Introduction to Economic History : Capital, Inequality, Growth

(Master APE & PPD)

(EHESS & Paris School of Economics)

Thomas Piketty

Academic year 2026-2027

Lecture 1: Growth, Degrowth & Well-Being: Material and Monetary Accounts, from Social Tables to Ghost Hectares

Roadmap of the lecture

- Measuring Social & Economic Progress: Material Accounting and Monetary Accounting Are Both Essential
- The Law of Cumulated Growth: Small Annual Growth Rates Have Enormous Long-Run Impact (Population, Per Capita GDP, Total GDP)
- National Accounts: from Land & Social Tables (18c) to Capital & GDP (19c-20c) to Ecological Accounts & Ghost Hectares (21c)
- From Output to GDP (Gross Domestic Product), NDP (Net Domestic Product), GNI (Gross National Income) & NNI (Net National Income)
- Multiple Sectors & Relative Prices: Uneven Growth & Technical Progress and the Illusion of Market-Driven Dematerialization

Brief Bibliography

- R. Stone, The Accounts of Society, Nobel Lecture, 1984
- ***A. Madison, *The World Economy - A Millennial Perspective*, 2001**
  (Maddison 2010 Database , Updated Versions)
- R. Giffen, The Growth of Capital, 1889
- S. Kuznets, Shares of Upper Income Groups in Income & Savings, 1953
- System of National Accounts (SNA), UN-EC-IMF-OECD-WB, 2008
- T. Piketty, G. Zucman, Capital is Back: Wealth-Income Ratios in Rich Countries, 1700-2010, QJE 2014 (Macro-Historical Database)
- WID National Accounts Series (DINA Guidelines 2025)
- L. Chancel et al, Prosperity Within Limits? Planetary Habitability, Global Convergence and Structural Transformation, 2026 (WSEED.world)

Measuring Social & Economic Progress: Material & Monetary Accounting Are Both Essential

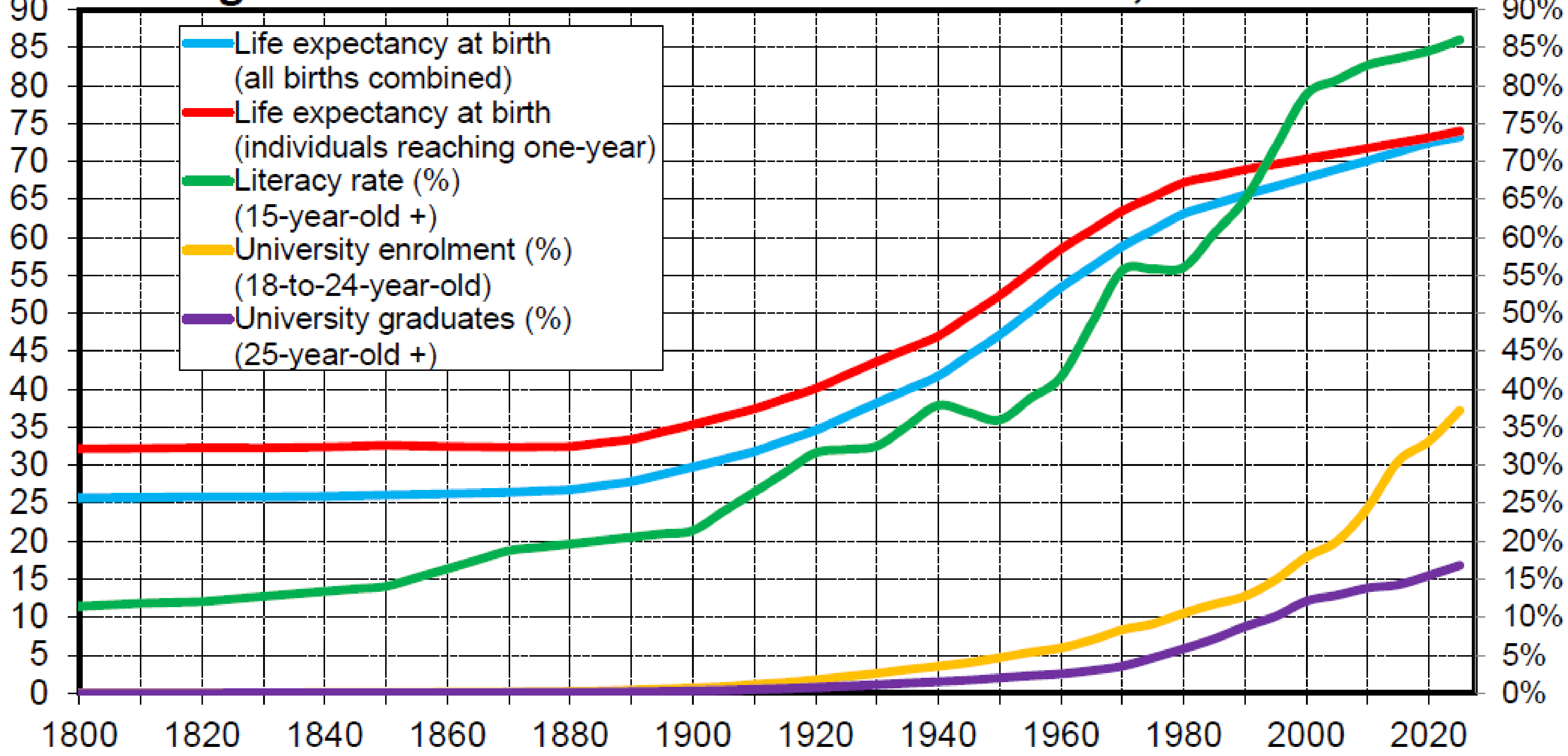
- **Q.: Which Indicators Should We Use to Measure Socioeconomic Change, both to Study the Past and to Analyze Policy Options for the Future?**
- **Material Accounting: real quantities of food, housing, energy, education, health, land use, forest cover, GHG emissions, temperature etc.**

→ **arguably the best way to measure real progress** (e.g. improved access to fundamental goods like education and health)....**or real decline** (e.g. global warming, biodiversity loss, deforestation, etc.)

- **Monetary Accounting: GDP, NNI (net national income), wages, wealth, etc.**

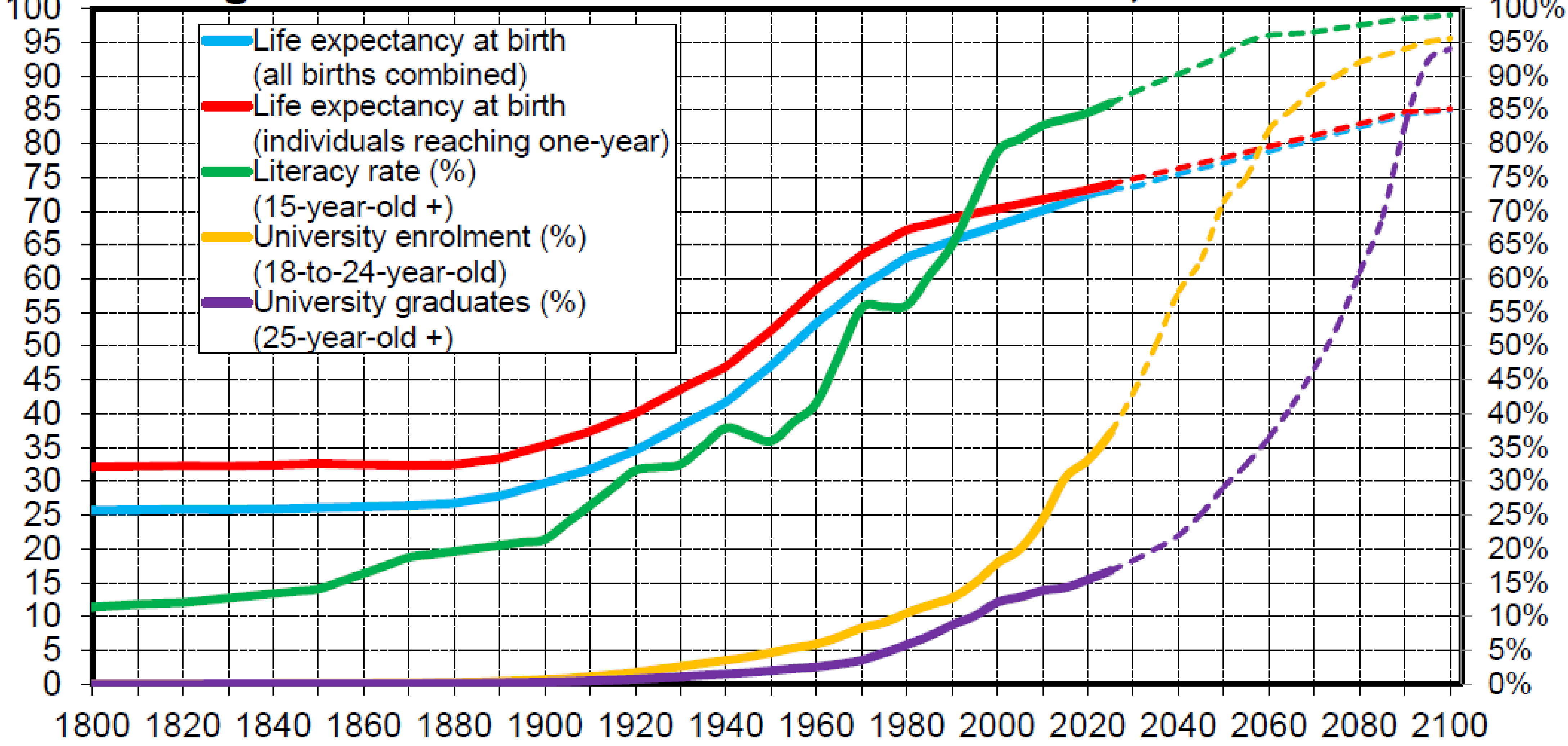
→ **also very useful, but one has to be very careful & explicit about « relative prices »**, i.e. how the relative value of education, climate, etc., affects aggregate indicators, **& about inequality.** Aggregate GDP with no attention to relative prices, externalities & inequalities can be a pretty bad measure of well-being!

Fig. 1a. Health and education in the world, 1800-2025



Interpretation. Life expectancy increased from an average of 26 years in the world in 1800 to 73 years in 2025. Life expectancy for those living to age 1 rose from 32 years to 74 years (because infant mortality before age 1 decreased from 20% in 1800 to less than 1% in 2025). The literacy rate for the 15-year-olds-and-over rose from 12% to 86%. University enrolment for the 18-to-24-year-olds rose from less than 1% to 37%. The proportion of university graduates for the 25-year-olds-and-over rise from less than 1% to 17%. **Sources and series**: wid.world

Fig. 1b. Health and education in the world, 1800-2100



Interpretation. Assuming that past trends continue in the future, life expectancy could reach about 85 years worldwide by 2100, while literacy rates, university enrolments rates & proportions of university graduates could reach 95% or more. As time passes & quantitative improvements continue, the key question will increasingly become the quality of health care and education provision. **Sources and series**: wid.world

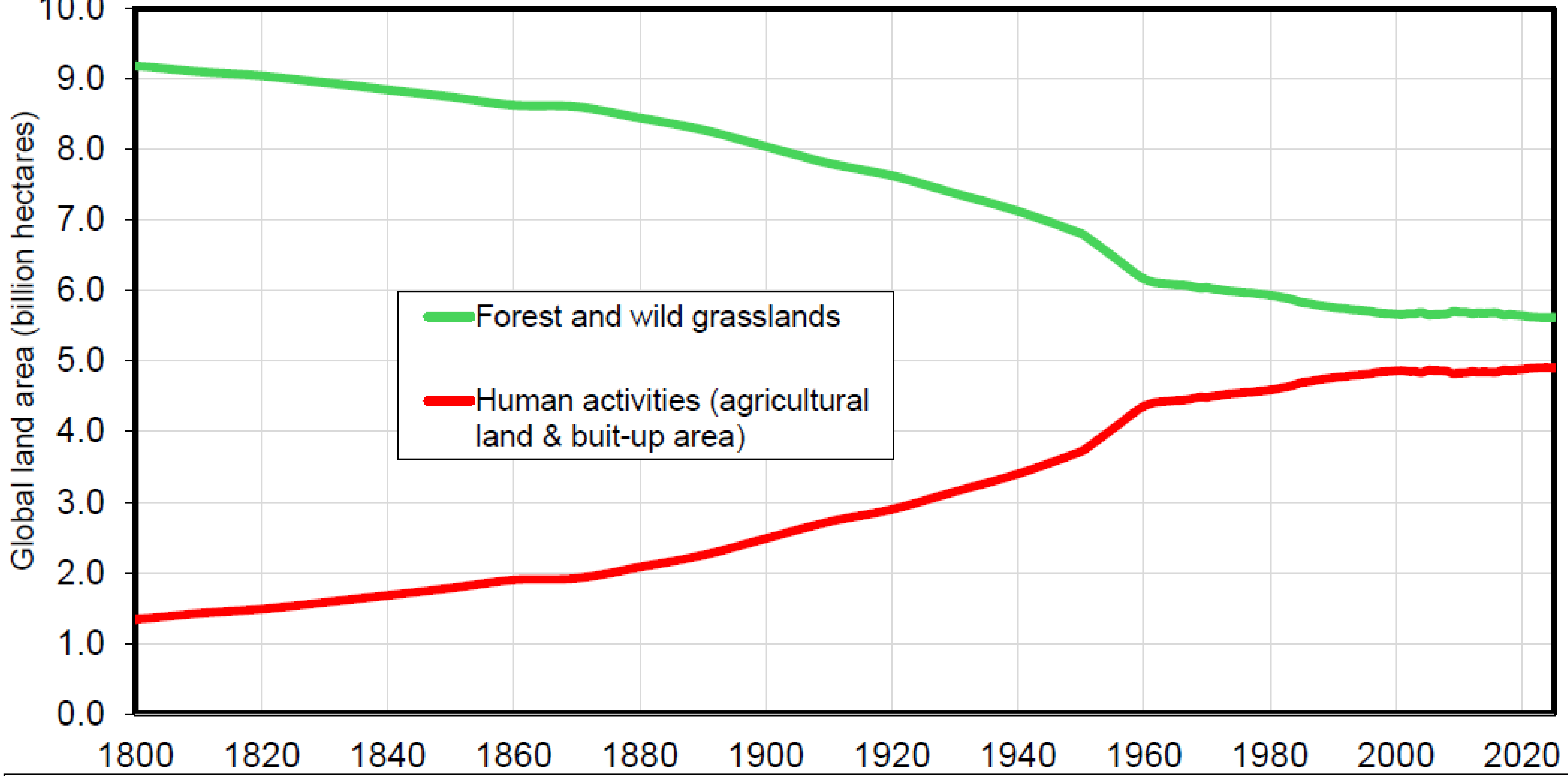
Global land area (2025)

	Area (billion hectares)	% total
Total land area	**14.8**	***100%***
incl. Human activities	***4.9***	***33%***
incl. Built up area	*0.1*	*1%*
incl. Grazing land (cattle)	*3.2*	*22%*
incl. Cropland	*1.6*	*11%*
incl. Forest & wild grasslands	***5.6***	***38%***
incl. Forests	*4.1*	*28%*
incl. Wild grasslands & shrubs	*1.5*	*10%*
incl. Other Barren Land *(mountains, deserts..)*	***4.3***	***29%***

Interpretation. Global land area amounts to about 14.8 billions hectares in 2025, including approximately 33% used by human activities (mostly grazing land and cropland), 38% in forests and wild grasslands and 29% in other barren land (mountains, deserts, etc.).

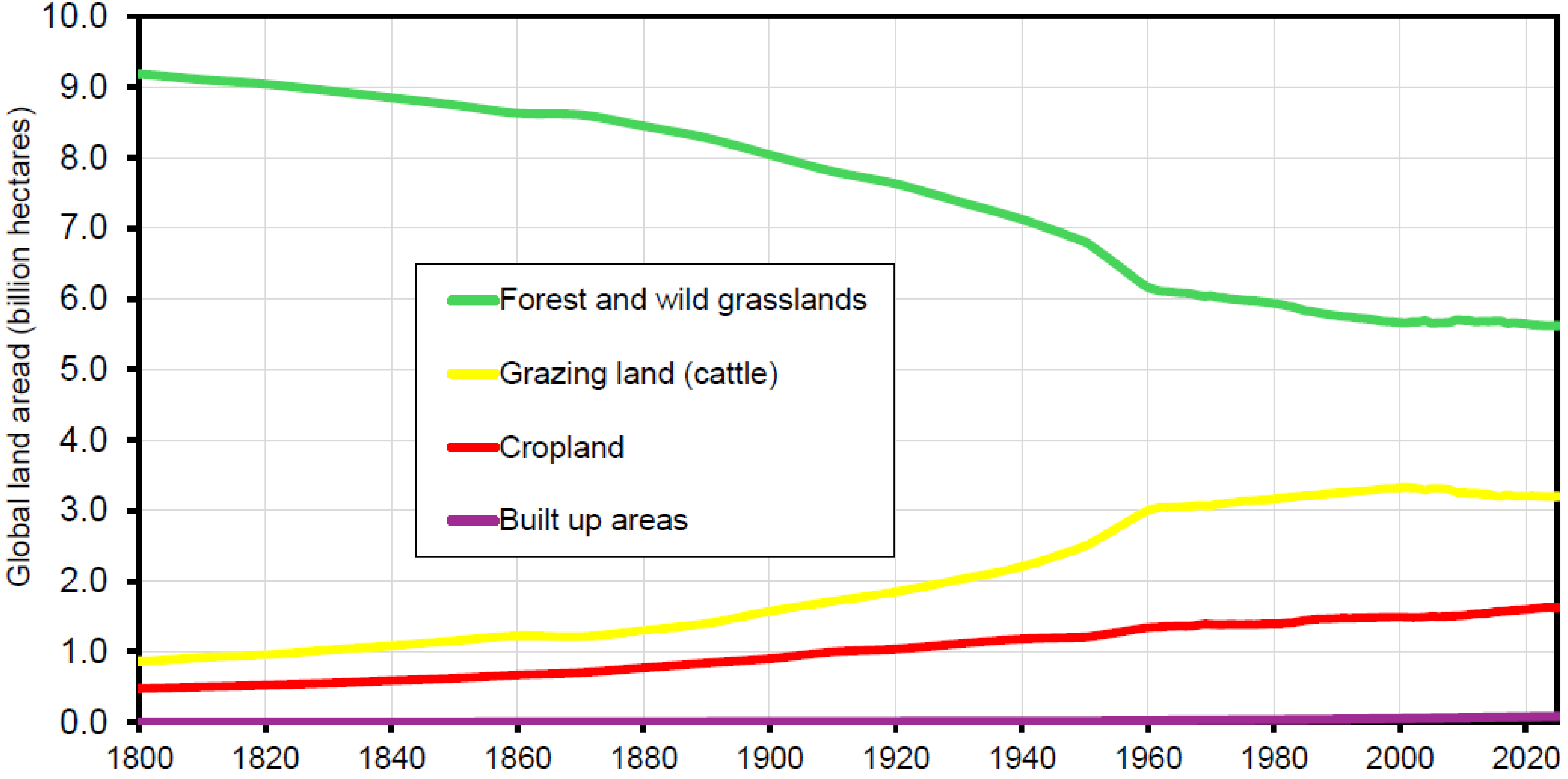
Sources and series: wseed.world (U1a)

Global Land Use, 1800-2025: the Decline of Forest & Wild Grasslands, the Rise of Human Activities



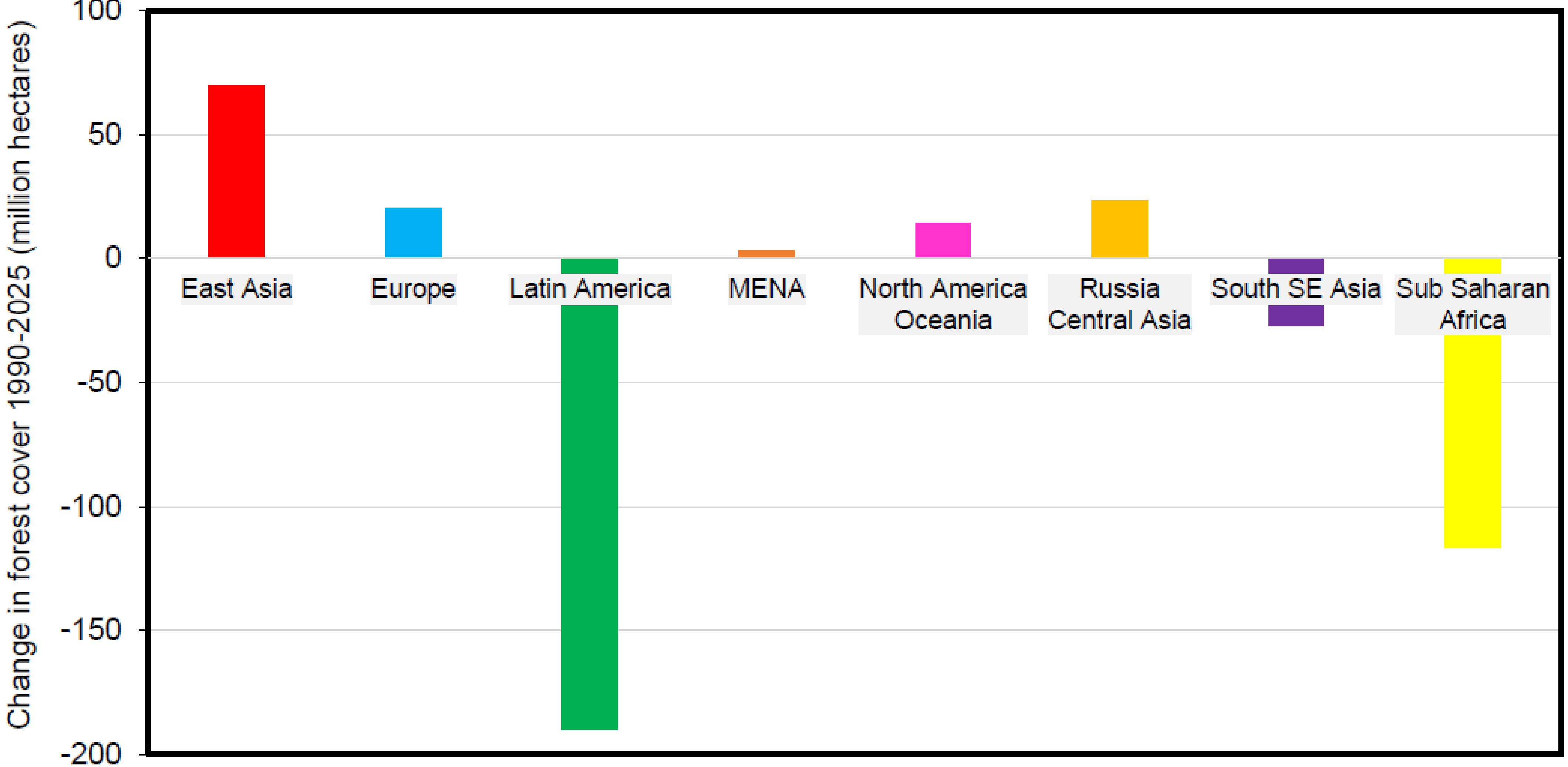
Interpretation. Global land area covered by forest & wild grasslands declined from about 9.2 billion hectares in 1800 (incl. 5.2 for forest and 4.0 for wild grasslands) to 8.0 billion in 1900 (incl. 4.8 and 3.2) and 5.6 billion in 2025 (incl. 4.1 and 1.5). Land area covered by human activities rose from 1.3 billion in 1800 to 2.5 billion in 1900 and 4.9 billion in 2025 (including 4.8 for agricultural land and 0.1 for built-up area). **Note.** Total land area also includes about 4.3 billion in other barren land (mountains, deserts, etc.), which has been approximately constant over time. **Sources and series**: wseed.world (U1a)

