

Inequality and Institutions: Global Inequality

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1. Global inequality trends

1.1 Global income

- Regional incomes over a century
- Foreign income flows
- The functional distribution

1.2 Global wealth

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- The Wealth-to-income ratio
- Wealth composition in the long run
- The rise of private capital

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- Top incomes in the long run
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- Growth incidence curves
- The rise of Asia

Roadmap (2/2)

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Global inequality trends

Global income

Income in an international perspective

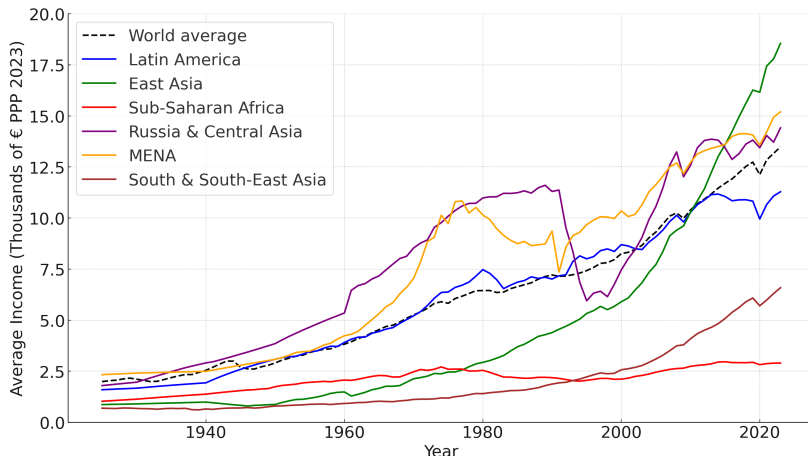
National level

- Income = net domestic output + net foreign income
- $Y = Y_D + NFI$

Global level

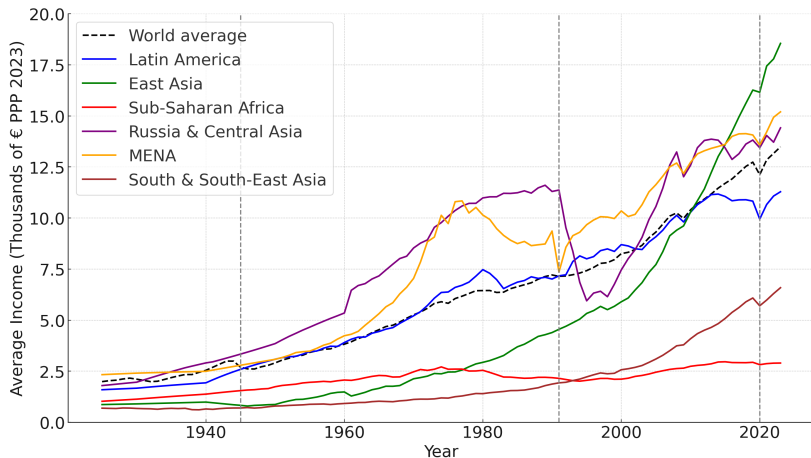
- $Y = Y_D$
- The sum of NFI is 0

Incomes in the global south, over a century



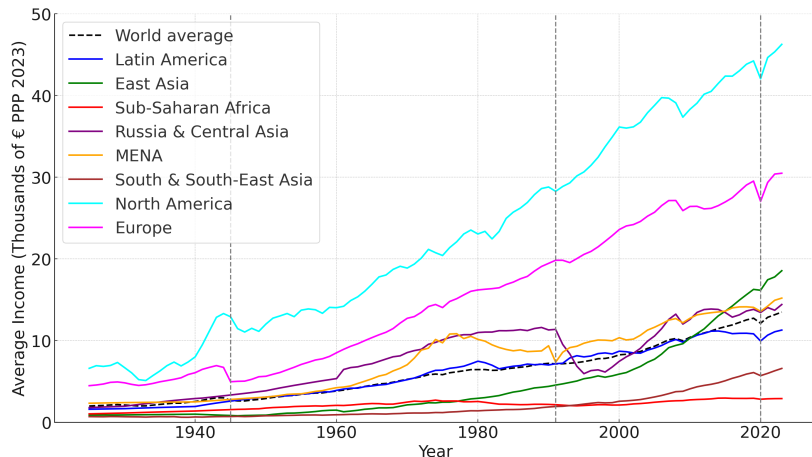
- **Notes.** The global average was multiplied by 5 in a century. East Asia saw the fastest increase while sub-Saharan Africa stagnates. Latin America follows the average closely, but recently decoupled. Based on WID.world

