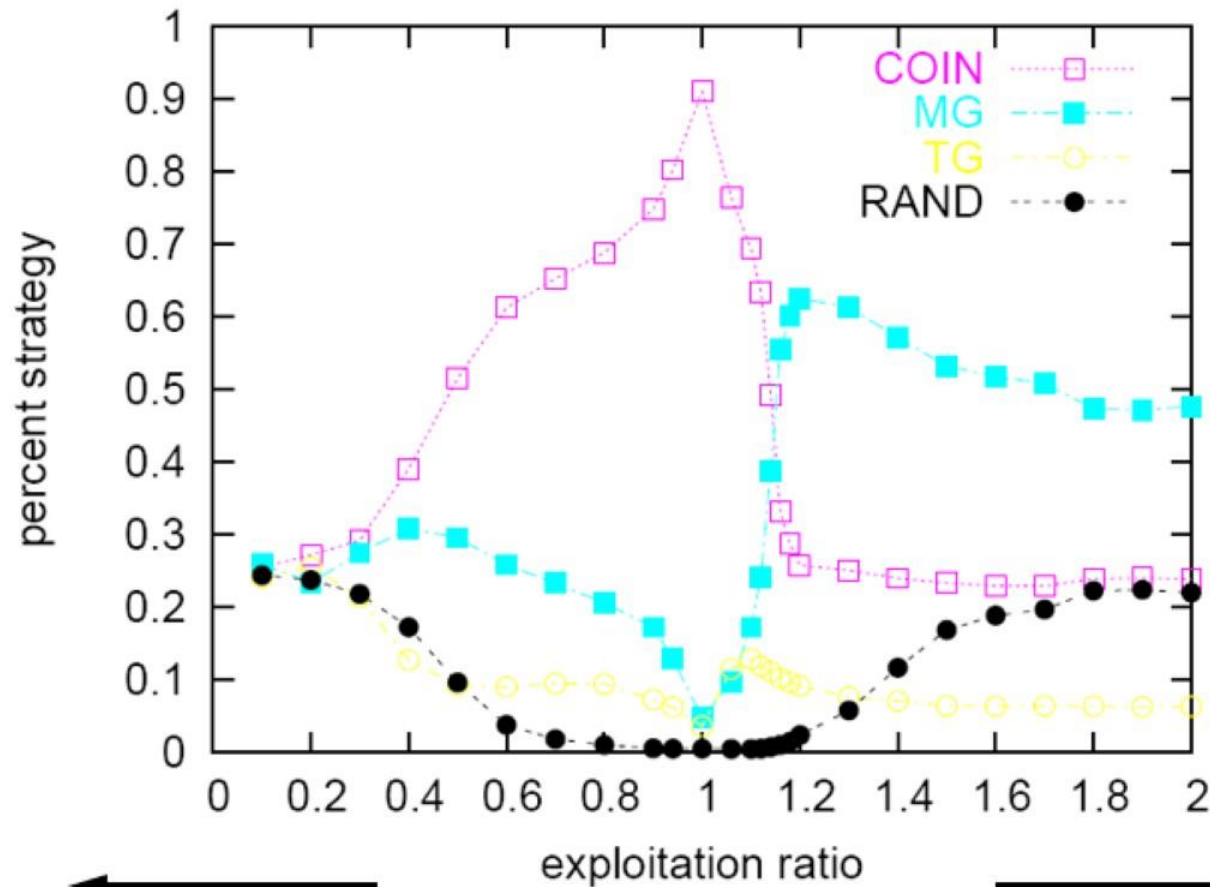
N agents, where to go fishing?

- Strategies:
  - A) select randomly?
  - B) select selfishly?
  - C) work/share as a team?
  - D) “collective intelligence”?
- Time horizons for planning?