The Great Transformation of Global Land Use 1800-2025: The Key Role of Grazing Land (Cattle)



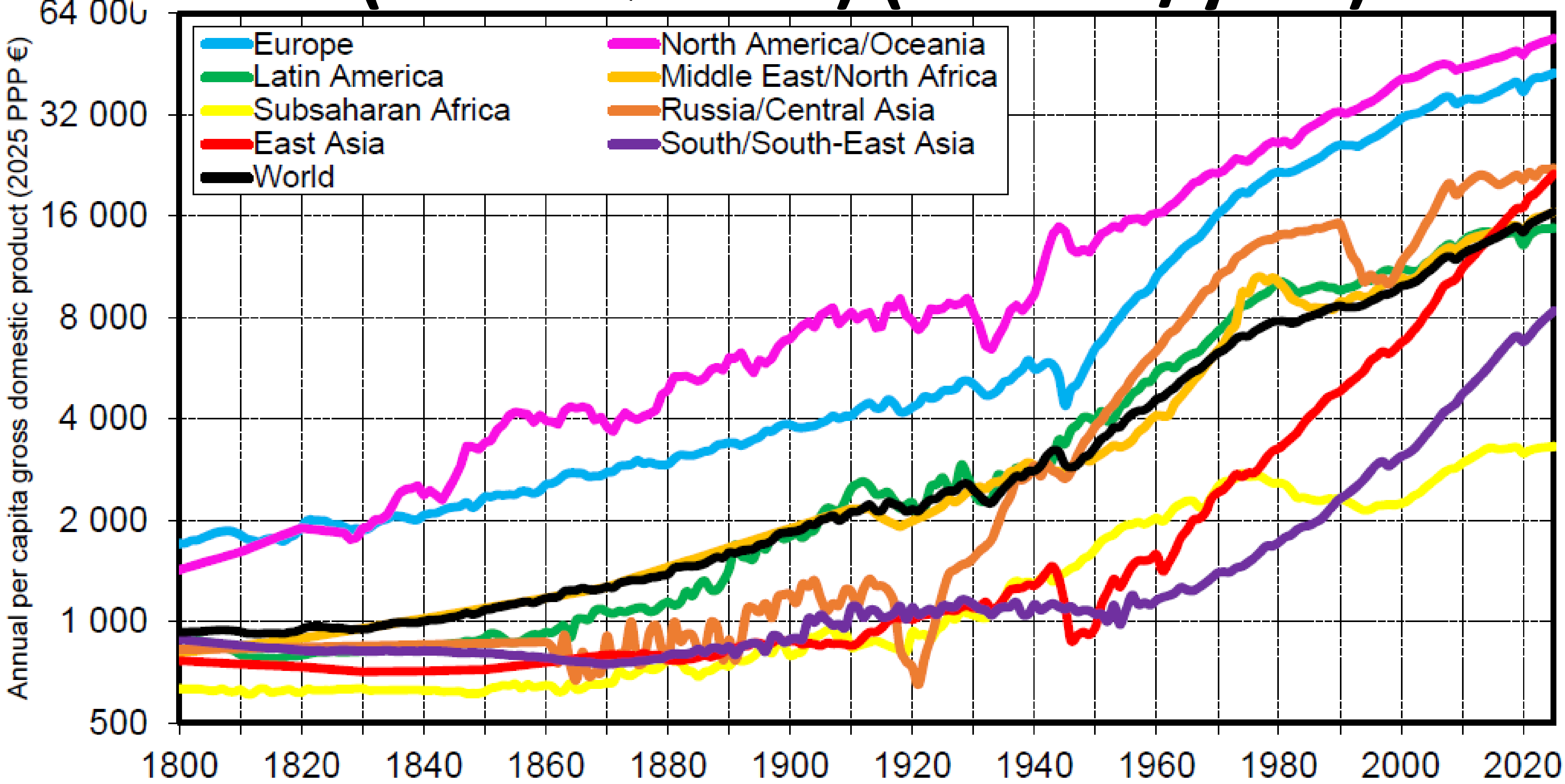
Interpretation. Global land area covered by forest and wild grasslands declined from about 9.2 billions hectares in 1800 to 8.0 billions in 1900 and 5.6 billions in 2025. In the meantime land area covered by human activities rose from 1.3 billions in 1800 to 2.5 billions in 1900 and 4.9 billions in 2025 (including 3.2 for grazing land, 1.6 for cropland and 0.1 for built-up area). **Note.** Total land area also includes about 4.3 billions in other barren land (mountains, deserts, etc.), which has been approximately constant over time. **Sources and series**: wseed.world (U1b)

The Continuing Fall in Forest Cover 1990-2025
(Global evolution over the period: -203 million hectares)



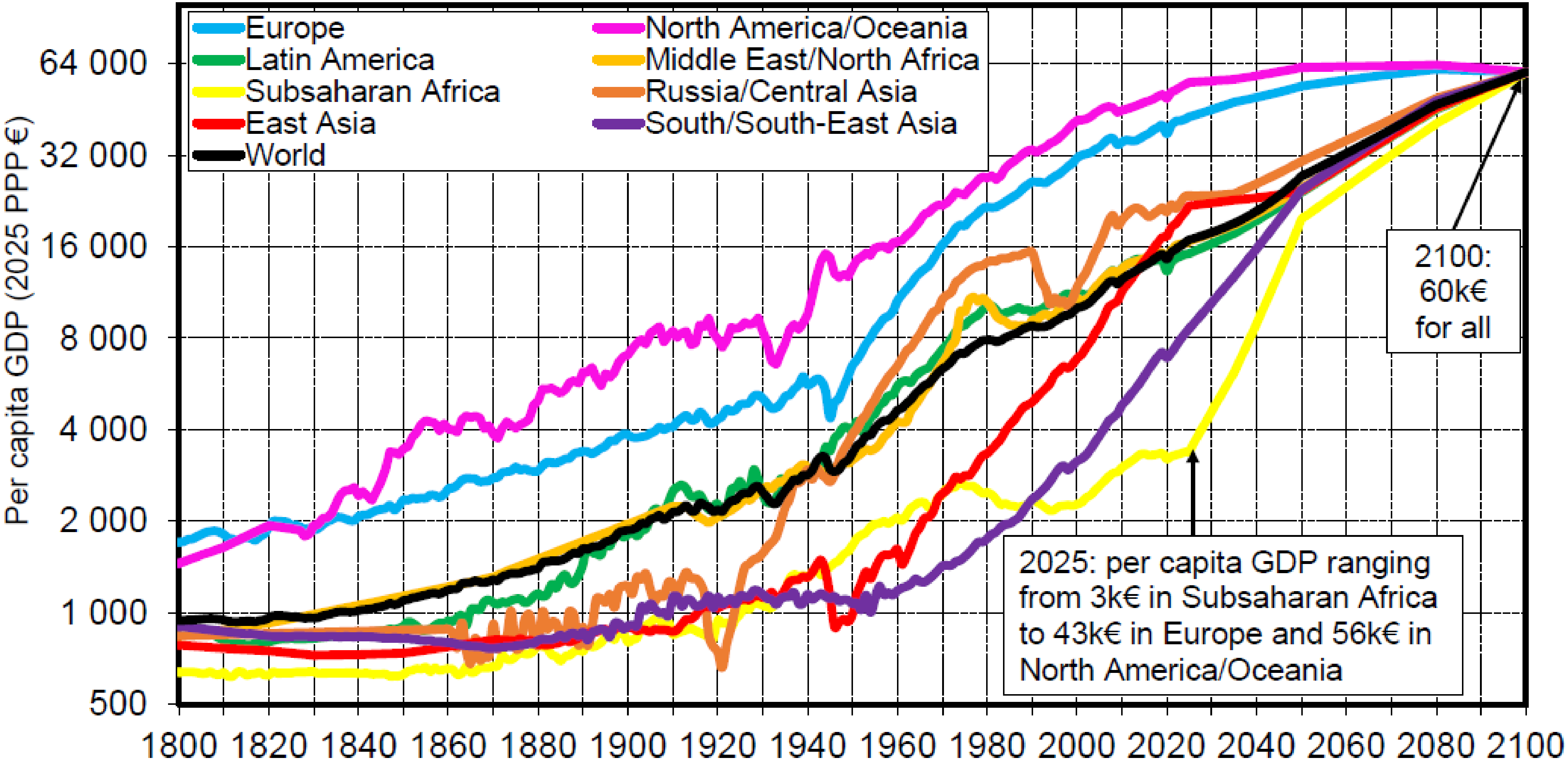
Interpretation. Global forest area declined by 203 millions hectares between 1990 and 2025 (in line with the long run decline of about 1.1 billion hectares observed between 1800 and 2025). This continued global forest decline results from large deforestation in the global South (Latin America, Subsaharan Africa, South & South-East Asia) and small reforestation in the global North (East Asia, Europe, North America, Russia). In addition, the areas which are currently under deforestation include denser forests with much stronger CO2 absorption capacities per hectare (two to three times larger) than the areas under reforestation. **Sources and series**: wseed.world (U2)

Per capita GDP 1800-2025: x18 (0.9k€ →16k€) (h=1.3%/year)

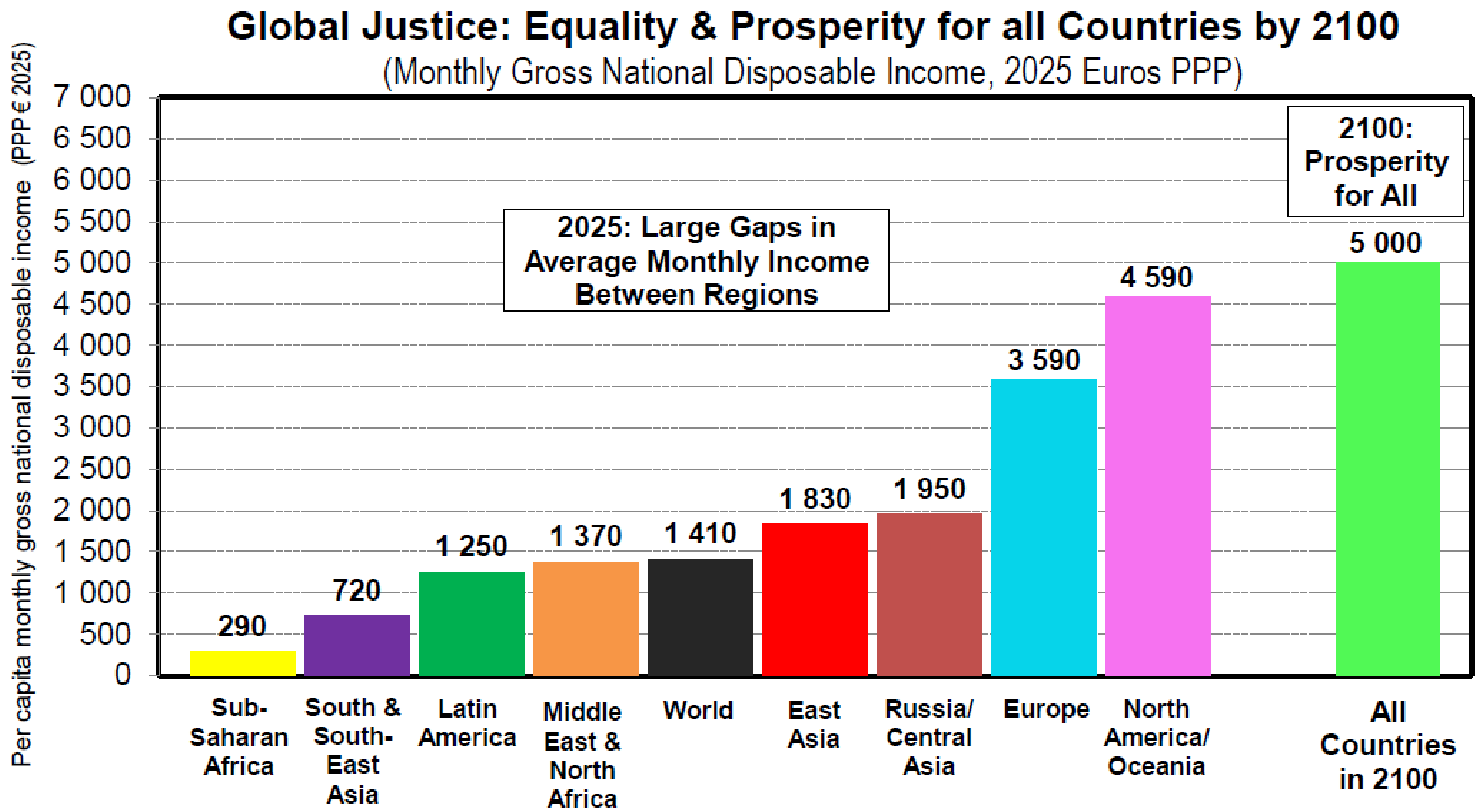


Interpretation. Expressed in 2025 PPP €, annual per capita gross domestic product (GDP) rose from about 900€ in 1800 to about 16 000€ in 2025 at the global level, with large disparities across world region: about 3 000€ in Subsaharan Africa, vs 40 000-50 000€ in Europe and North America/Oceania. Between 1800 and 2025, per capita GDP was multiplied by about 18 at the world level in PPP terms, which corresponds to average annual real growth rate of 1,3% per year. **Sources and series**: see wid.world

Prosperity for All Is Possible but Requires Sobriety
(Growth Cap for Rich Countries) & Inequality Compression

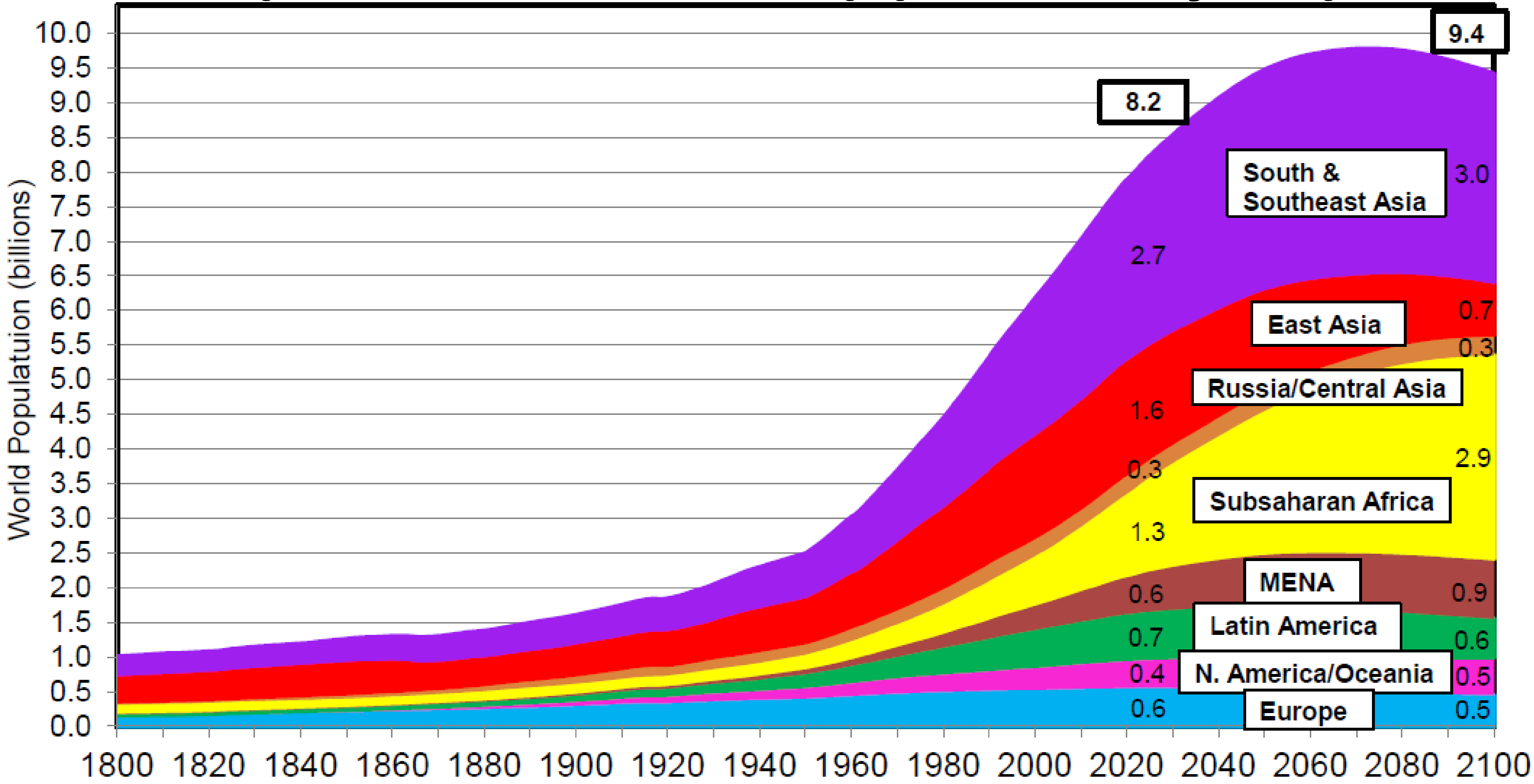


Interpretation. According to the Global Justice Platform, prosperity for all is compatible with planetary boundaries if it comes with sobriety, incl. a large reduction in labour hours (so as to cap per capita GDP close to today's richest countries level), and a sharp compression in inequality (so that bottom 90% income earners in rich countries benefit from rising incomes over 2026-2100 period). **Sources and series**: wseed.world (A1a)



Interpretation. The Global Justice Platform aims to combine equality and prosperity for all countries with planetary habitability (global warming below 2°C). In 2025, per capita monthly gross national incomes ranges from 290 Euros in Sub-Saharan Africa to 4590 Euros in North America/ Oceania. It is projected to reach 5000 Euros in all countries by 2100. **Sources & series**: gjp.wid.world (A0a)

World Population 1800-2025: x8
(1.0 billion → 8.2b) (n=0.9%/year)



Interpretation. According to the Sustainable Convergence scenario (and to all existing population projections), population growth over the 2025-2100 period will come entirely from the world's poorest regions, namely Subsaharan Africa and to a lesser extent South & South-East Asia.
Sources and series: wseed.world (Z1b)

The Law of Cumulated Growth: Small Annual Growth Rates Have Enormous Long-Run Impact
(Population, Per Capita GDP, Total GDP)

- **World Population 1800-2025: x 8** (from 1.0 billion to 8.2 billion)
- Average annual growth rate of world population over 1800-2025 period:

n = 0.94%

- I.e. 1.0094^{225}=8.2/1.0, or conversely $(8.2/1.0)^{1/2025}$ = 1.0094
- **Assume n = 0.94% continues over 2025-2250. Then world population will again be multiplied by 8.2, i.e. 67.2 billion inhabitants in 2250.**
- Maybe this would be too much for the planet.
- UN population projections: stabilization around 9-10 billion by 2080-2100 (with n close to 0%, or maybe around -0.1%/-0.2%)

The Changing Structure of World Growth, 1800-2100

(annual growth rate)	Population	Per Capita GDP	Total GDP
1800-2025	**0.9%**	**1.3%**	**2.2%**
1800-1910	0.5%	0.7%	1.3%
1910-1950	0.9%	1.1%	2.0%
1950-1990	1.9%	2.4%	4.4%
1990-2025	1.2%	1.9%	3.1%
2025-2100	**0.2%**	**1.7%**	**1.9%**
2025-2050	0.6%	1.9%	2.5%
2050-2080	0.1%	1.8%	1.9%
2080-2100	-0.2%	1.2%	1.1%

Interpretation. At the world level, population has been rising at 0.9% per year on average between 1800 and 2025, while per capita GDP rose at a rate of 1.3%, resulting into an total growth rate of 2.2% for aggregate GDP. By the end of he 21st century, most or all of the growth will come from per capita GDP. **Source:** wseed.world (Z1b)

On the simple arithmetics of demographic growth

- Assume **fertily = f** children per women, with **average childbearing age = 30** and **stable age structure** (i.e. ignoring ageing). Then: $\mathbf{1+n = (f/2)^{1/30}}$

- f=2 → n=0%
- f=4 → n=2.34% = pop. doubles every 30 years (never happened at world level)
- **f=3.5** → n=1.88% = pop. rises by 75% of every 30 years (**≈World 1950-1990**)
- **f=3** → n=1.36% = pop. rises by 50% every 30 years (**≈World 1990-2025**)
- **f=2.4** → n=0.61% = pop. rises by 20% every 30 years (**≈World 2025-2050**)
- **f=1.9** → n=-0.17% = pop. drops by 5% every 30 years (**≈World 2080-2100**)
- f=1.5 → n=-0.95% = pop. drops by 25% every 30 years (≈World post-2100?)