Global events setting the pace



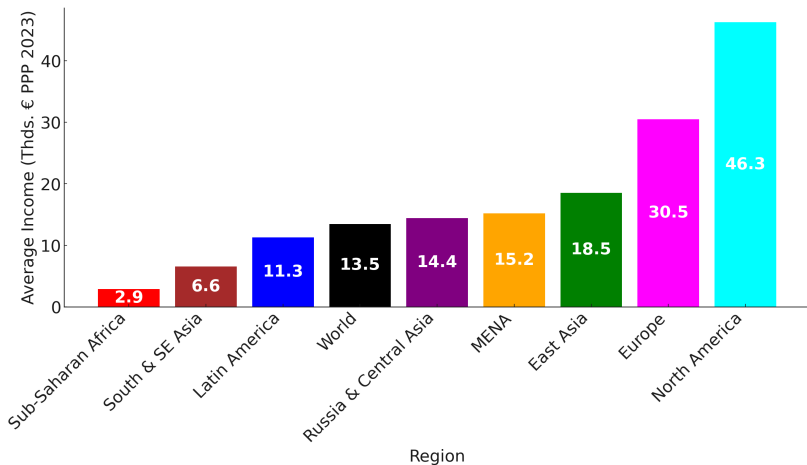
- **Notes.** The dashed vertical lines refer to the end of WW2, the fall of the Berlin wall and COVID-19. Based on WID.world.

The clear dominance of the global north



- **Notes.** Europe and North America stand at a different order of magnitude. Based on WID.world

Average incomes in 2023



- **Notes.** The North American average is 50% higher than the European. It is almost 16 times higher than in Sub-Saharan Africa. Based on WID.world, june 2024

More detail on foreign incomes

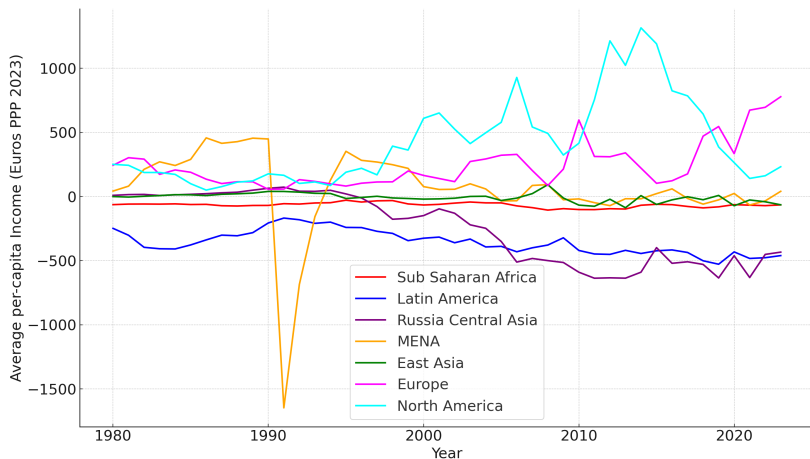
Net domestic output

- Domestic output = GDP - capital depreciation
- $Y_D = GDP - d$
- Depreciation is asset- and country-specific