Fishermen (agents) choose the fishing area on the basis of the best (highest catch) strategy



# Fishing strategies: An Agent-Based evolutionary simulation Model



**Human behaviour:  
is resource  
exploitation  
strategy – and the  
associated ethics  
– dependent on  
resource  
abundance?**

← under-exploited

→ over-exploited

COIN Collective INtelligence  
MG Minority Game  
TG Team Game  
RAND Random



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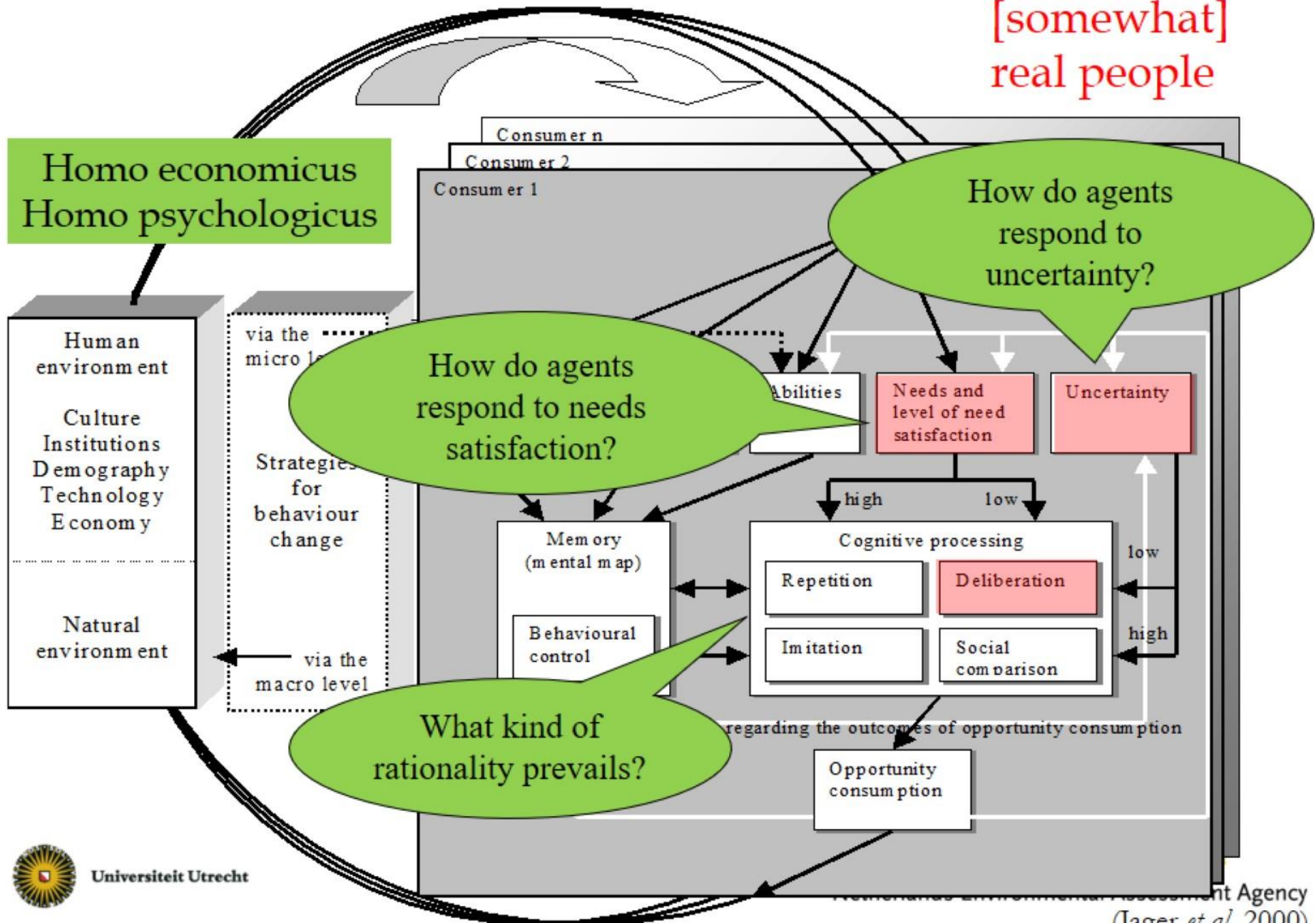