Demographic growth in the very long-run (0-1800)

- **According to Maddison 2010, world population rose from ≈220m in 0 to 270m in 1000, 440m in 1500, 600m in 1700 and 1.0b in 1800**

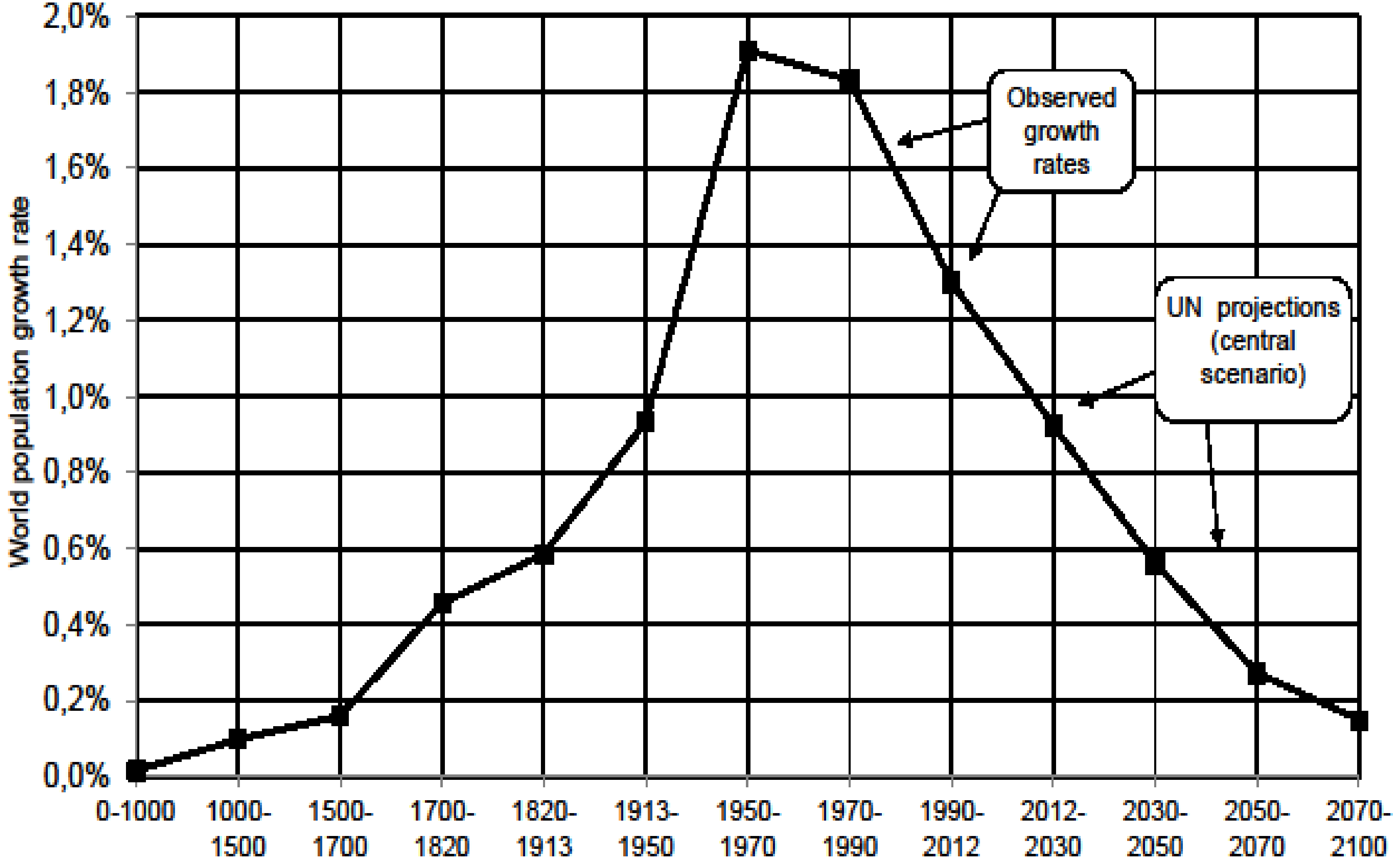
→ very very small population growth in the long-run (n≈0.09%/year 0-1800), but still positive (1.0009^{1800}=5.0) (i.e. surviving fertility rate f≈2.05)

- **A 5-fold multiplication in population is not a stagnant economy**: enormous demographic expansion, deforestation, rise in agricultural productivity, etc.
- At the same time average living standards have been quasi-stagnant over 0-1800, i.e. close to subsistence level

→ the « **augmented Malthusian poverty trap** » (Young 1792, Malthus 1798)

- **Ok but the complete story is more complex: demographic behavior is not determined by economic factors alone**: role of **religion** (early French fertility decline around 1750-1780), role of **conflicting beliefs & norms** about **gender equality**, **planetary habitability**, etc. → **more on this in Lecture 2**

Figure 2.2. The growth rate of world population from Antiquity to 2100



The growth rate of world population was above 1% per year from 1950 to 2012 and should return toward 0% by the end of the 21st century. Sources and series: see piketty.pse.ens.fr/capital21c.

Table 2.3: Demographic growth since the industrial revolution

Average annual growth rate	**World population**	Europe	America	Africa	Asia
0-1700	**0,1%**	0,1%	0,0%	0,1%	0,1%
1700-2012	**0,8%**	0,6%	1,4%	0,9%	0,8%
incl: 1700-1820	**0,4%**	0,5%	0,7%	0,2%	0,5%
1820-1913	**0,6%**	0,8%	1,9%	0,6%	0,4%
1913-2012	**1,4%**	0,4%	1,7%	2,2%	1,5%
Projections 2012-2050	***0,7%***	*-0,1%*	*0,6%*	*1,9%*	*0,5%*
Projections 2050-2100	***0,2%***	*-0,1%*	*0,0%*	*1,0%*	*-0,2%*

Between 1913 and 2012, the growth rate of world population was 1,4% per year, including 0,4% for Europe, 1,7% for America, etc.

Sources: see piketty.pse.ens.fr/capital21c. Projections for 2012-2100 correspond to the UN central scenario.

Table 2.1: World growth since the industrial revolution

Average annual growth rate	**World output**	World population	Per capita output
0-1700	**0,1%**	0,1%	0,0%
1700-2012	**1,6%**	0,8%	0,8%
incl.: 1700-1820	***0,5%***	*0,4%*	*0,1%*
1820-1913	***1,5%***	*0,6%*	*0,9%*
1913-2012	***3,0%***	*1,4%*	*1,6%*

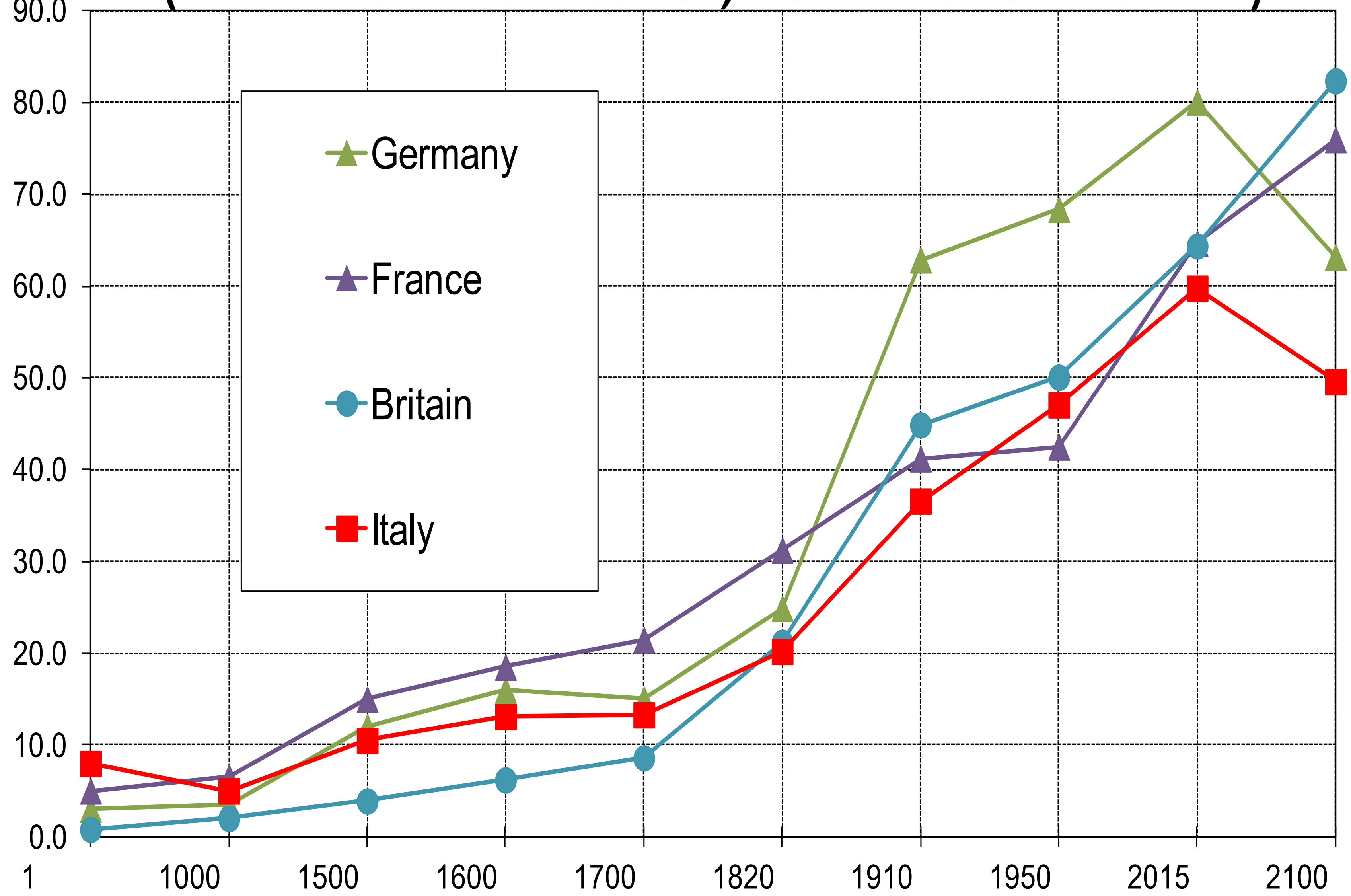
Between 1913 and 2012, the growth rate of world GDP was 3,0% per year on average. This growth rate can be broken down between 1,4% for world population and 1,6% for per capita GDP.

Sources: see piketty.pse.ens.fr/capital21c.

Table S2.1: World growth from the Antiquity (growth rate per period)			
Average annual growth rate	**World output**	World population	Per capita output
0-1700	**0.07%**	0.06%	0.02%
dont: 0-1000	***0.01%***	*0.02%*	*0.00%*
1000-1500	***0.14%***	*0.10%*	*0.04%*
1500-1700	***0.20%***	*0.16%*	*0.04%*
1700-2012	**1.60%**	0.79%	0.81%

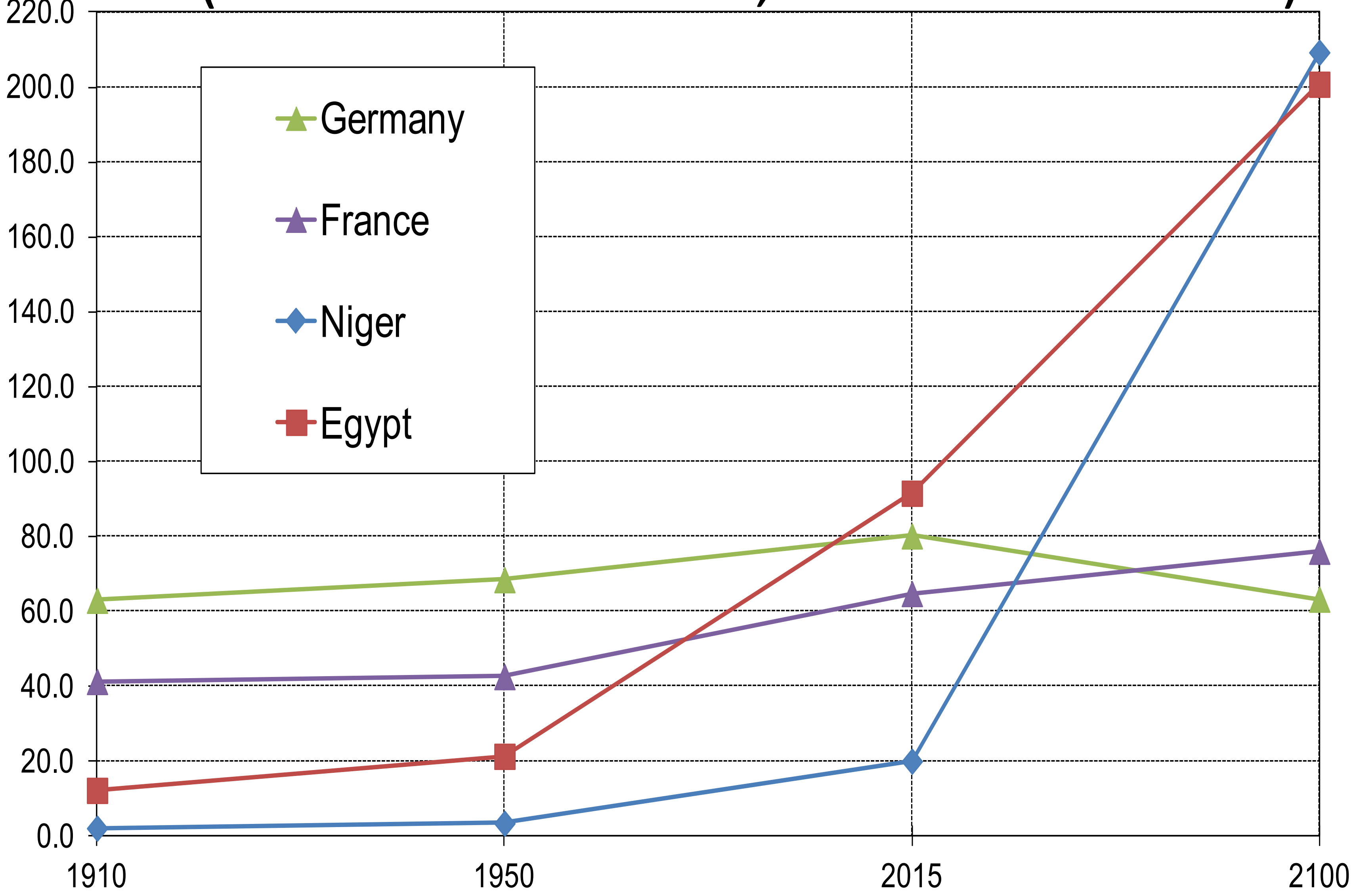
Small Differences in Population Growth Rates Can Have Huge Long-Run Effects

(millions inhabitants, current territories)

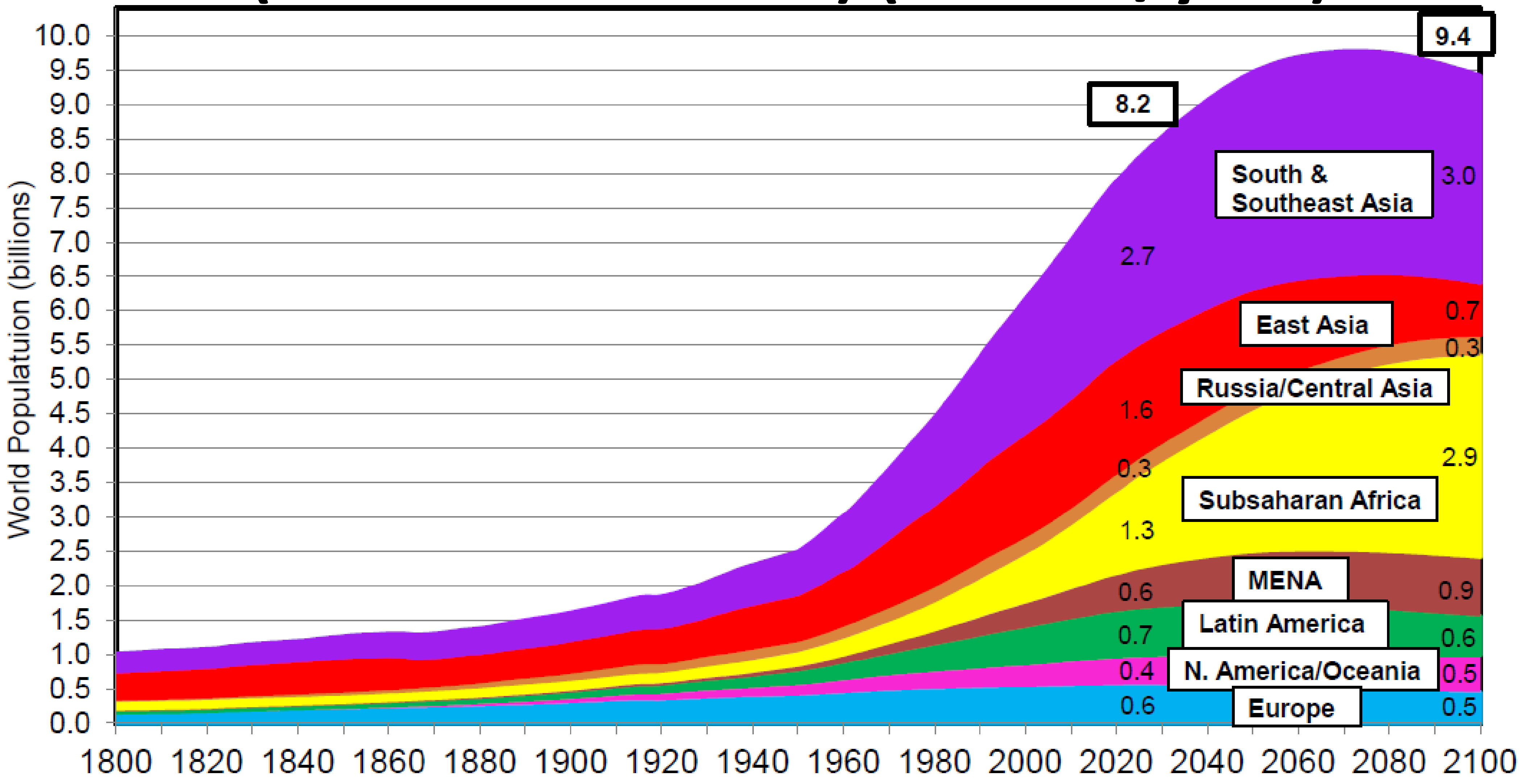


Small Differences in Population Growth Rates Can Have Huge Long-Run Effects

(millions inhabitants, current territories)



World Population 1800-2025: x8
(1.0 billion → 8.2b) (n=0.9%/year)



Interpretation. According to the Sustainable Convergence scenario (and to all existing population projections), population growth over the 2025-2100 period will come entirely from the world's poorest regions, namely Subsaharan Africa and to a lesser extent South & South-East Asia.
Sources and series: wseed.world (Z1b)

- **World Per Capita GDP 1800-2025: x 18** (from 900€ to 16 000€) (**PPP 2025 €**)
- Average annual growth rate of per capita GDP over 1800-2025 period:

h = 1.27%

- I.e. $1.0127^{225}=16/0.9$, or conversely $(16/0.9)^{1/225} = 1.0127$
- **In other words, a relatively small annual growth rate cumulated over very long periods generate enormous growth**
- **Assume h = 1.27% continues over 2025-2250, then per capita GDP will again be multiplied by 18, i.e. 288 000€ in 2250.**
- Maybe this would be too much for the planet, & maybe we do not need so much per capita GDP

→ **In order to answer these questions, one needs to look at sectoral composition of GDP, material footprint, GHG emissions, etc., i.e. one needs to look at material accouting and not only at monetary accounting**

- **World Population 1800-2025: x 8** (from 1.0 billion to 8.2 billion)
- **World Per Capita GDP 1800-2025: x 18** (from 900€ to 16 000€) (**PPP 2025 €**)
- World Aggregate GDP 1800-2025: **x 146** (from 0.9 trillion € to 131.2 trillion €)
- Average annual growth rate of aggregate GDP over 1800-2025 period:

g = 2.24%

- I.e. $1.0224^{225}=131.2/0.9$, or conversely $(131.2/0.9)^{1/225} = 1.0224$
- **By definition, g = n + h, or more precisely 1+g = (1+h) x (1+n)**

With **g = 2.24%** = aggregate GDP growth rate

n = 0.94% = population growth rate

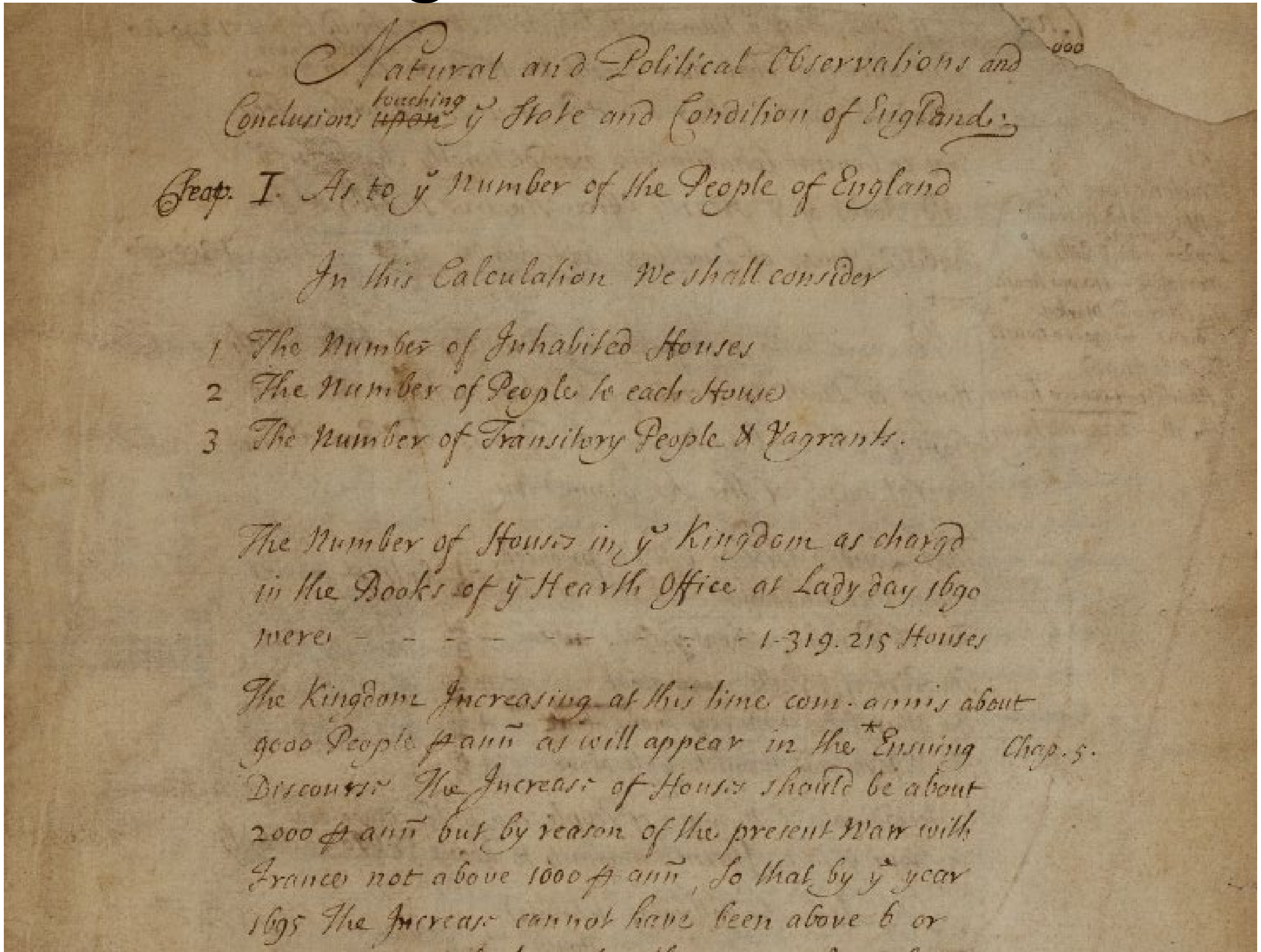
h = 1.27% = per capita GDP growth rate

→ Bottom line: population growth has been a large part of total GDP growth over 1800-2025 (almost half); it is slowly diminishing and it will become close to zero (or slightly negative) by 2100

National Accounts: from Land & Social Tables (18c) to Capital & GDP (19c-20c) to Ecological Accounts/Ghost Hectares (21c)

- On the long history of national accounts, see R. Stone, The Accounts of Society, Nobel Lecture, 1984; see also Maddison 2001 and Piketty-Zucman 2014 for extensive historical references.
- **General lesson: all modern societies create national accounts** in order to measure social change & organize centralized state power; **the set of indicators entirely depends on political choices** about socioeconomic priorities & the representation of conflicting claims
- Petty 1691, King 1696, Boisguillebert 1695, Vauban 1707: **estimates of total land & other property value of England & France + "social tables" on income & wealth distribution** (closely linked to the process of state centralization & social conflict going on at the time)

G. King 1696: Natural & Political Observations and Conclusions touching the State & Conditions of England



Natural and Political Observations and
Conclusions ~~upon~~ touching ye State and Condition of England.

Chap. I. As to ye Number of the People of England

In this Calculation we shall consider

1 The Number of Inhabited Houses
2 The Number of People to each House
3 The Number of Transitory People & Vagrants.

The Number of Houses in ye Kingdom as charged in the Books of ye Hearth Office at Lady day 1690 were - - - - - - - - 1.319.215 Houses

The Kingdom Increasing at this time com. annis about 9000 People p ann as will appear in the *Ensuing Discourse the Increase of Houses should be about 2000 p ann but by reason of the present Warr with France not above 1000 p ann, So that by ye year 1695 The Increase cannot have been above 6 or

*Chap. 5.