Net foreign income

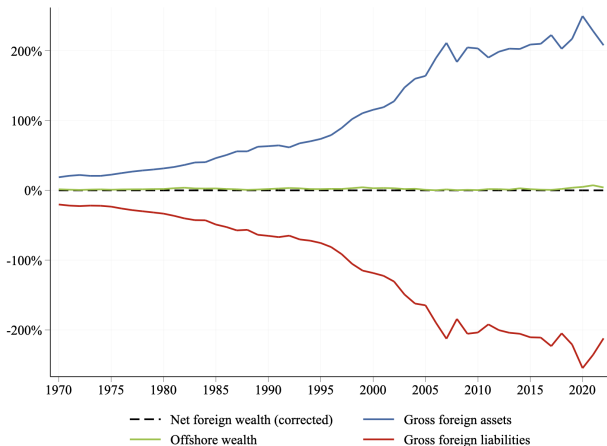
- Net foreign income = NFI from labor + NFI from Capital
- $NFI = NFI_L + NFI_K$
- Can be positive or negative
- $NFI_K = FA \times r_A - FL \times r_L$

Net foreign income flows



- **Notes.** Foreign income flows have increased since the 1990s. Some regions send more than what they receive (Latin America, Russia, S.S. Africa), while others receive more (Europe and North America). Based on WID.world

Foreign capital accumulation, in the recent decades



- **Notes.** Foreign Capital income flows are attached to foreign assets, which now accrue to 2 times the world GDP. Source: Nievas and Sodano, 2024

The functional distribution of income

Net domestic output

- Income = labor income + capital income
- $Y_D = Y_L + Y_K$

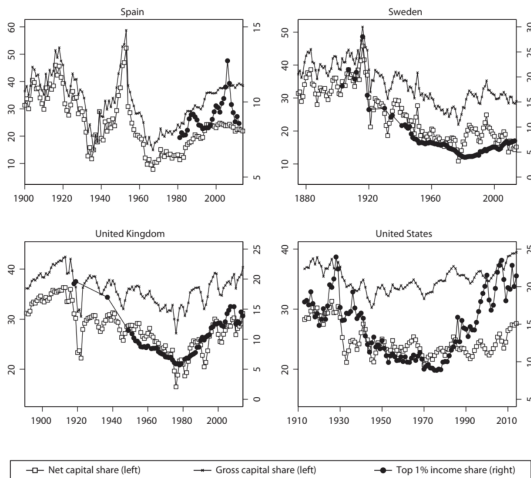
Capital income (domestic + foreign)

- Incl. corporate profits, rents, interest, K component of mixed income
- The capital share: $\alpha = Y_K/Y_D$

Labor income (domestic + foreign)

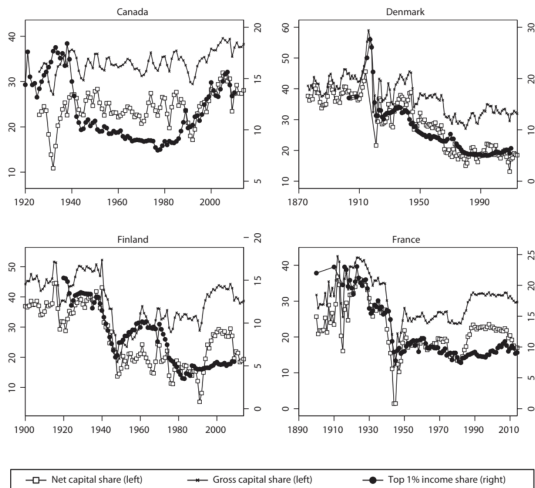
- Incl. wages, supplements, labor component of mixed income
- The labor share: $(1 - \alpha) = Y_L/Y_D$

Long run capital shares and the top 1% (1/2)



- **Notes.** The capital share of income α is not constant, as hypothesized by the Kaldorian stylized facts. They vary and are correlated with top incomes. Source: Bengtsson and Waldenström, 2018