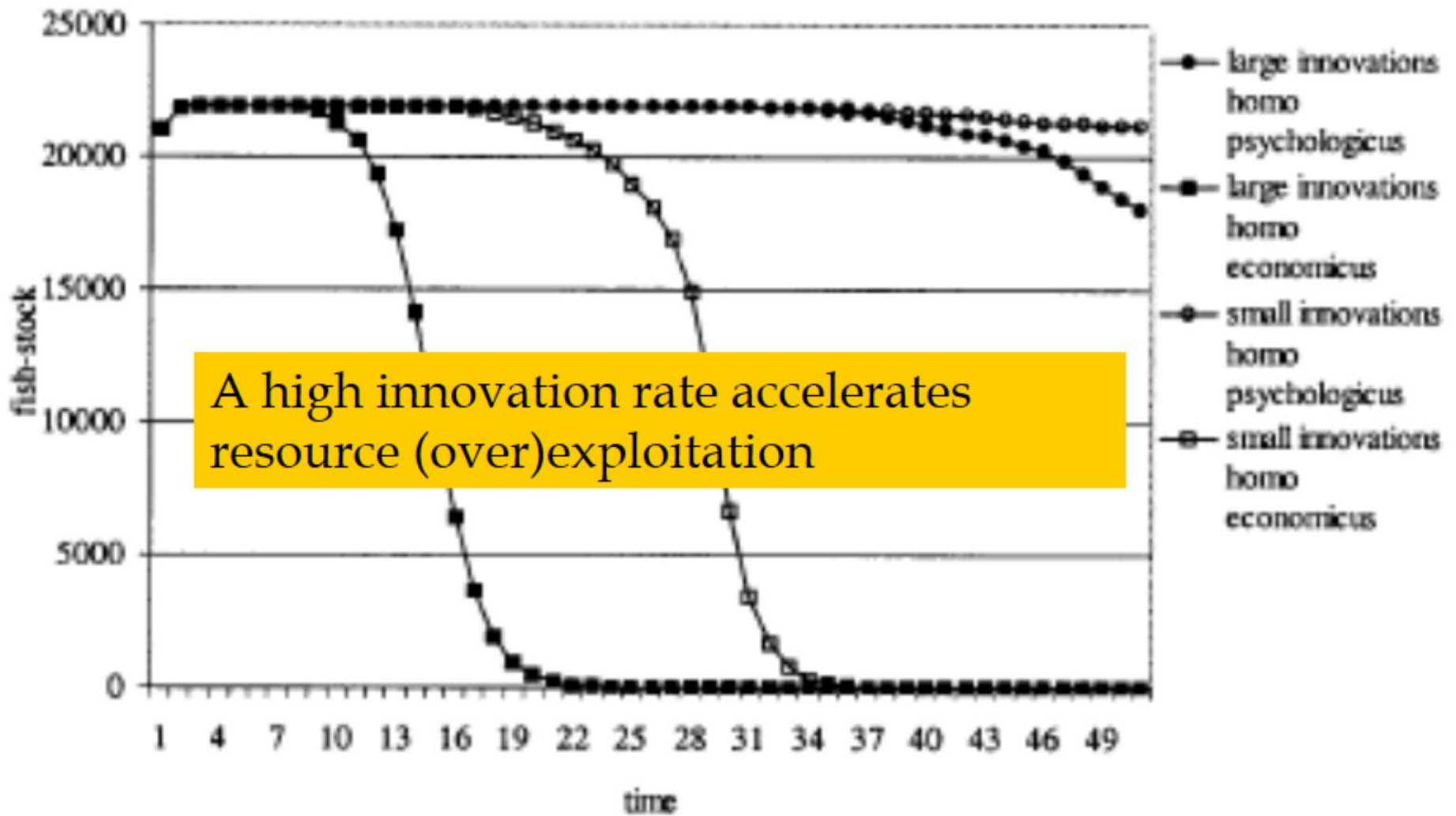
Netherlands Environmental Assessment Agency

(Brede and De Vries 2011)

# ABM: THE CONSUMAT INHABITANTS OF LAKELAND

[somewhat]  
real people





## The ambiguity of innovation

The fish stock for the first 50 timesteps for the Homo economicus and Homo Psychologicus (averages for 100 simulation runs) in a fishing-only no-gold-mining world, without and with a small and large innovation made in timestep 10 (Jager et al. 2000).

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*Dank voor uw aandacht*  
*Merci pour votre attention*  
*Thank you for your attention*  
*Danke für Ihre Aufmerksamkeit*