The Social Tables of G. King 1696

Ranks, Degrees, Titles and Qualifications	Number of families	Heads per family	Number of persons	Income per family £	Income per head £	Expence per head £	Increase per head £
Temporall Lords	160	40	6 400	2 800	70	60	10
Spiritual Lords	26	20	520	1 300	65	55	10
Baronets	800	16	12 800	880	55	51	4
Knights	600	13	7 800	650	50	46	4
Esquires	3 000	10	30 000	400	40	37	3
Gentlemen	12 000	8	96 000	240	30	27.5	2.5
Persons in greater Offices and Places	5 000	8	40 000	240	30	27	3
Persons in lesser Offices and Places	5 000	6	30 000	120	20	18	2
Eminent Merchants & Traders by Sea	2 000	8	16 000	400	50	40	10
Lesser Merchants & Traders by Sea	8 000	6	48 000	200	33.3	28.3	5
Persons in the Law	10 000	7	70 000	140	20	17	3
Eminent Clergymen	2 000	6	12 000	60	10	9	1
Lesser Clergy-men	8 000	5	40 000	45	9	8	1
Freeholders of the better sort	40 000	7	280 000	84	12	11	1
Freeholders of the lesser sort	140 000	5	700 000	50	10	9.5	0.5
Farmers	150 000	5	750 000	44	8.8	8.55	0.25
Persons in Liberal Arts and Sciences	16 000	5	80 000	60	12	11.5	0.5
Shopkeepers and Tradesmen	40 000	$4\frac{1}{2}$	180 000	45	10	9.5	0.5
Artisans and Handicrafts	60 000	4	240 000	40	10	9.5	0.5
Naval Officers	5 000	4	20 000	80	20	18	2
Military Officers	4 000	4	16000	60	15	14	1
	511 586	$5\frac{1}{4}$	2 675 520	67	12.9	12	0.9
Common Seamen	50 000	3	150 000	21	7	7.5	−0.5
Labouring People & outservants	364 000	$3\frac{1}{2}$	1 275 000	15	4.3	4.4	−0.1
Cottagers & Paupers	400 000	$3\frac{1}{4}$	1 300 000	5	1.5	1.75	−0.25
Common Soldiers	35 000	2	70 000	14	7	7.5	−0.5
	849 000	$3\frac{1}{4}$	2 795 000	10.5	3.25	3.45	−0.2
Vagrants	..	..	30 000	..	2	4	−2
	849 000	$3\frac{1}{4}$	2 825 000	10.5	3.19	3.41	−0.22

From Giffen 1889 to Lenin 1916: Measuring Capital

THE

GROWTH OF CAPITAL.

6691

BY

ROBERT GIFFEN.

LONDON:

GEORGE BELL AND SONS, YORK STREET,
COVENT GARDEN.

1889.

CONTENTS.

APPENDIX.

WORKERS OF ALL COUNTRIES, UNITE!

V. I. LENIN

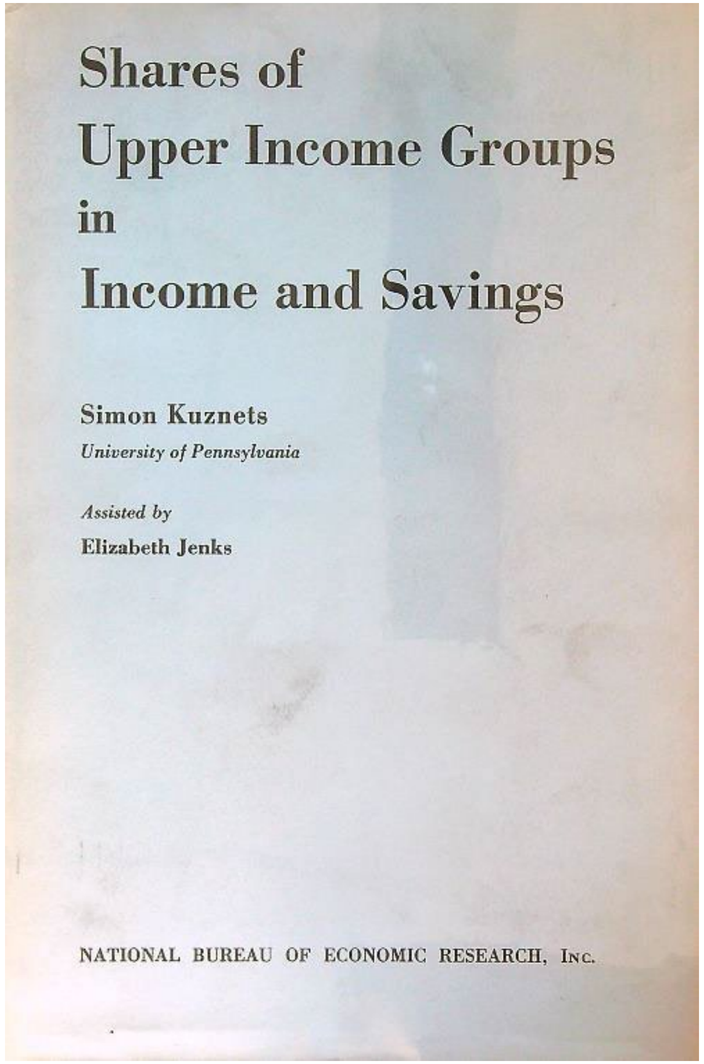
IMPERIALISM,
THE HIGHEST STAGE
OF CAPITALISM[1]

A POPULAR OUTLINE

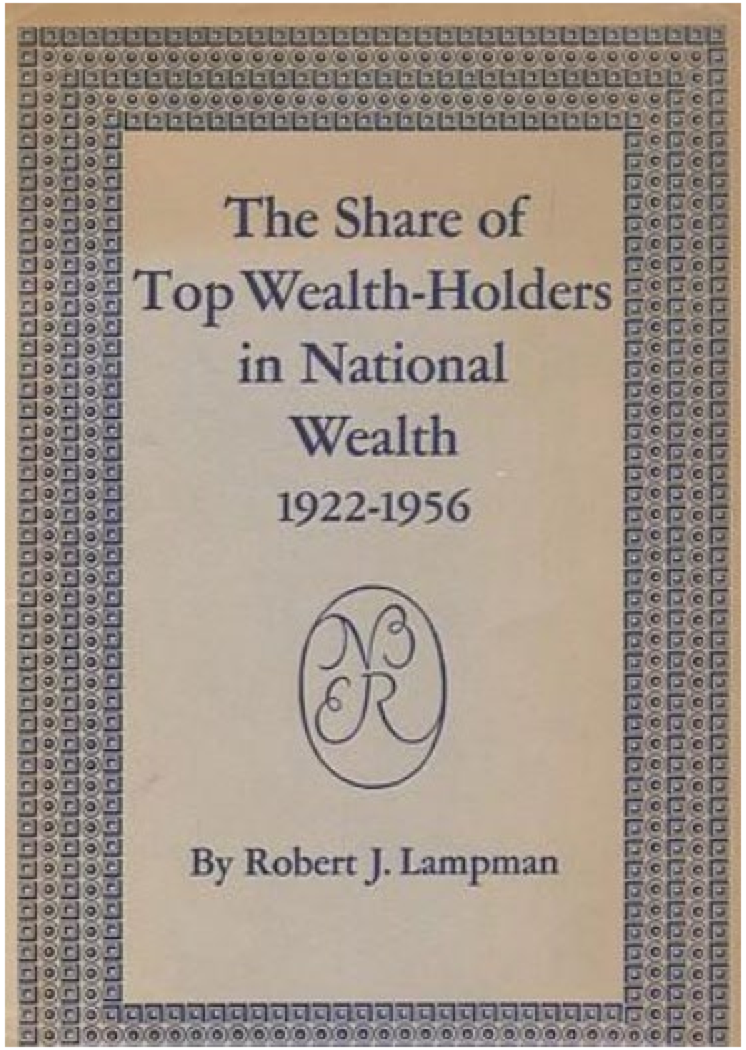
Eleventh Impression

FOREIGN LANGUAGES PUBLISHING HOUSE
Moscow

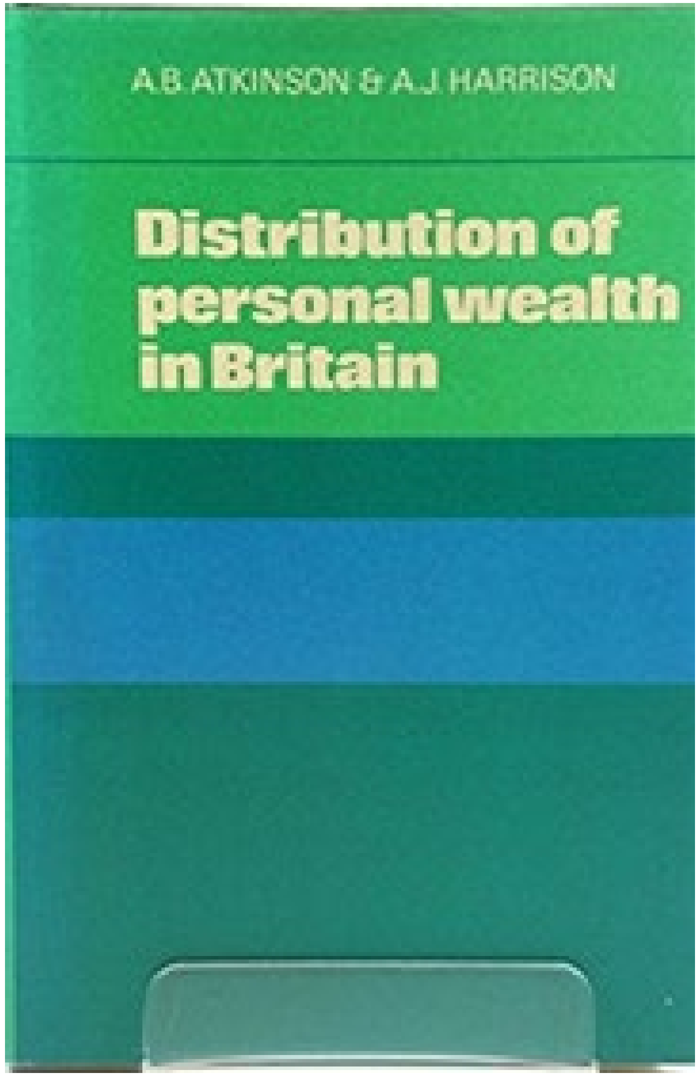
Kuznets 1953: the Birth of Distributional National Accounts



S. Kuznets, 1953

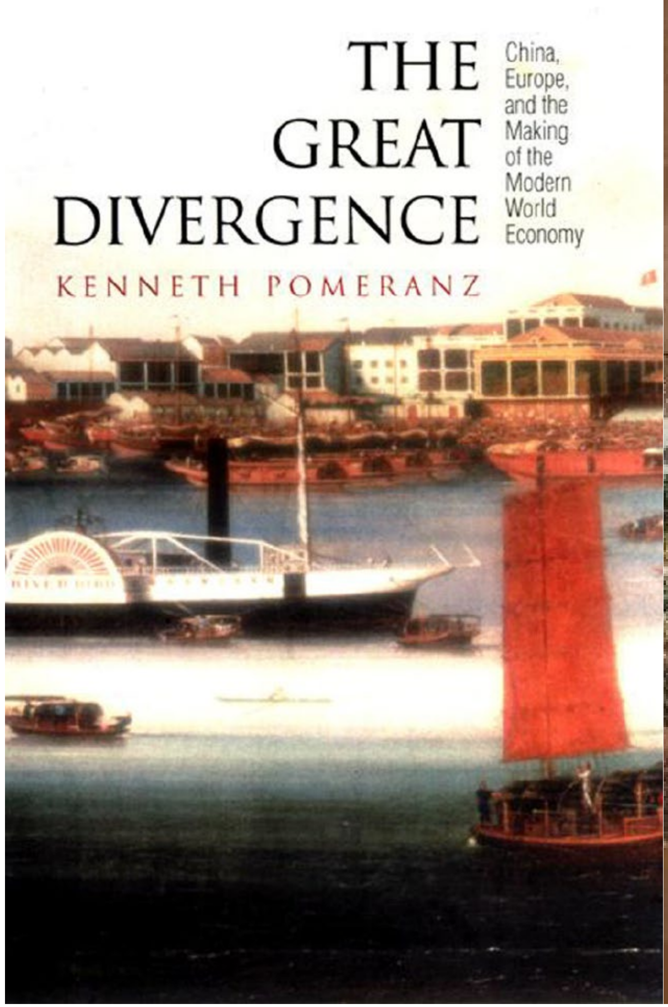


R. Lampman, 1962

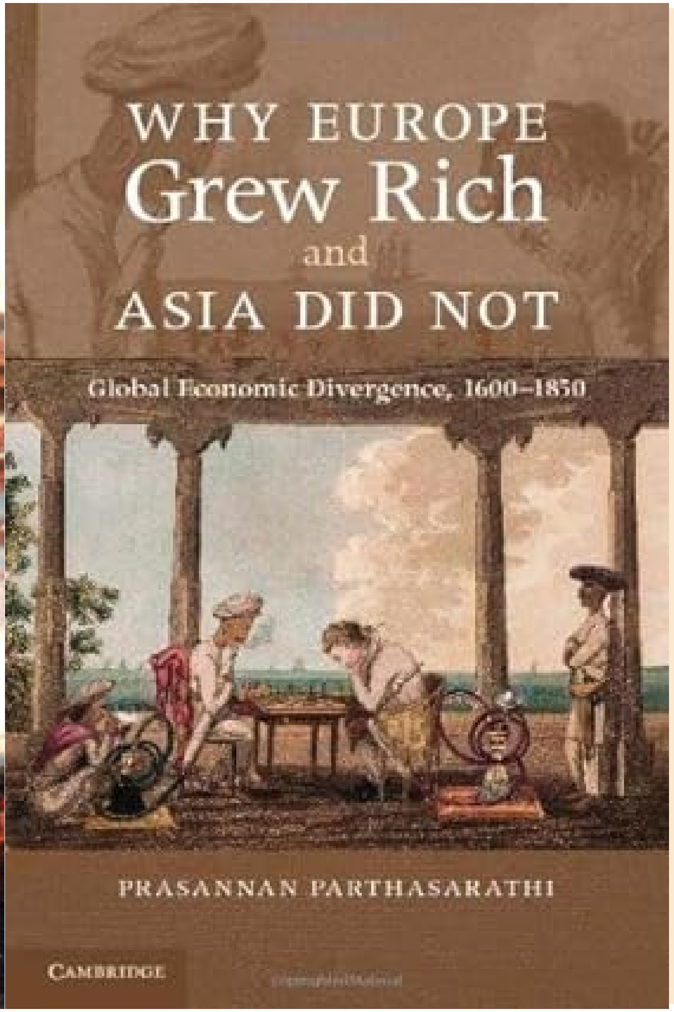


Atkinson & Harrison, 1978

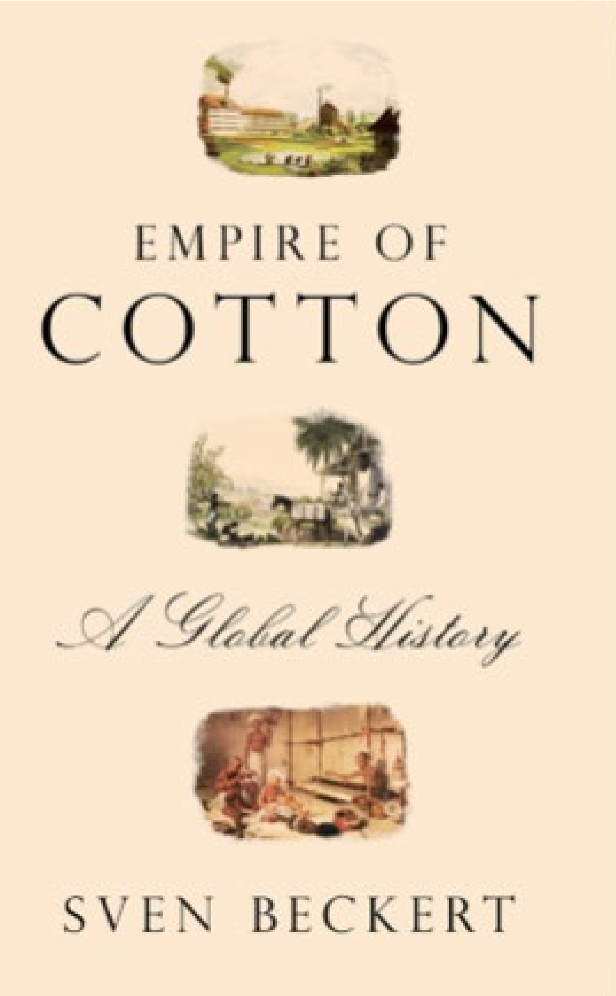
Pomeranz 2000: Ghost Hectares & Ecological Accounting



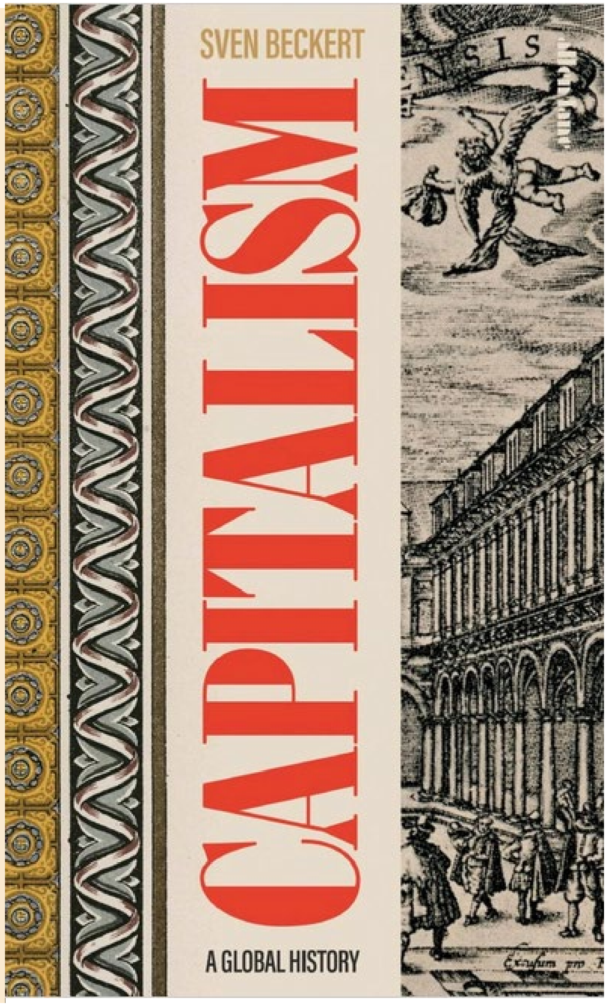
K. Pomeranz, 2000



P. Parthasarathi, 2011



S. Beckert, 2015



S. Beckert, 2025

From Output to GDP (Gross Domestic Product), Net Domestic Product (NDP), Gross National Income (GNI) and NNI (Net National Income)

- The concept of GDP is more complicated than it seems

(1) GDP is different from Output
I.e. GDP = Value Added = Output – Intermediate Consumption

(2) GDP includes both market and non-market production

(3) NDP = GDP – CFC (Consumption of Fixed Capital)

(4) NNI = NDP + NFI (Net Foreign Income) (NFI=0 at world level)

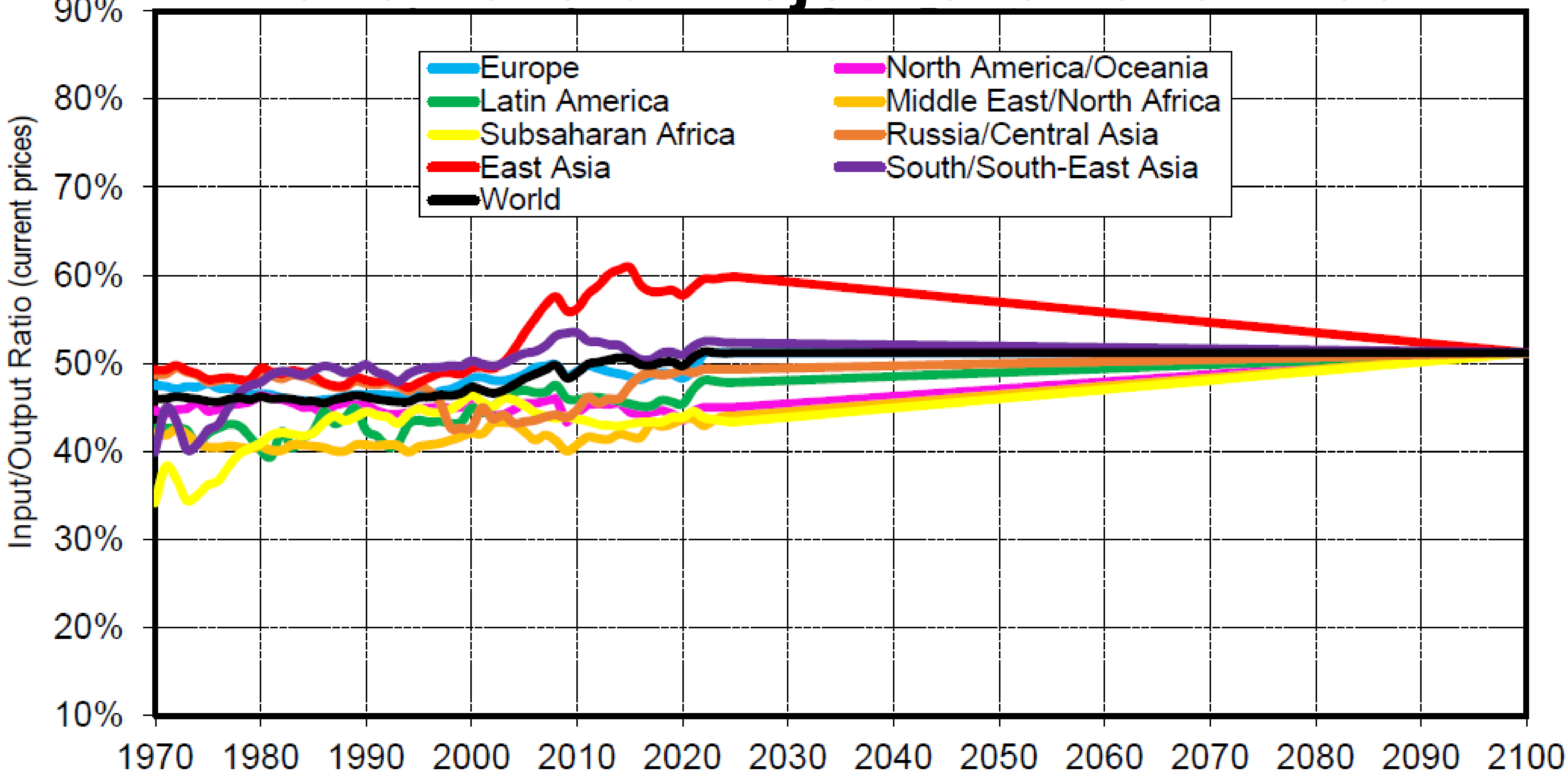
(similarly, GNI = GDP + NFI)