Long run capital shares and the top 1% (2/2)



- **Notes.** The capital share of income α is not constant, as hypothesized by the Kaldorian stylized facts. They vary and are correlated with top incomes. Source: Bengtsson and Waldenström, 2018

The link between capital income and wealth

- Define r = average rate of return to wealth:

$$r = \frac{Y_K}{W}$$

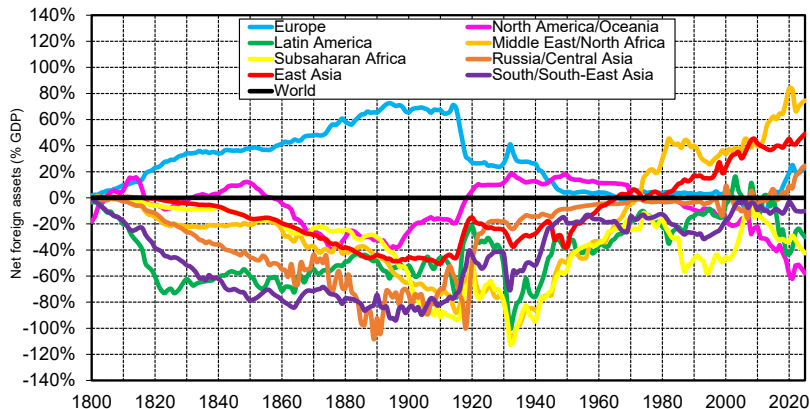
- Basic accounting relationship:

$$\alpha = r \times \beta$$

- **Typical values:** $\beta = 600\%$, $r = 5\%$, $\alpha = 30\%$
- In practice, the average rate of return to capital r varies substantially across asset classes and individuals.

Global wealth

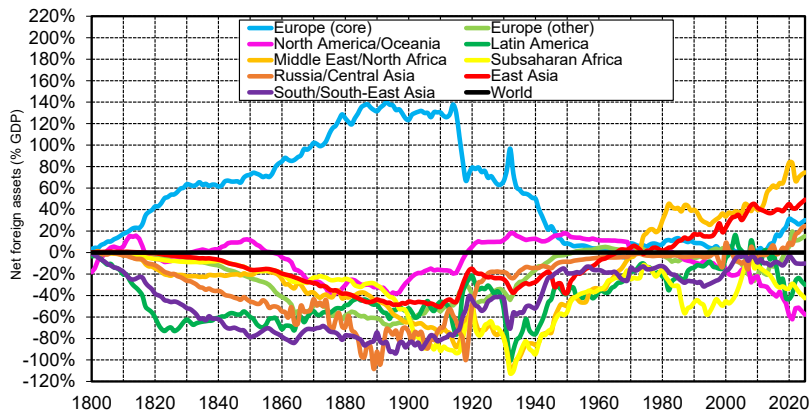
Foreign Wealth in a historical perspective (1/2)



Interpretation. Between 1800 & 1914, Europe owns a rising fraction of the rest of the world. In 1914, Europe's foreign wealth (i.e. net foreign assets held by European residents in the rest of the world) reach about 70% of Europe's GDP. These foreign assets vanish between 1914 and 1950. They are partly replaced by foreign assets owned by the US between 1920 and 1970 and by oil countries (particularly in the Middle East) and East Asia since the 1970s-1980s. **Sources and series:** wid.world