(5) GDP & other aggregates can be measured in PPP (purchasing power parities) **or MER** (market exchange rates)

(1) GDP is different from Output

- **Output** = total production of goods and services, whether they are used as **Final Consumption Expenditure** (FCE), **Investment Expenditure** (IE) or **Intermediate Consumption** (IC) (inputs used by production units to produce output)
- **GDP = Output – Intermediate Consumption (IC) = Valued Added**
- In practice, **IC ≈ almost as large as GDP: both around 50% of Output**
- I.e. **Output is ≈ twice as large as GDP**: about half of output is used as input by firms to produce output (large sectoral variations: energy is mostly used as intermediate input: key to measure material footprint) (potentially also important for inequality measurement)
  (see D. Leite, The Firm as Tax Shelter: Micro Evidence and Aggregate Implications of Consumption Through the Firm, 2024)

Input/Output Ratios: Observed Series 1970-2025 & Projections 2026-2100



Interpretation. At the world level, intermediate inputs made on average 46% of total output in 1970 (all sectors combined). The global input-output ratio rose to 52% by 2025, with moderate variations across regions. East Asia's high ratio is due to the large manufacturing sector. In our benchmark simulations, we assume that this ratio will converge to 52% in all countries by 2100. **Sources and series**: wseed.world (O0)

- **GDP = sum of value-added (VA)** of all sectors = sum of output of all sectors – sum of intermediate consumption of all sectors **(production approach)**
- **GDP = sum of final consumption expenditure (FCE) & investment expenditure (IE)** of all sectors **(expenditure approach)**
- **GDP = sum of incomes** generated by all sectors: labour income (wages), capital income (profits) and mixed income (self-employment) **(income approach)**

→ These 3 ways to compute GDP rely on different raw sources but should in principle lead to the same GDP aggregate

→ In practice not all countries are able to reconcile the three approaches
E.g. some of the less developed countries do not always provide the income decomposition (i.e. no wage-profit income split)

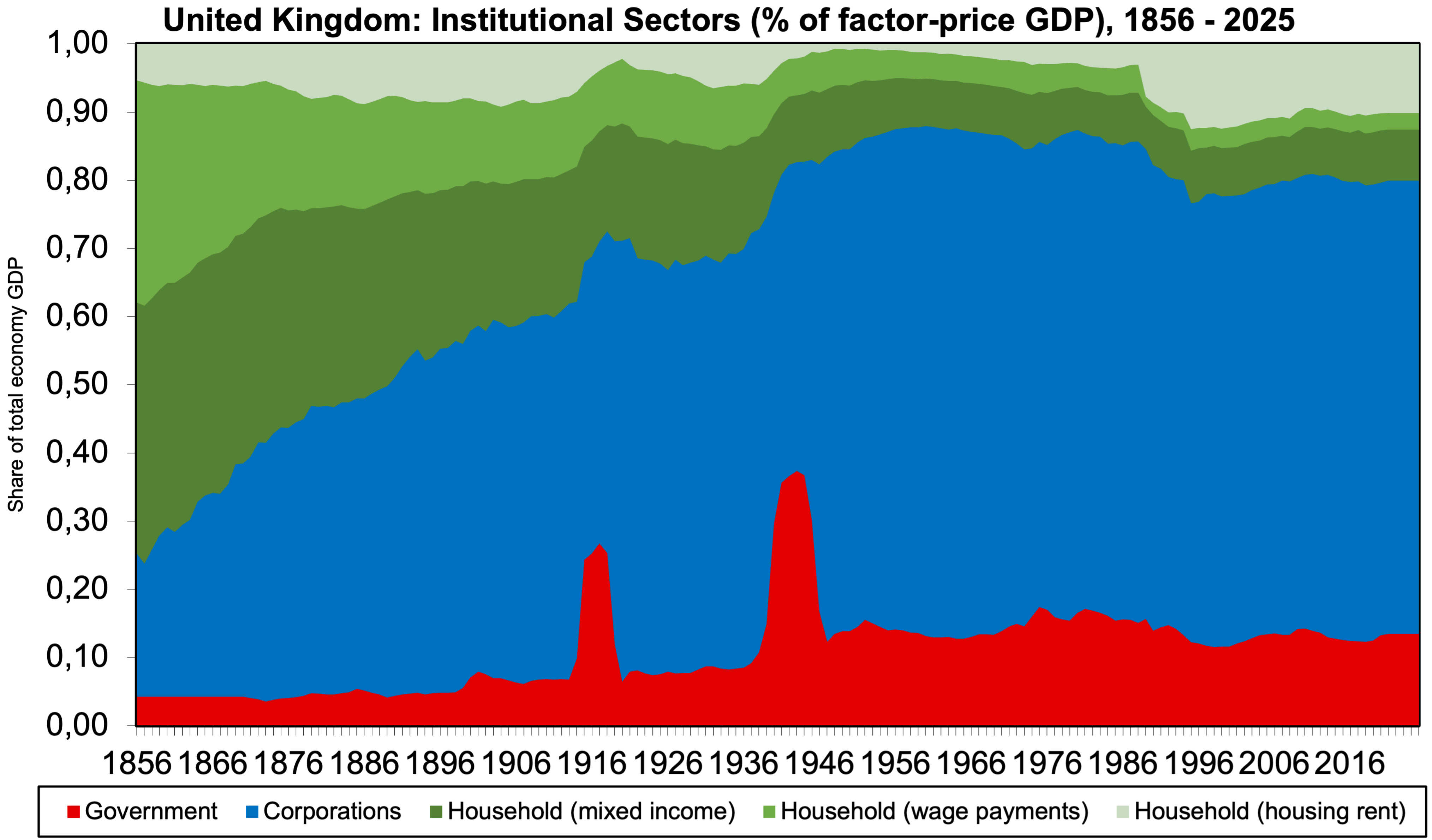
(2) GDP includes both market & non-market production

According to official national accounts definition (SNA 2008), output is split between various institutional sectors (see Dietrich et al 2025):

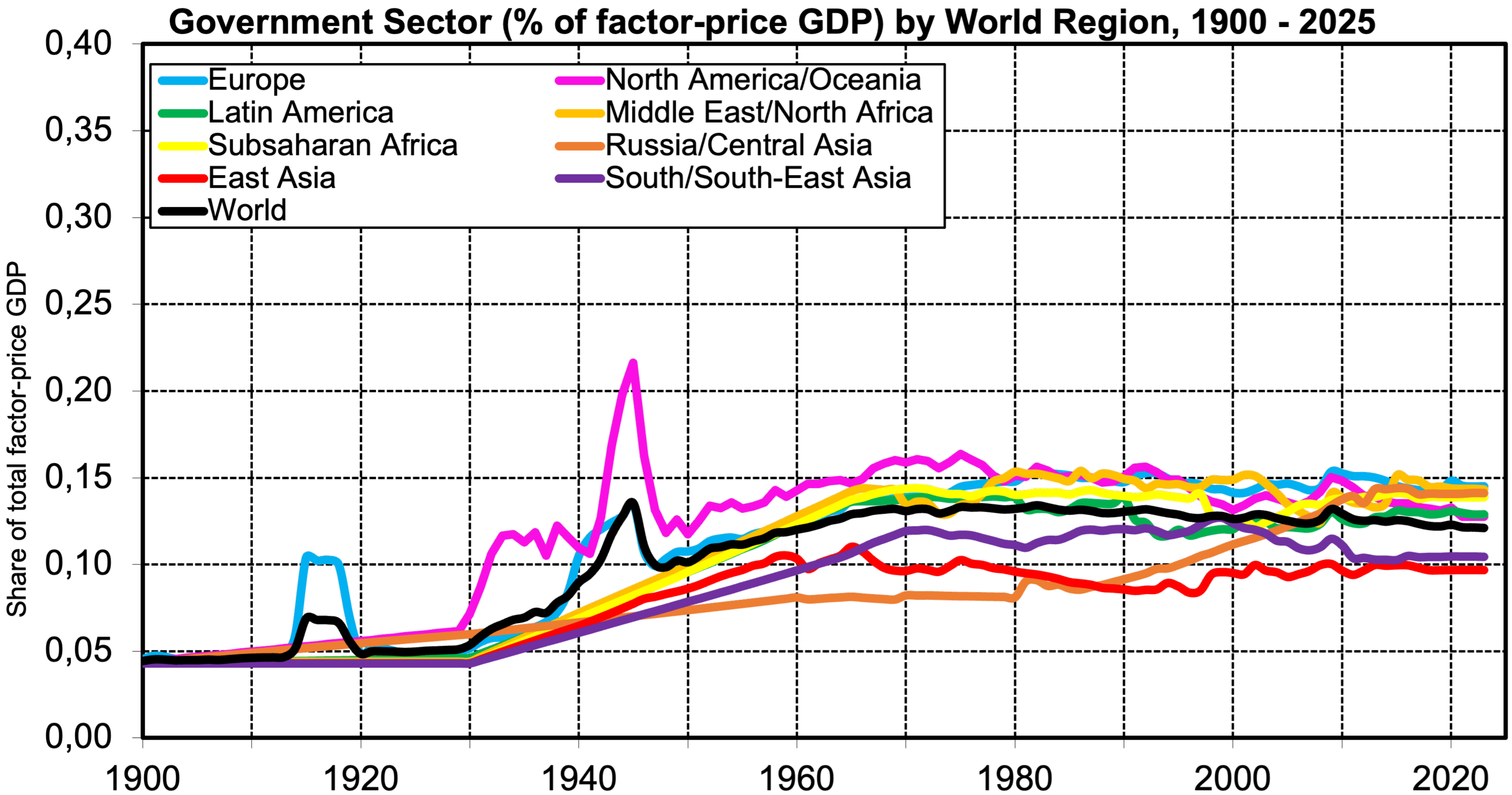
Government sector: institutional units whose main activity is to produce **non-market goods**, i.e. goods & services provided for free or at a price that is "not economically significant" (i.e. typically covering less than half of the costs), in which case these goods & services are valued using production costs (e.g. teachers' wages for public schools)

Corporate sector & **Household sector** (self-employed individuals): institutional units whose main activity is to produce **market goods**, i.e. goods & services sold at "economically significant prices", in which case they are valued using market prices (incl. taxes & subsidies)

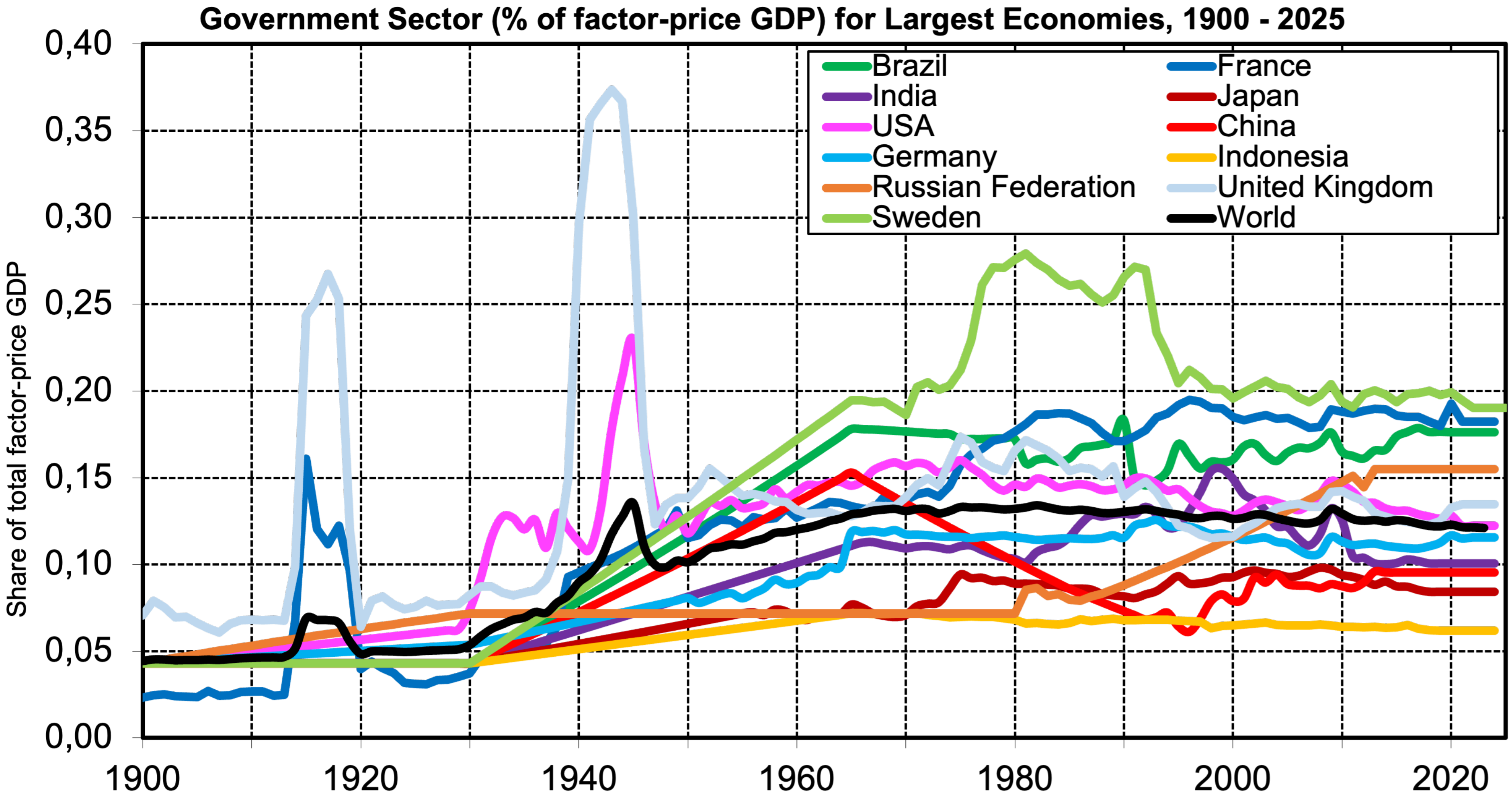
(+ **Non-profit sector** : non-market producers receiving gifts)



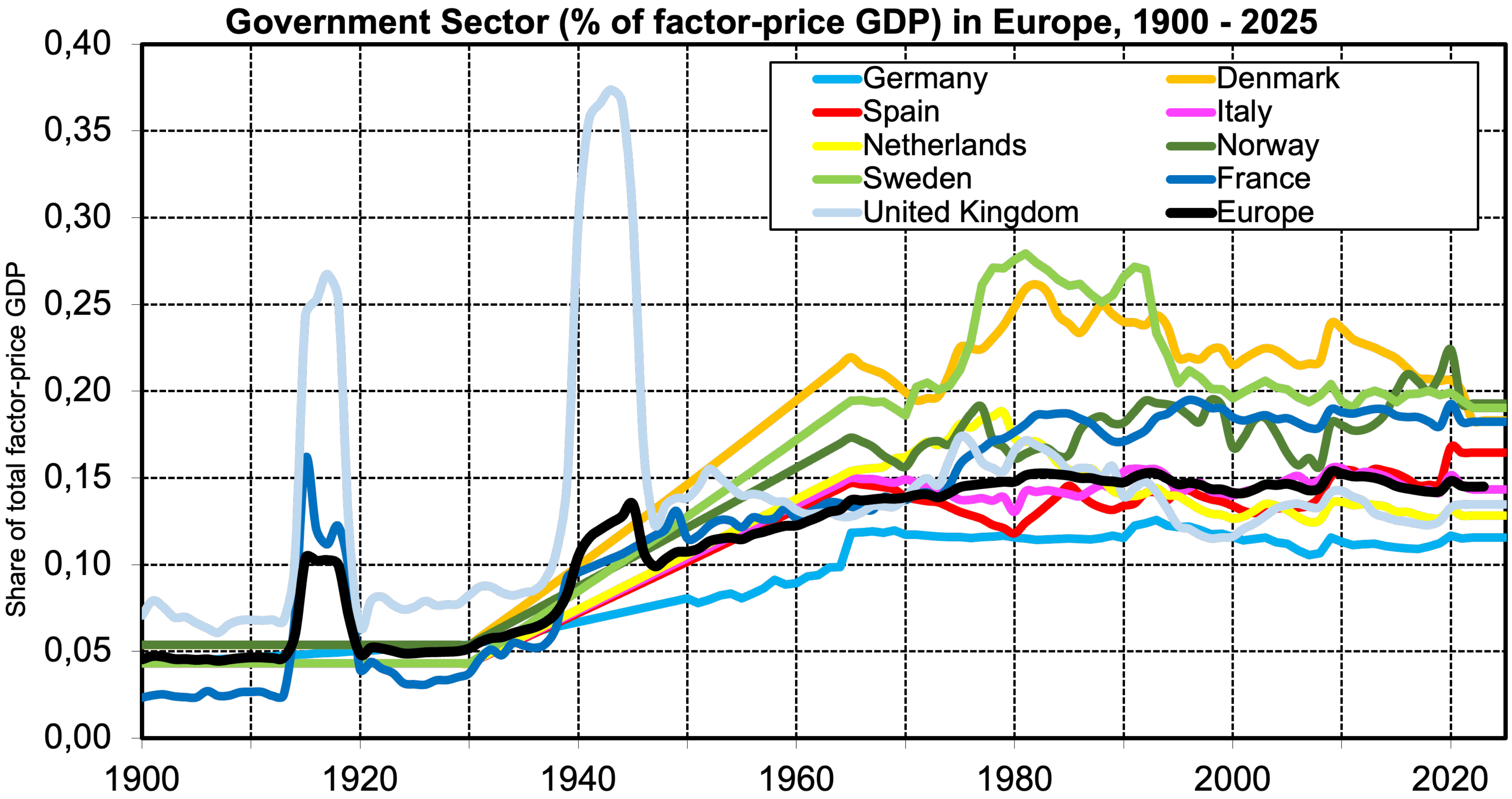
Interpretation: Over the past 150 years, the corporation sector has strongly increased in size while the household sector (unincorporated buisnesses) has declined. Government sector rose until the 1970s with spikes during the world wars and stagnated after.
Sources and series: UN SNA, Piketty & Zucman (2014)



Interpretation: Rise in government share in production until 1970s, stagnated after with slight decrease in some regions. Asian regions lowest, Europe and MENA highest, which is in line with government employment shares. World Wars stand out due to large military spending.
Note: General government sector are institutional units whose main activity is to produce non-market goods and services.
Sources and series: see wid.world



Interpretation: Rise in government share in production until 1970s, stagnant after. Substantial variations across countries which are in line with the variations in share of government employment (Asian countries low, European high). Sharp decline in Sweden correlates with liberalization and privazation of 1990s.
Note: Government sector are institutional units whose main activity is to produce non-market goods and services.
Sources and series: see wid.world



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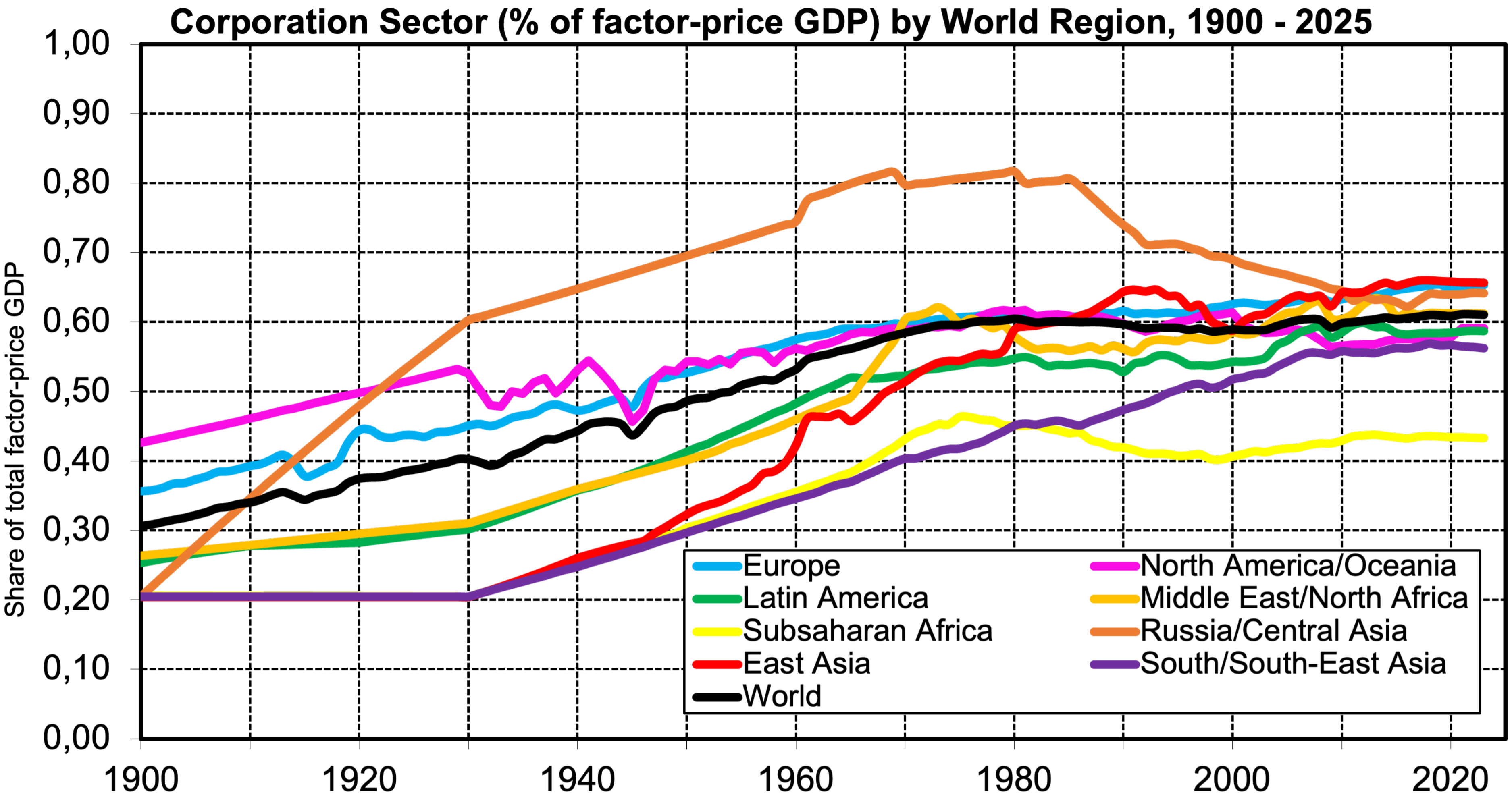
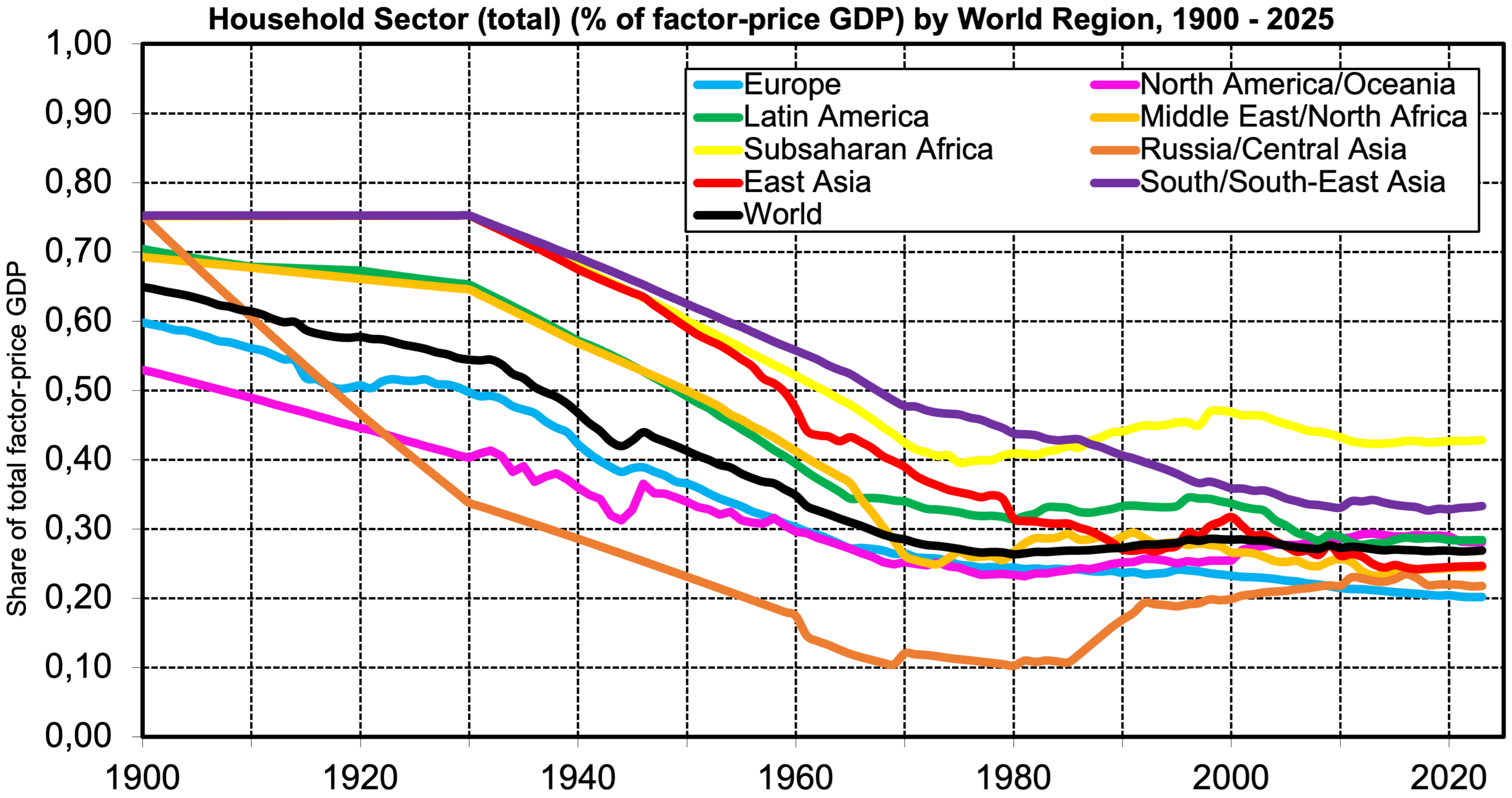
Sources and series: see wid.world



Interpretation: Long-term rise of corporation sector that replaces the household sector, in line with the formalization of economy and employment. Until today substantially lower in Subsaharan Africa than other regions, very high in Russia/Central Asia during Soviet era.
Note: Includes financial and non-financial corporations: enterprises with separate legal entity (or seperate account) from owner.
Sources and series: see wid.world



Interpretation: Long-term decline in household sector that is replaced by corporate and to a smaller degree government sector, in line with formalization of economy and employment. Today largest in Subsaharan Africa and South/South-East Asia, very low during Soviet Union.
Note: Household production includes home production, unincorporated businesses, non-profit institutions serving households (NPISH) and housing services (imputed and real).
Sources and series: see wid.world

(3) NDP = GDP – CFC

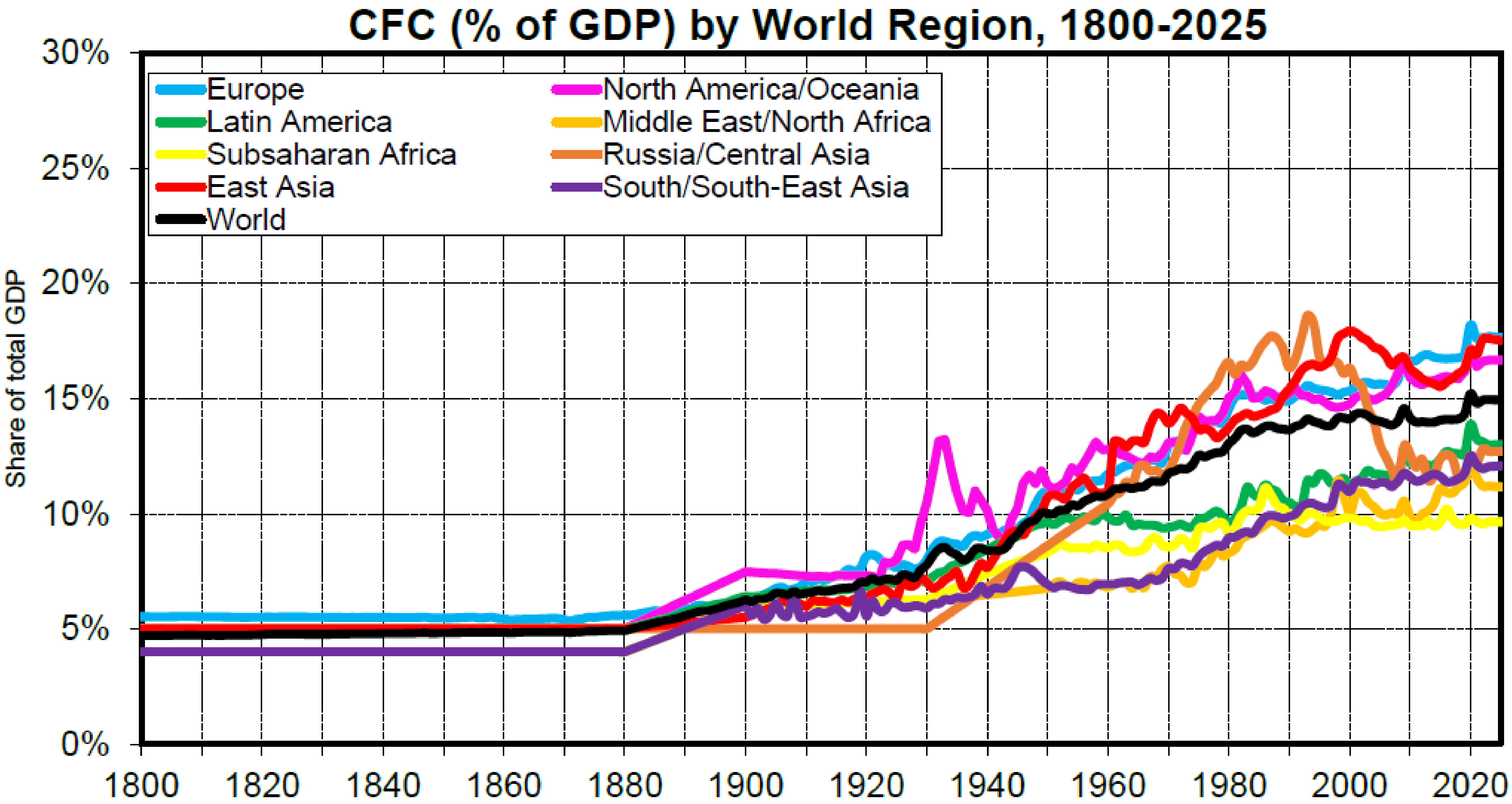
NDP = Net Domestic Product

GDP = Gross Domestic Product

CFC = Consumption of Fixed Capital (CFC) (capital depreciation)

CFC ≈ 10-15% GDP (2-3% capital stock if K ≈ 500% GDP) & rising over time = accelerated capital obsolescence, i.e. cars & computers need to be replaced or repaired more often than buildings or land

See Bauluz et al, "Global Wealth Accumulation and Ownership Patterns, 1800-2025", 2025, for a more detailed analysis of capital depreciation by asset categories



Interpretation: We observe a gobal rise in consumption of fixed capital (CFC) over the past two centuries. Richer Countries have on average a higher CFC rates as share of their GDP. On the world level CFC increased from about 5% in 1800 to 15% today, reflecting the transition from agriculture (with relatively low CFC rates) to manufacturing (higher CFC rates) and the rise of equipment with faster depreciation and capital obsolescence (e.g. computers). **Sources and series**: wid.world

(4) NNI = NDP + NFI

NNI = Net National Income (or more simply National Income)

NDP = Net Domestic Product

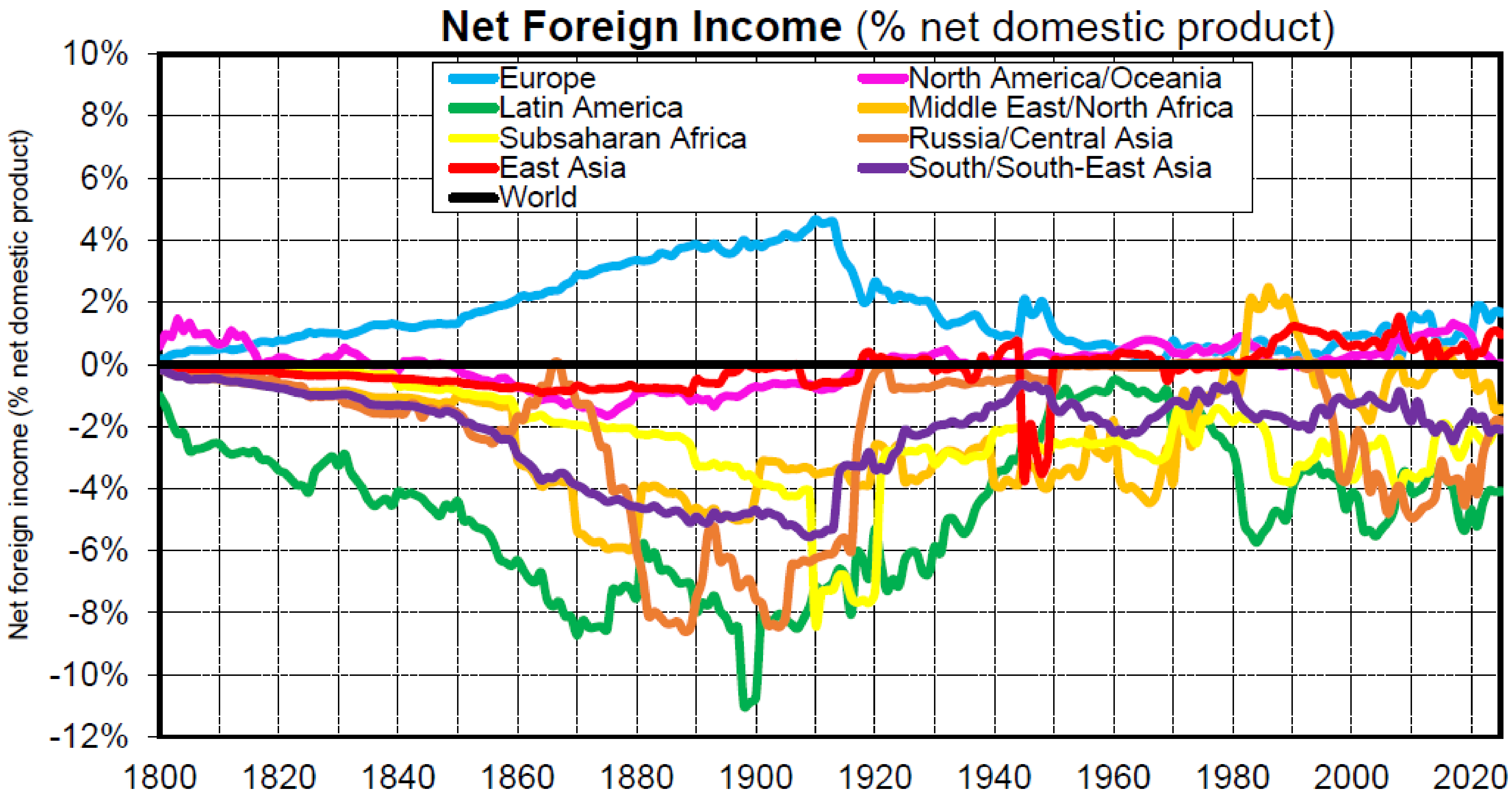
NFI = Net Foreign Income

(= Net Foreign Capital Income + Net Foreign Labour Income)

NFI = 0 at the world level (by definition), so **world NNI = world NDP** (and **world GNI = world GDP**) (Income = Product)

But at the country level, NFI can be >0 or <0 depending on whether the country has NFA (Net Foreign Asset Position) >0 or <0 (+ rates of return differentials etc.): **foreign-owned countries can have a much smaller income than their production, especially during colonial period**

See G. Nievas, T. Piketty, "Unequal Exchange and North-South Relations: Evidence from Global Trade Flows and the World Balance of Payments 1800-2025", 2025 (WBOP.world), for a detailed analysis



Interpretation. Between 1800 and 1914, Europe owns a rising fraction of the rest of the world and is receiving an increasing flow of capital income from the rest of the world. In the 2010s-2020s, Europe and North America are still receiving positive foreign income, in spite of the fact that their foreign wealth is small or negative. This reflects the fact that they receive higher rates or returns on their assets (and pay small returns on their liabilities) than the rest of the world (so-called "exorbitant privilege"). **Sources and series**: wid.world

(5) PPP (purchasing power parities) **vs MER** (market exchange rates)

PPP: estimated using price surveys for similar goods and services for all countries. Last one: ICP 2021 (International Comparison Program) (WB)

PPP: most accurate estimates in order to compare purchasing power and real volumes of goods and services across countries

Exemple: 1€ = 1.5$ in PPP, but only 1.1$ in MER.

I.e. prices are ≈40% higher in US than in EU

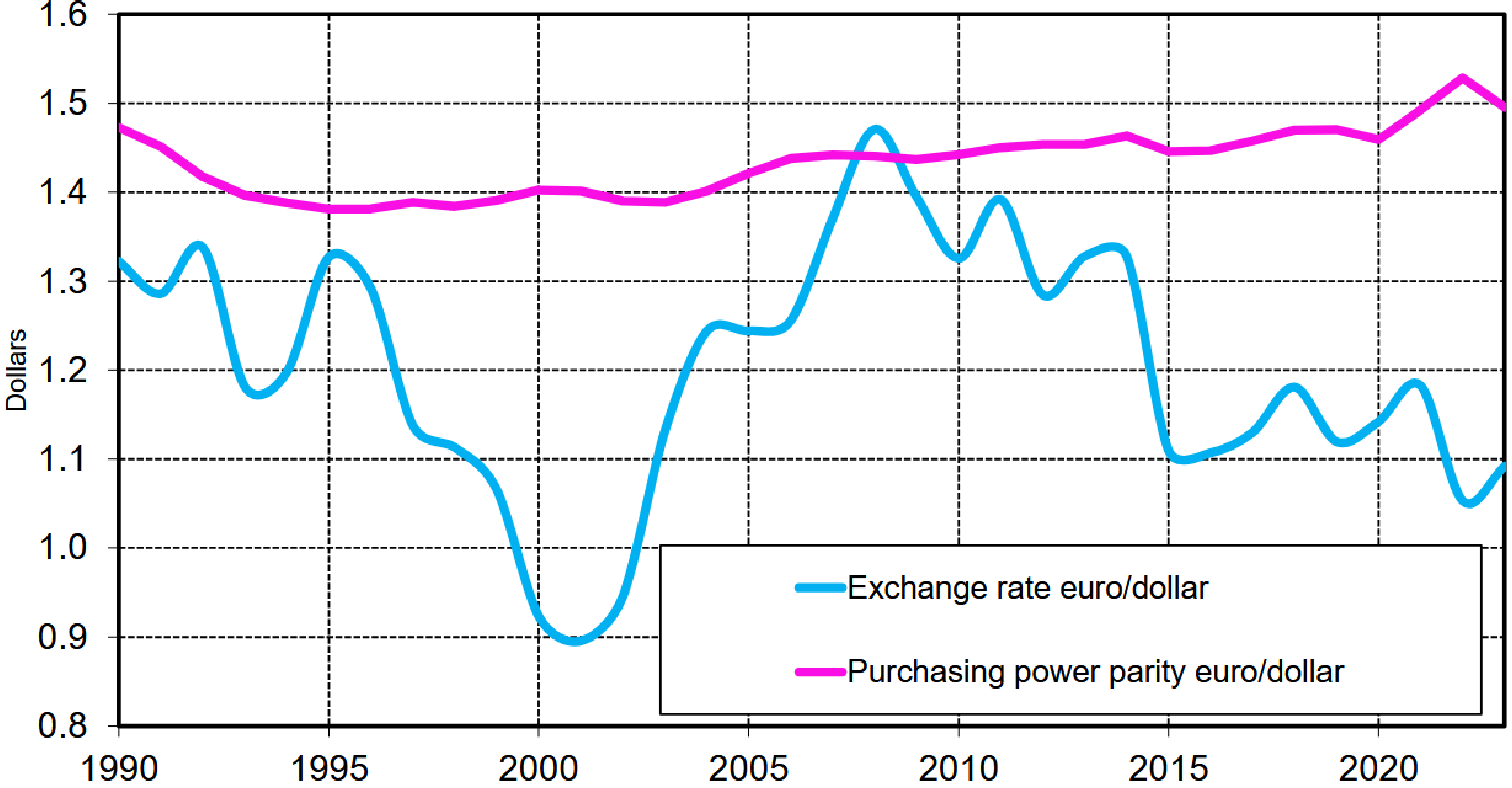
I.e. by using MER, real US GDP is overestimated by ≈40%

→ with PPP, US is not so rich, & China GDP is already >> US GDP

MER: too volatile & not meaningful for volume comparisons.

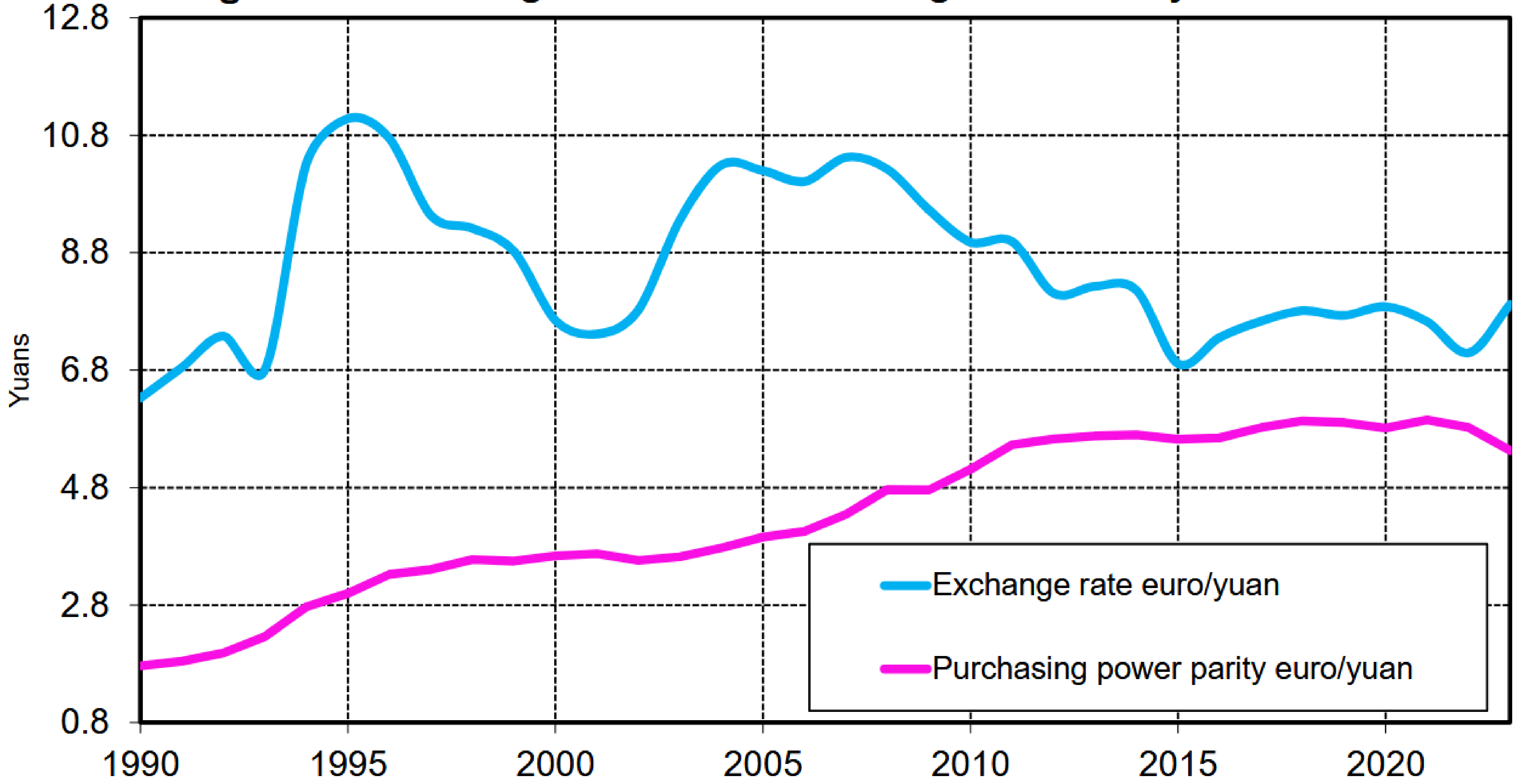
But MER are still very relevant for international trade, capital flows & asset purchases