○ **Source.** Nieves and Piketty, 2025

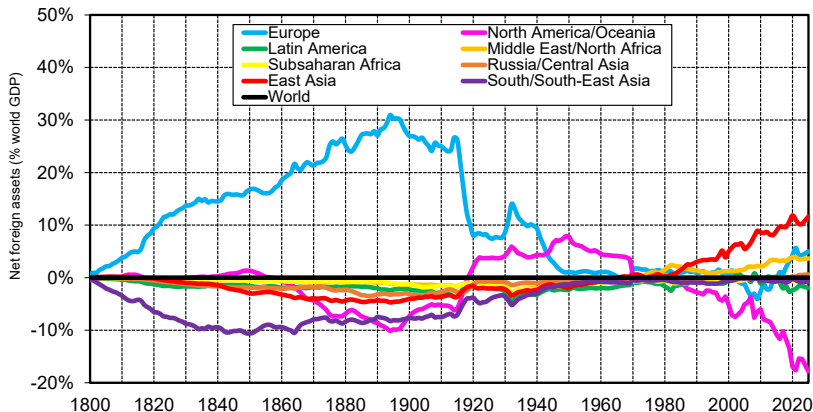
Foreign Wealth in a historical perspective (2/2)



Interpretation. If we look at core European colonial powers (Britain, France, Germany, Netherlands, making 68% of Europe's GDP in 1914), we find that their net foreign assets reach almost 140% of their GDP in 1914. In contrast other European countries have large negative foreign wealth (approximately of the same magnitude as other parts of the world). I.e. core European powers own assets in South Europe, Eastern Europe and Nordic Europe with approximately the same proportions as in the rest of the world. **Sources and series:** wid.world

○ **Source.** Nieves and Piketty, 2025

Foreign Wealth as % World GDP



Interpretation. If we express net foreign assets as a fraction of world GDP (rather than as a fraction of the GDP of each country or region), then we find that Europe's pre-WW1 foreign wealth is about 2.5-3 times larger than East Asia's foreign wealth today (and 5-6 times larger than Middle East's foreign wealth today). **Sources and series:** wid.world

○ **Source.** Nievas and Piketty, 2025

Measuring wealth stocks

Capital vs. Wealth

- Capital is mostly produced and generates profit (machines, buildings, sometimes human capital too)
- Wealth can be a broader concept: it also incorporates non-produced assets (land, subsoil assets) and financial assets (equity, bonds), which produce economic rents and can be traded