Figure 0a. Exchange Rate and Purchasing Power Parity: Euro/Dollar



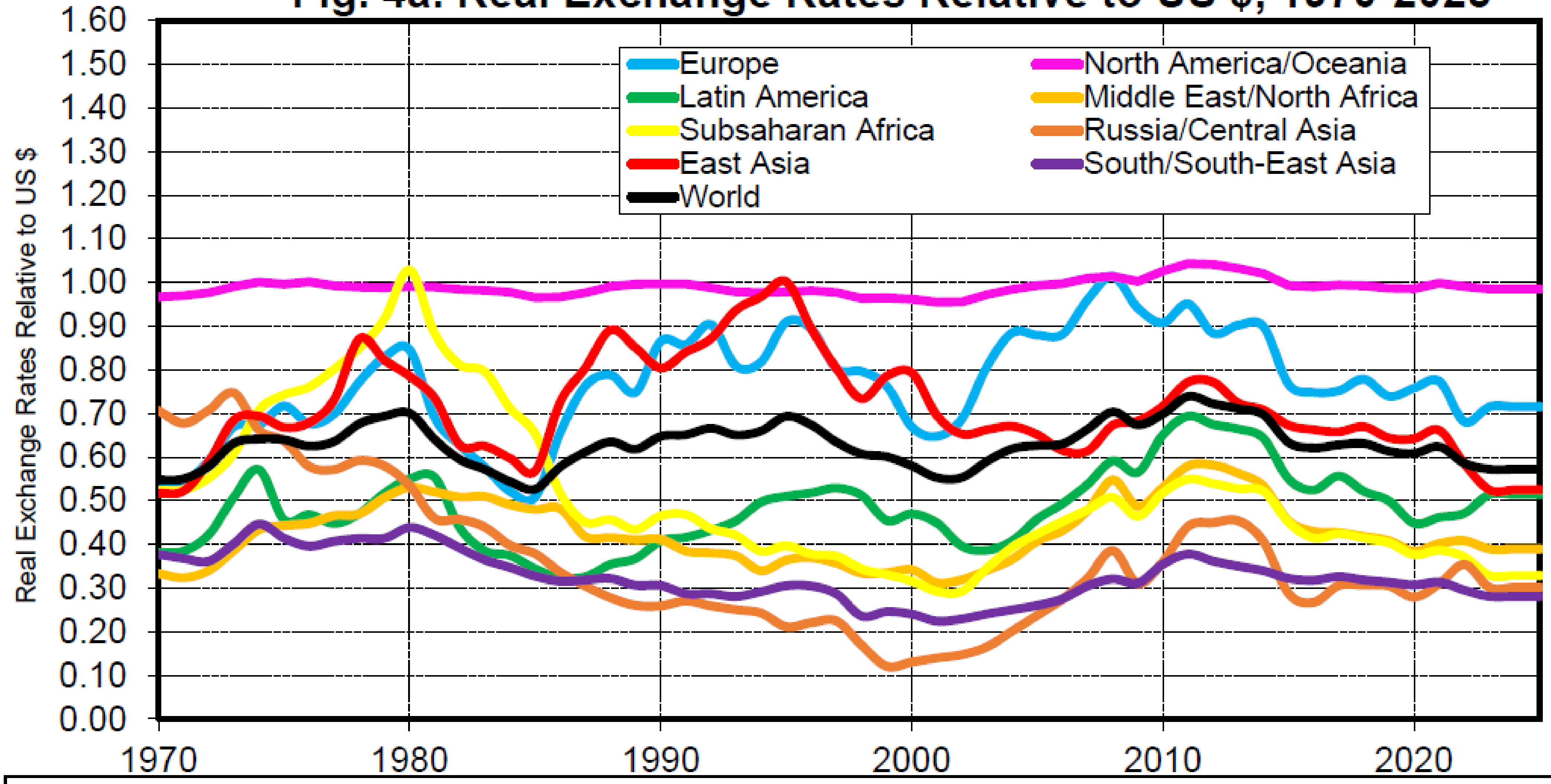
Interpretation. In 2023, 1 euro is worth 1.09 dollars according to current exchange rate, but 1.50 dollars in purchasing power partity.
Sources and series: wid.world

Figure 0b. Exchange Rate and Purchasing Power Parity: Euro/Yuan

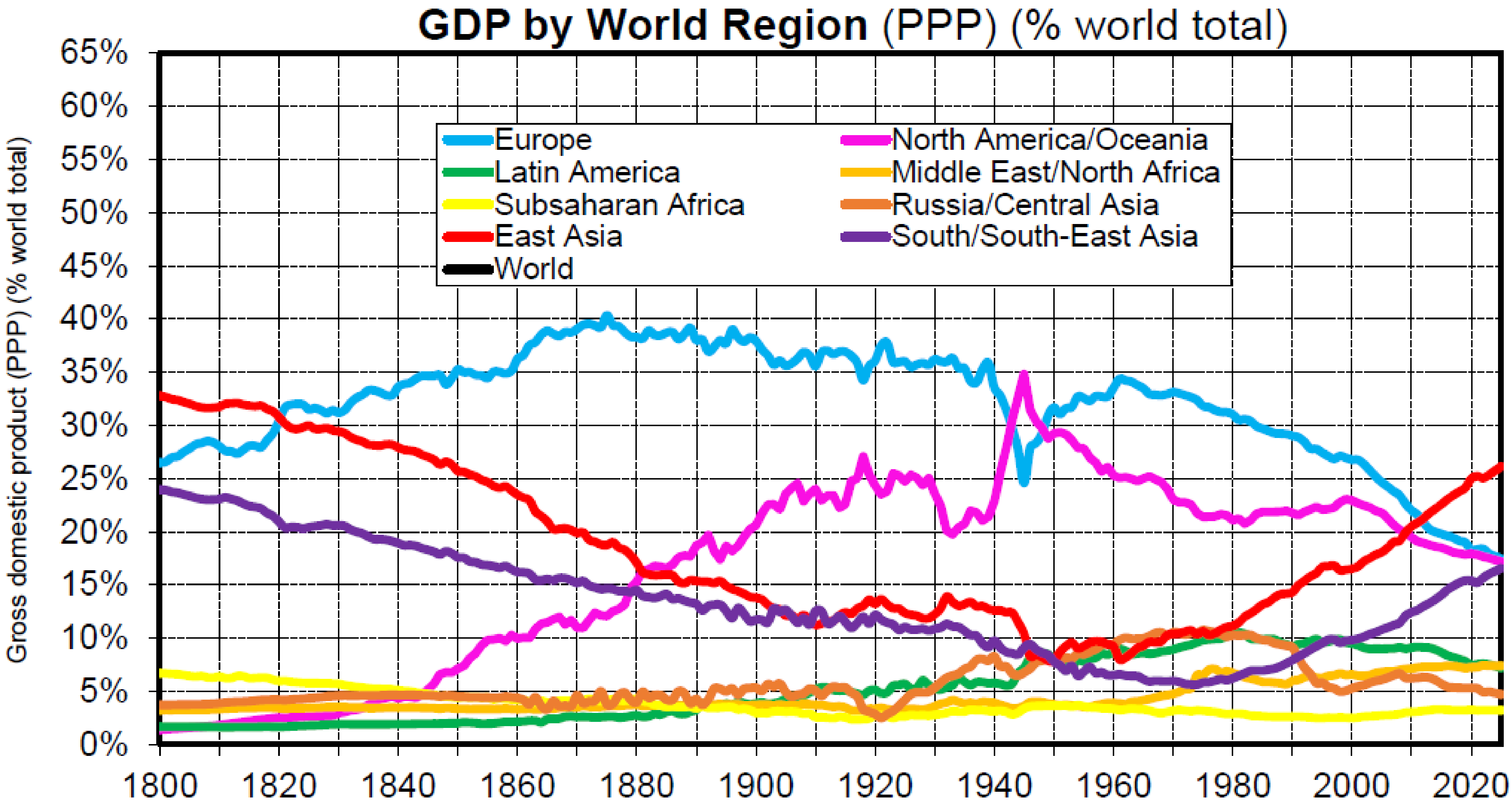


Interpretation. In 2023, 1 euro is worth 7.92 yuans according to current exchange rate, but 5.43 yuans in purchasing power partity.
Sources and series: wid.world

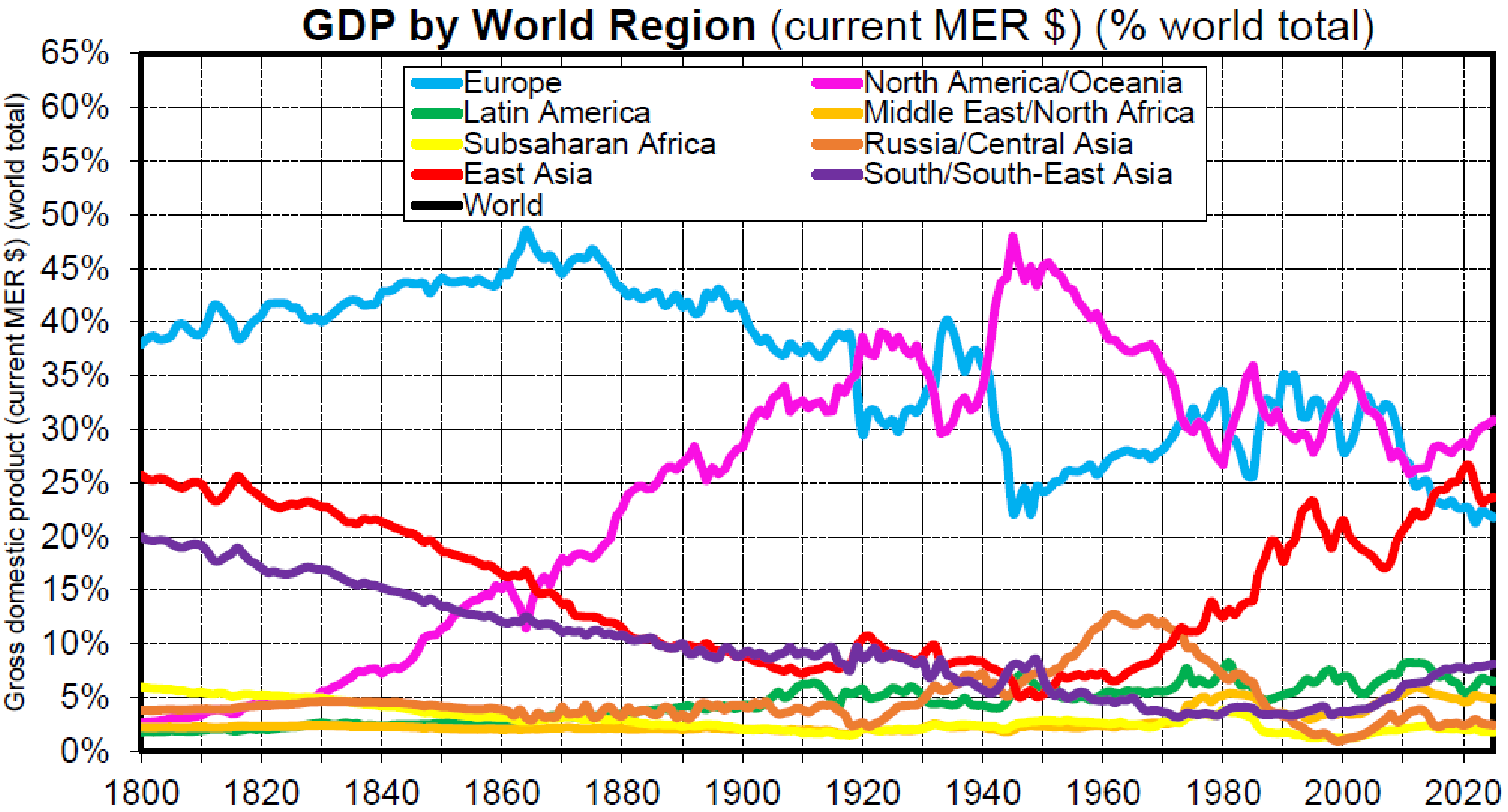
Fig. 4a. Real Exchange Rates Relative to US $, 1970-2025



Interpretation. Real exchange rates relative to US $ have generally been less than 1, and as low as 0.3-0.4 on average for countries in Subsaharan Africa or South & South-East Asia. I.e. if they were trading at PPP (purchasing power parity) rather than MER (market exchange rate) they would get about 3 times as much value for their exports. **Note**. Real exchange rates relative to US $ are defined as the ratio between GDP using MER with US $ and GDP using PPP. RERs below 1 mean that domestic currency should appreciate (and/or US $ dollar should depreciate) in order to restore price parity. Since the 1970s-1980s, prices are compared using ICP surveys (here we use the latest one: 2021). **Sources and series**: see wid.world



Interpretation. Using PPP values (purchasing power parity), North America/Oecania represents about 17% of world GDP in 2025 (25% in 1900), vs 17% for Europe (37% in 1900) and 26% in East Asia (14% in 1900). Generally speaking, the share of NAOC and Europe in world GDP has always been substantially smaller if we use PPPs rather than MERs (market exchange rates). **Sources and series**: see wid.world



Interpretation. Using current MER $ (market exchange rates), North America/Oecania represents about 30% of world GDP in 2025 (about the same level as in 1900), vs 23% for Europe (41% in 1900) and 24% in East Asia (8% in 1900). **Sources and series**: see wid.world

Multiple Sectors & Relative Prices: Uneven Growth & Technical Progress and the Illusion of Market-Driven Dematerialization

It is critical to study the multi-sector GDP structure:

(1) **Material footprint** (in particular the size of energy/minerals inputs and carbon emissions) **varies enormously across sectors**

(2) **Technical progress is highly uneven across sectors: it is much faster in material sectors** (typically manufacturing) **than in the services, implying that the growth in volume is much larger than the growth in value in material sectors** – and also much more difficult to reduce in a market-driven future

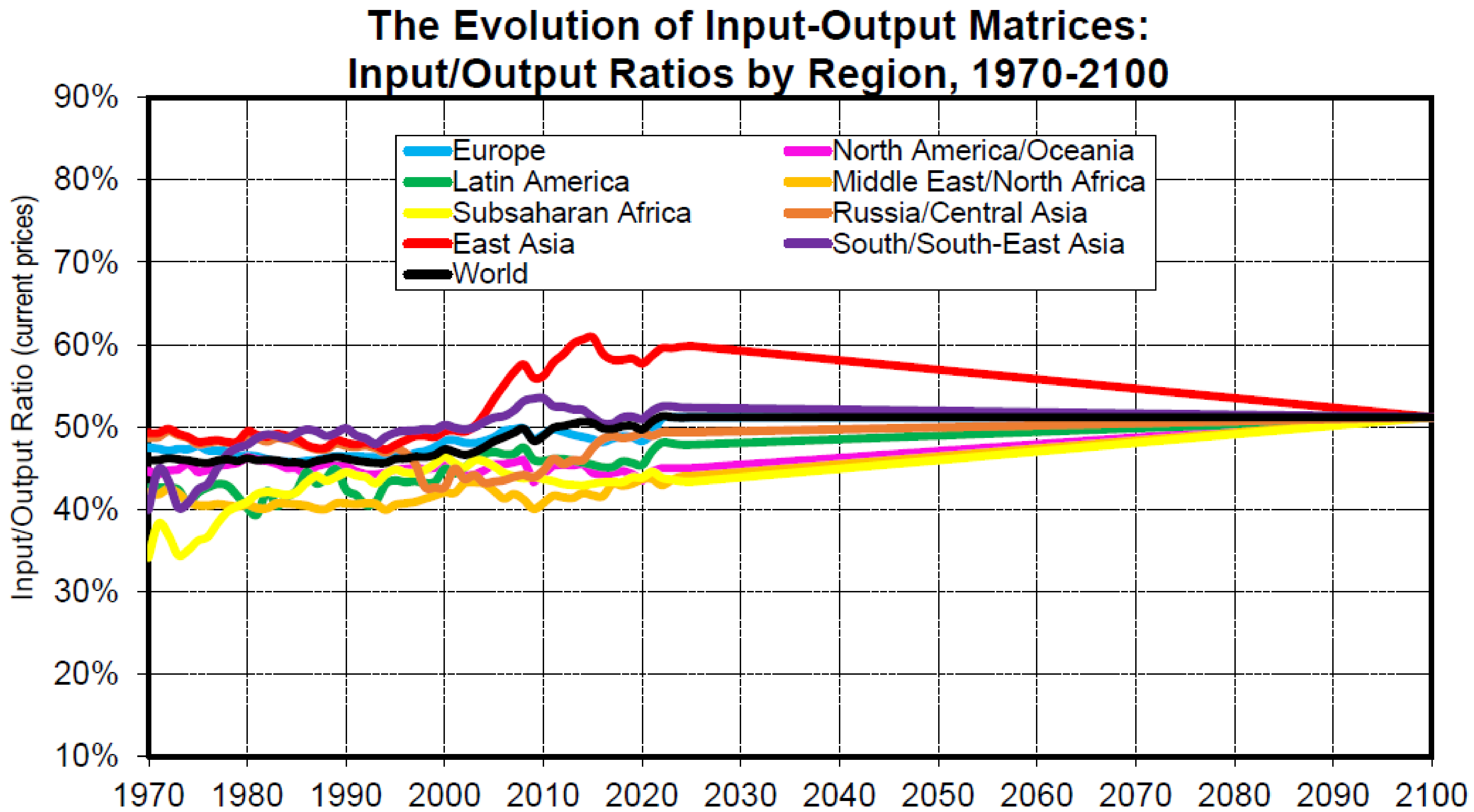
See Chancel et al, Prosperity Within Limits?, 2026 (WSEED.world)

(World Input-Output Database 1970-2025 & Projections 2026-2100)

The Classification of Economic Sectors Used in the World Sectoral Economy-Environment Database (WSEED)

	Sector	ISIC 3 Code	ISIC 4 Code	Included Sectors and Industries
Material Sectors	**Food** (incl. agriculture & processed food)	A+B+D15-16	A+C10-12	Agriculture; fishing; forestry; Manufacturing of food, beverages, tobacco
	Housing/Construction (incl. housing services and construction)	F + K (part)	F + L (part)	Housing services; Construction
	Manufacturing (incl. textiles, electronics, cars, etc.)	D exc. D15-16	C exc. C10-12	All manufacturing except food products: e.g. textiles, electrical equipment, machniery, vehicles, paper, chemicals, metals, plastics, etc.
	Energy (incl. mining)	C + E	B + D+E	Electricity, oil, gas; Water treatment and supply; Sewerage and waste managment; Mining and quarrying
	Transport (incl. train, bus, air, boat, etc.)	I	H	Land, water, air transport; pipelines; warehousing
Immaterial Sectors	**Education/Health** (incl. other public services)	L+M+N	O+P+Q	Education; Human health; Residential care and social work activities; Public Administration: public order, defense, foreign affairs
	Leisure/Culture (incl. shops, restaurants, bars, hotels, movies, books, etc.)	G+H+O+P	G+I+J+R+S+T	Wholesale & retail trade; Accomodation & food service activities ; Repair; Publishing, movie, broadcasting; Arts, museum, libraries; Sports & recreation
	Other services (incl. legal, financial, consulting, computing, architecture, etc.)	J+K	K+L+M+N	Financial, insurance, pension, IT, consultancy; Real estate (exc. Housing services); Legal, Accounting; Scientific R&D; Advertising, architectural, technical

Description. This research relies on the construction of a novel eight-sector database to analyse structual transfromation and track sectoral emissions for the 57 WID core territories from 1970 to 2025. All sources are harmonized to eight equivalent sectors. These eight sectors (five "material" and three "immaterial") are partly based on ISIC classifications (International Standard Industrial Classification for all Economic Activities, United Nations), with a number of changes and adjustments. The distinction between material and immaterial sectors is based upon input intensity: material sectors have more input intensity and material footprint than immaterial sectors. This differs from traditional classifications and is arguably more suitable for the study of sustaiable development and well-being. The extent to which the immaterial sectors are truly immaterial – and/or can become even more so in the future – is a central issue which is closely investigated in this research. **Source:** wseed.world (A0a)



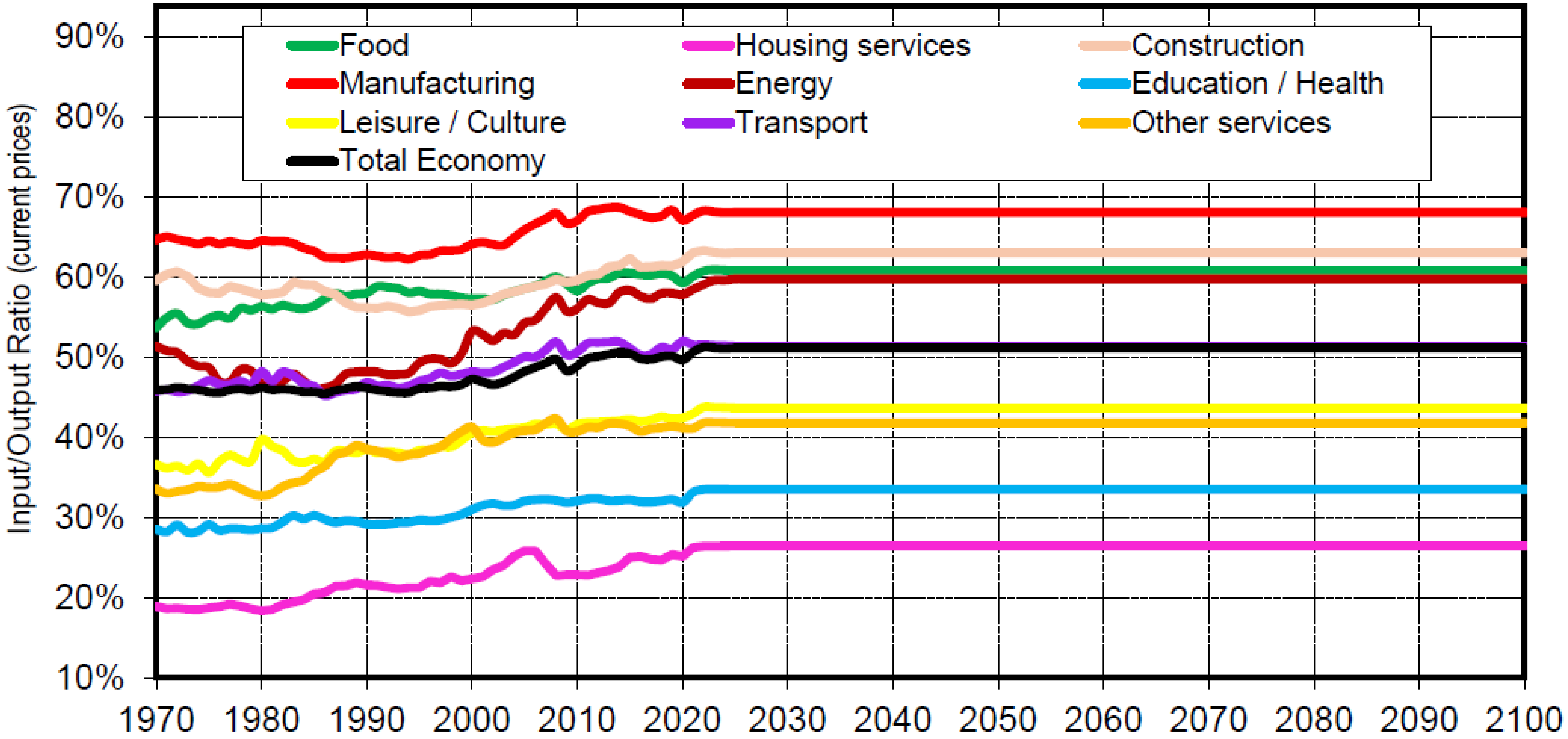
Interpretation. At the world level, intermediate inputs made on average 46% of total output in 1970 (all sectors combined). The global input-output ratio rose to 52% by 2025, with moderate variations across regions. East Asia's high ratio is due to the large manufacturing sector. In our benchmark simulations, we assume that this ratio will converge to 52% in all countries by 2100. **Sources and series**: wseed.world (O0)

The Global Input-Ouput Matrix in 2025

Each column reports intermediate consumption inputs used by each sector as % of its total output	**Total Economy**	Food	Housing Services	Construction	Manufacturing Goods	Energy	Education/ Health	Leisure/ Culture	Transport	Other Services
Food	**5%**	35%	0%	1%	3%	1%	2%	5%	1%	0%
Housing Services	**2%**	0%	3%	1%	0%	0%	2%	4%	1%	2%
Construction	**2%**	0%	6%	8%	0%	1%	2%	1%	1%	1%
Manufacturing Goods	**16%**	6%	2%	29%	41%	6%	7%	6%	8%	5%
Energy	**8%**	3%	2%	5%	9%	38%	3%	3%	15%	2%
Education/Health	**1%**	0%	1%	0%	0%	0%	4%	1%	1%	1%
Leisure/Culture	**7%**	8%	2%	7%	9%	4%	7%	10%	9%	6%
Transport	**3%**	2%	0%	3%	3%	3%	2%	4%	13%	1%
Other Services	**9%**	3%	10%	7%	4%	4%	8%	10%	9%	23%
Total Intermediate Inputs	**52%**	**57%**	**26%**	**61%**	**69%**	**57%**	**36%**	**44%**	**58%**	**42%**
Sector Share in Ouput	100%	10%	5%	8%	22%	8%	12%	16%	4%	15%
Sector Share in GDP (value-added)	100%	8%	8%	6%	15%	7%	16%	19%	4%	18%
Sector Share in Intermediate Energy Use	100%	4%	1%	5%	25%	41%	5%	7%	8%	3%

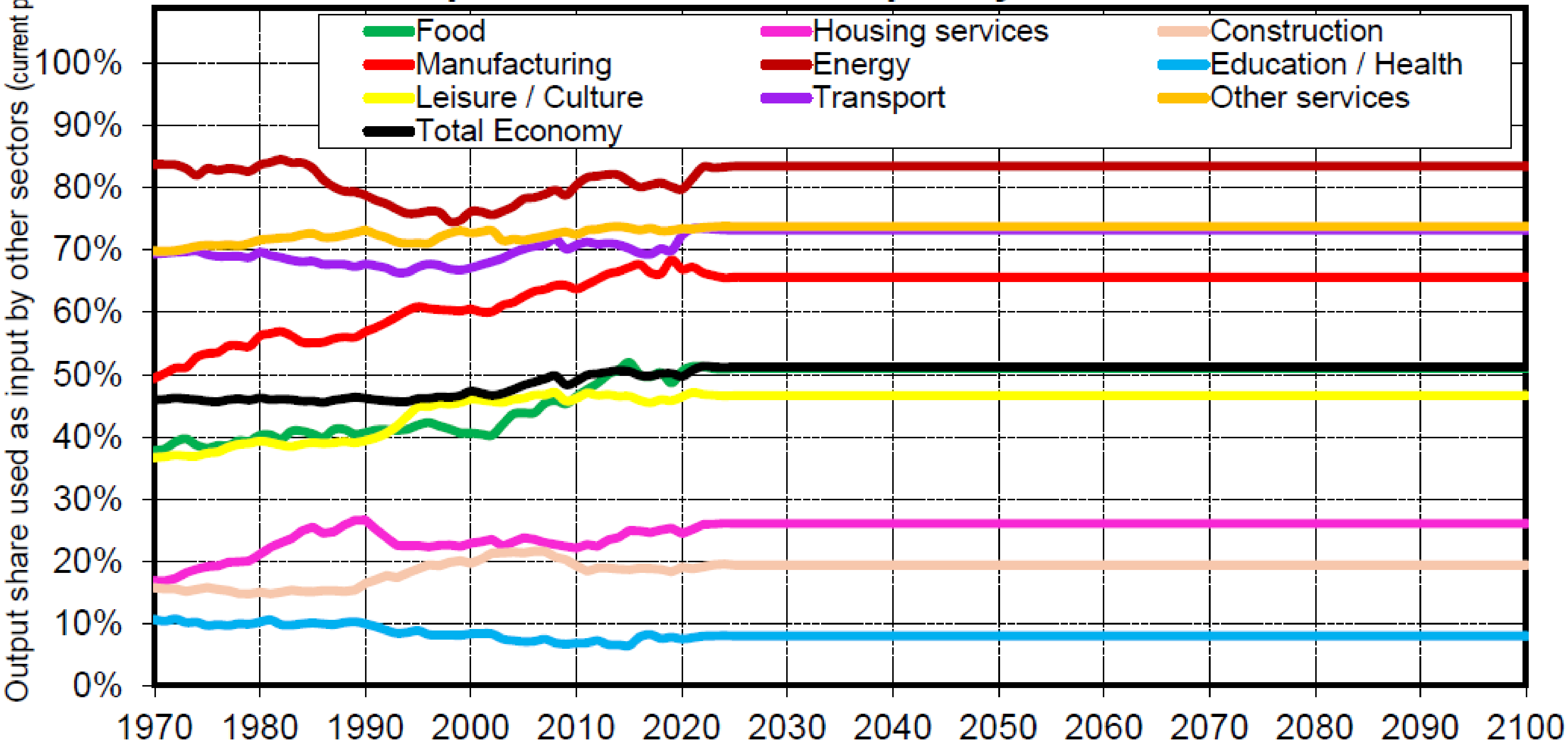
Interpretation. In order to produce 100€ of education/health. one spends 36€ in intermediate inputs (including 7€ in manufacturing goods and 3€ in energy). In order to produce 100€ in manufacturing goods, one spends 69€ in intermediate inputs (including 41€ in manufacturing goods and 9€ in energy). The material footprint of "immaterial" sectors is smaller than that of "material" sectors, but it should still be reduced substantially in order to become truly "immaterial". **Source:** wseed.world (O1a)

The Evolution of Input-Ouput Matrices: Input/Output Ratios by Sector, 1970-2100



Interpretation. Material sectors like manufacturing, construction, food and energy have always been the most input-intensive (with input-output ratios around 60-70% in 2025), while immaterial sectors like education/health, leisure/culture and other services have always been much less input-intensive (with input-output ratios around 30-40% in 2025). In our benchmark simulations, we assume that each country converges by 2100 to the world average ratio observed in 2025 in each sector . **Sources and series**: wseed.world (O0i)

The Evolution of Input-Output Matrices: Output Share Used as Input by Other Sectors



Interpretation. The share of each sector's output that is used as an intermediate input by other sectors (as opposed to the share that is used as final expenditure) has always been highest in energy (over 80% in 2025), followed by transport, other services and manufacturing (65-75%), food & leisure/culture (45-50%), construction & housing services (20-25%) and education/health (less than 10%). In our benchmark simulations, we assume that each country converges by 2100 to the average share observed in 2025 in each sector. **Sources and series**: wseed.world (O0s)

Much faster technical progress in material sectors (esp. manufacturing) than in the services → **relative price of material goods ↘**

→ this implies that material growth is even larger than usually measured (no GDP dematerialization in volume terms: the fall of relative material prices tends to undo satiation effects)
(**→ dematerialization requires specific policies**)

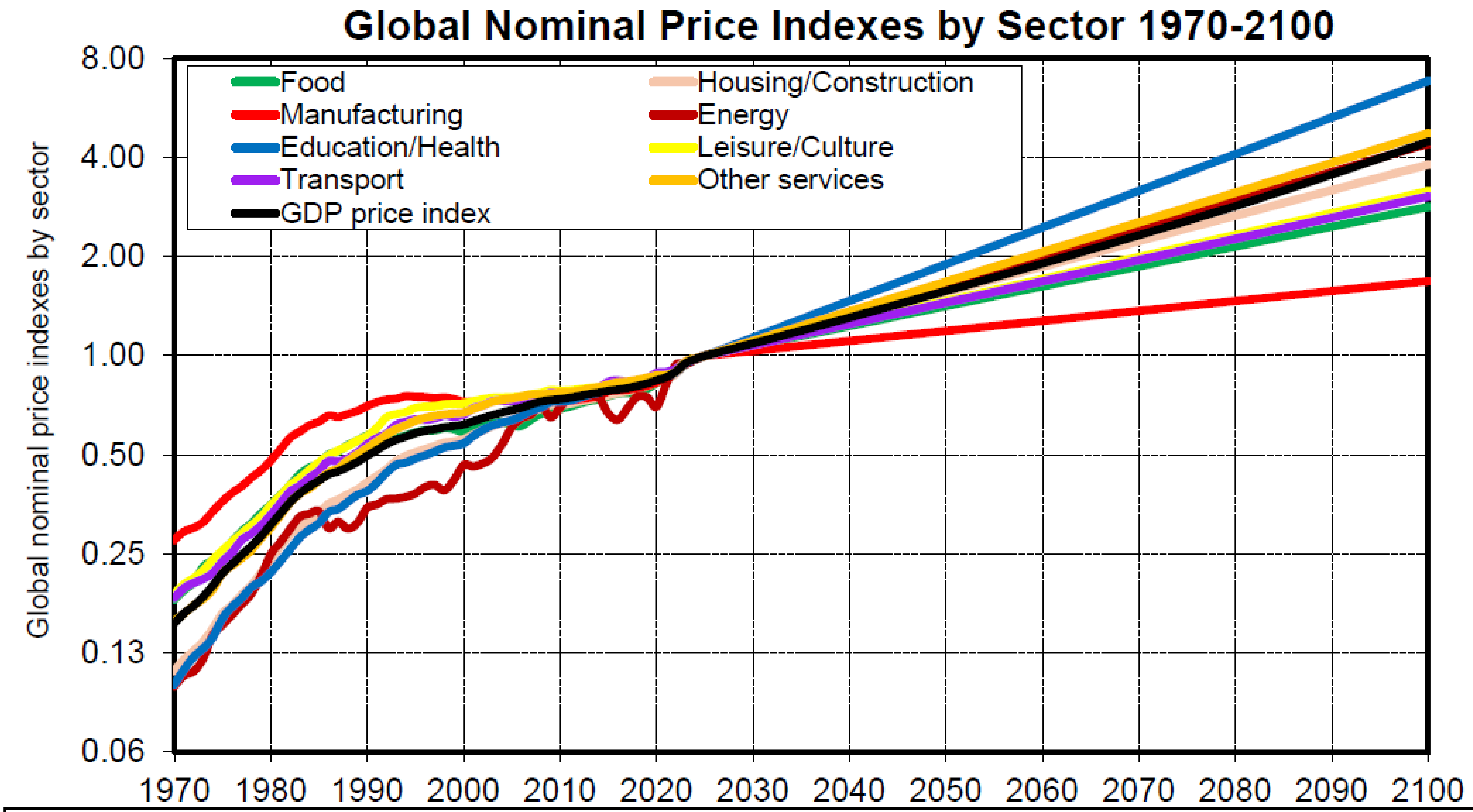
Per capita GDP: 1970 6.3k € ↗ 2025 16.5 €, i.e. **x2.6** (h=1.8%/year)

I.e. average monthly income in the world rose from 0.5k€ to 1.4k€

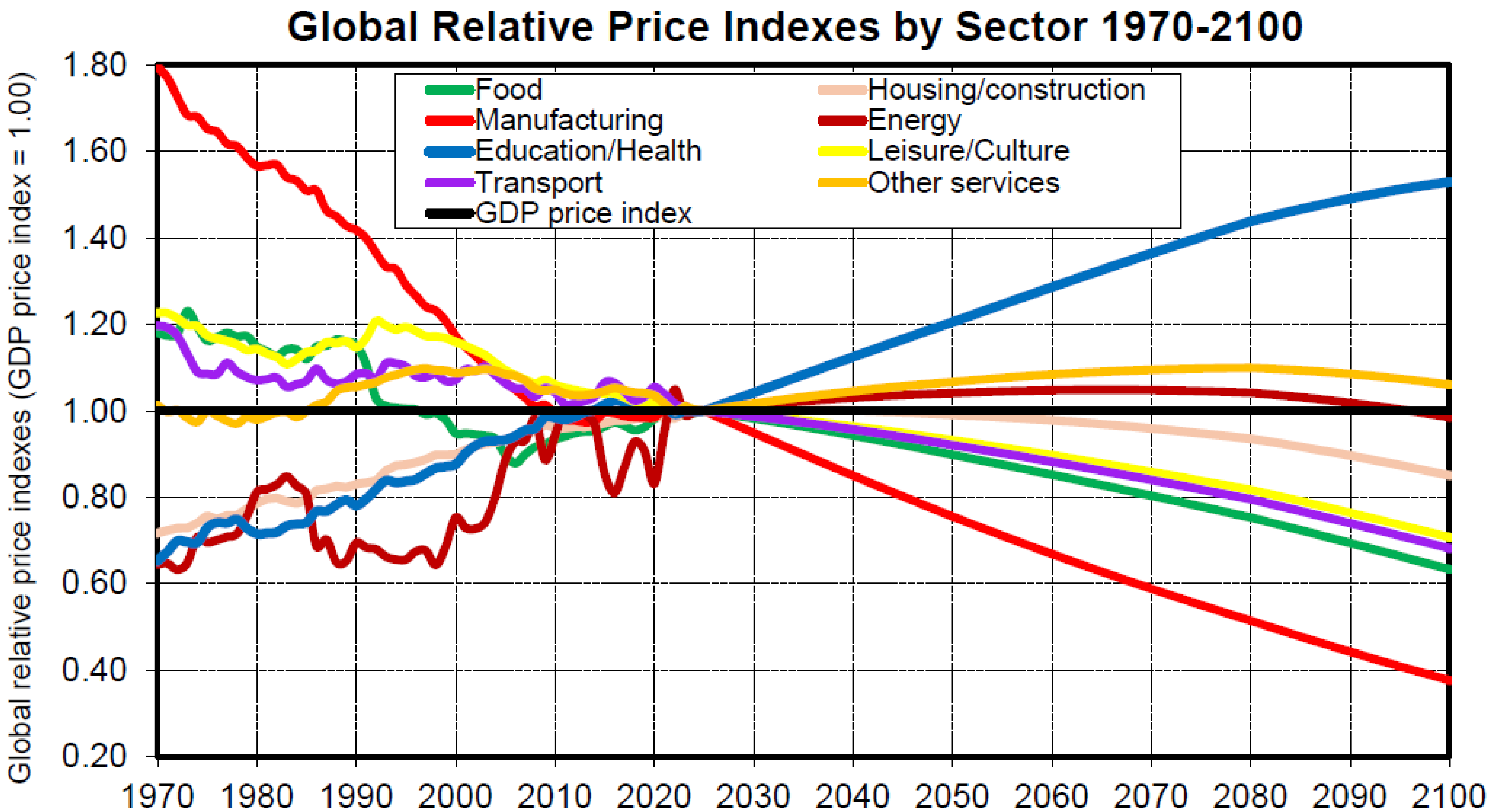
Relative price of manufacturing: 1970 1.80 ↘ 2025 1.00

Relative price of education/health: 1970 0.65 ↗ 2025 1.00

I.e. per capita expenditure in manufacturing **x4.7**,
but per capita expenditure in education/health **x1.7**

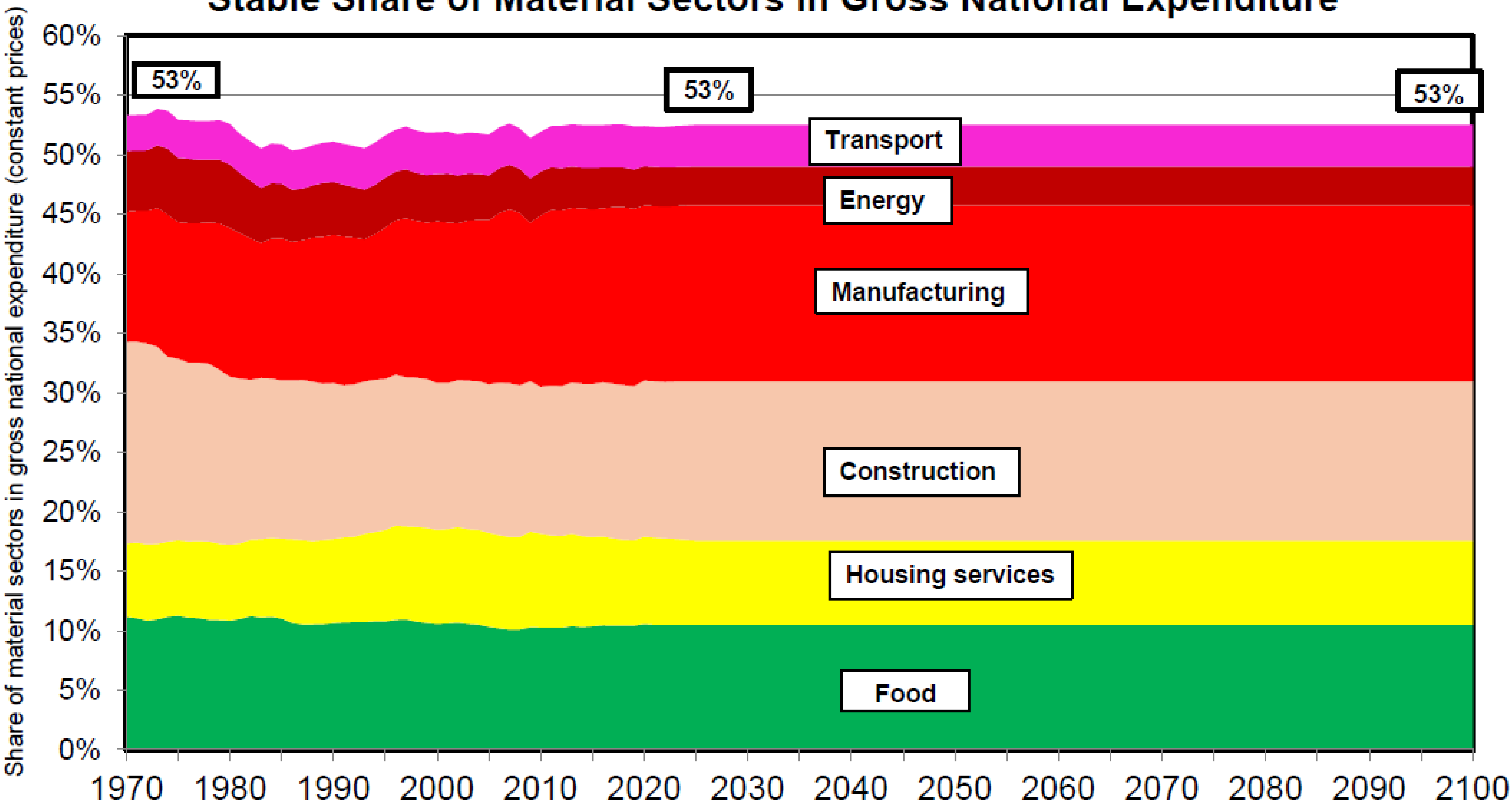


Interpretation. GDP price inflation has been 3.6% per year on average at the world level between 1970 and 2025 and is projected to be 2.0% over the 2025-2100 period. Inflation has always been lower in material sectors than in immaterial sectors (e.g. in manufacturig sector vs education/health), due to differential rates of technical change and is projected to follow the same pattern in 2025-2100. **Sources and series**: wiseed.world (C0a)



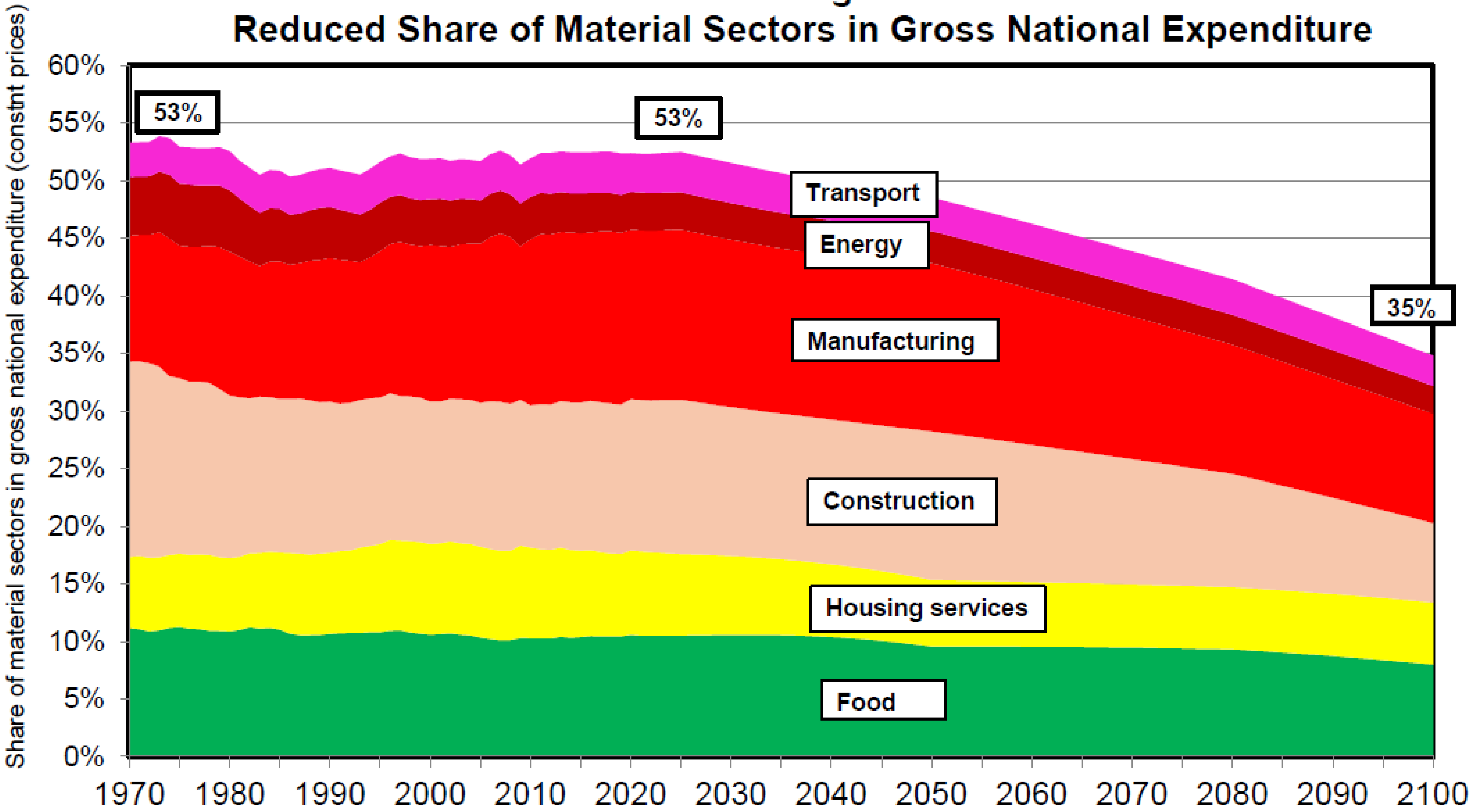
Interpretation. Price inflation has generally been smaller in material sectors than in immaterial sectors, due to differential rate of technical change, and is projected to follow the same pattern in 2025-2100. In effect, the relative price of manufacturing goods has been almost divided by 2 over 1970-2025 and is projected to be divided by more than 2 over 2025-2100. This corresponds in both cases to a relative price effect of about 0.5-1.0% per year relative to general GDP price index. **Sources and series**: wseed.world (C0b)

Productivist Convergence & Persistent Inequality Scenarios: Stable Share of Material Sectors in Gross National Expenditure



Interpretation. The share of material sectors in gross national expenditure (final consumption and investement) remained stable at 53% at the world level between 1970 and 2025. It is a projected to remain stable around 53% between 2025 and 2100 according to our productivist convergence and persistent inequality scenarios. **Sources and series**: wseed.world (G0p)

Sustainable Convergence Scenario: Reduced Share of Material Sectors in Gross National Expenditure



Interpretation. The share of material sectors in gross national expenditure (final consumption and investment) remained stable at 53% at the world level between 1970 and 2025. It is a projected to decline to 35% by 2100 according to our Sustainable Convergence scenario. This corresponds to a 30% reduction in the share of material sectors in consumption and investment expenditure. **Sources and series**: wseed.world (G0m)

Conclusion of Lecture 1

- **The measurement of social & economic progress is a key issue**. The choice of indicators reflects socioeconomic & political priorities & should not be left to statistical institutes: it is an issue for all social scientists (economists, historians, sociologists, etc.) and citizens to discuss & decide

- **Material accounting (volumes) and monetary accounting (income, wealth, wages, etc.) are both essential**