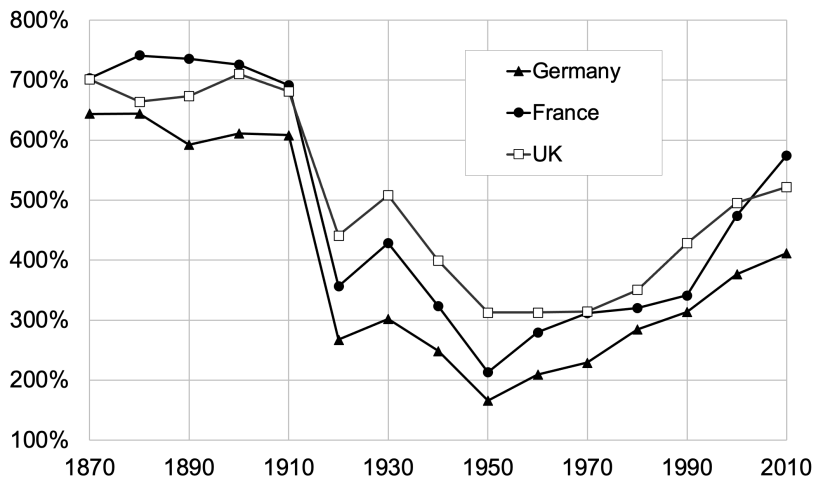
Net national wealth

- $W = W_P + W_G$
- National wealth = private wealth + public wealth

The wealth-to-income ratio

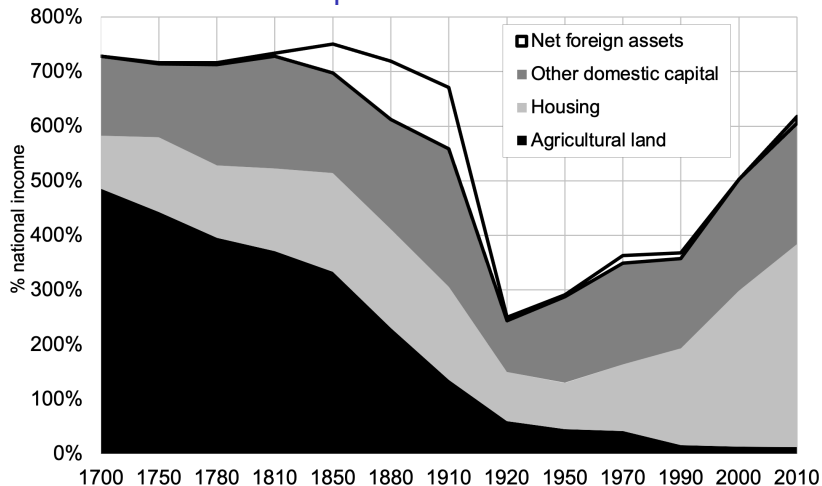
- $W/Y_D = \beta$

Long-run national wealth in Europe (β)



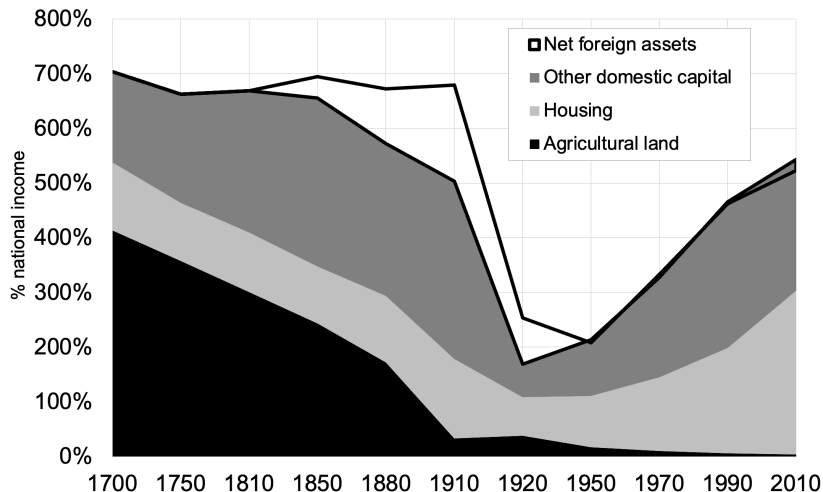
- **Notes.** National wealth was 6-7 times the national income by the end of the XIX century. Most of it was destroyed during the WW, then recovered slowly through decades. Source: Piketty and Zucman, 2014

National wealth composition in France



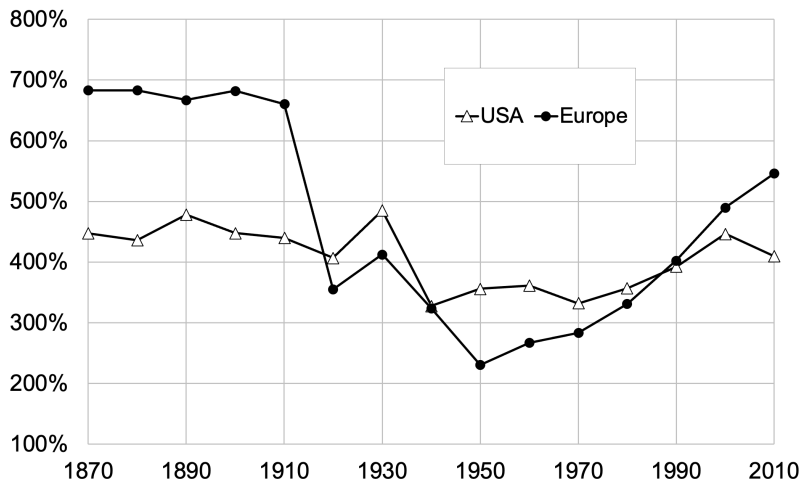
- **Notes.** Agricultural land was the most important asset during the XVIII and XIX centuries. The colonial period saw an increase in foreign assets. Housing assets rose during the XX century. Source: Piketty and Zucman, 2014

National wealth composition in the UK



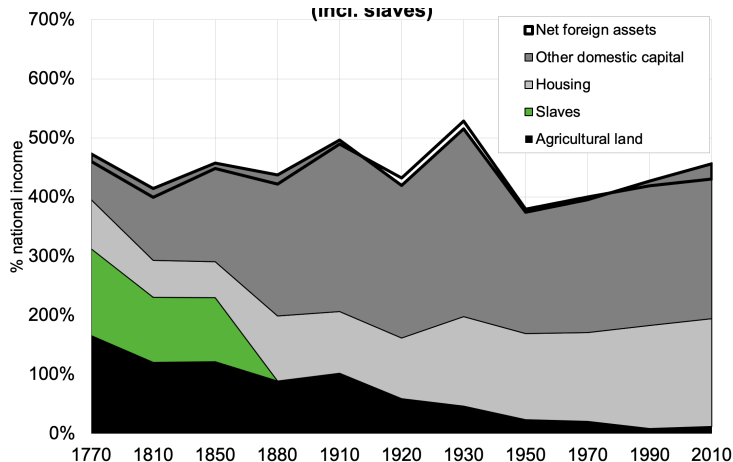
- **Notes.** Wealth experienced similar transformation in the United Kingdom and France since 1700. Source: Piketty and Zucman, 2014

National wealth in Europe vs. the USA



- **Notes.** Wealth accumulation was lower in the USA at the end of the XIX century. It remained relatively more stable throughout the century. Source: Piketty and Zucman, 2014

National wealth in the United States



- **Notes.** Before the end of the civil war, slaves were counted as wealth, which made a substantial part of the total. Other domestic capital (corporate assets, infrastructure) was relatively larger than in Europe. Source: Piketty and Zucman, 2014

Private vs. Public wealth

Private wealth

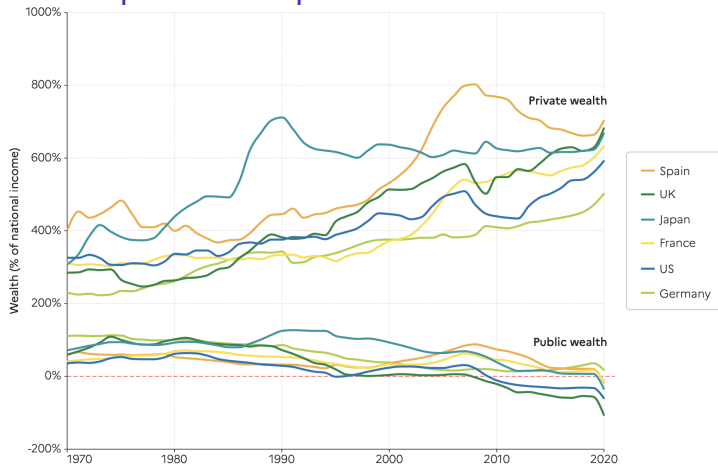
- $W_P = A_H - L_H$
- Private wealth = Households' Assets - Households' Liabilities
- Assets are financial (stock, deposits, bonds) and non-financial (land, housing)

Public wealth

- $W_G = A_G - L_G$
- Public wealth = Public Assets - Public Liabilities
- Assets are financial and non-financial

More recent estimates are more detailed

The rise of private capital



- **Notes.** In the UK, public wealth dropped from 60% of national income to -106%, while private capital keeps rising. The trend is common to most countries with data. More on this in the following sections. Source: The world inequality report (2022)

The long-run Wealth-Income ratio

In the long-run, the wealth-to-income ratio β is equal to the ratio of the saving rate s to the growth rate g .

Proof of the formula $\beta = s/g$:

- Future wealth: $W_{t+1} = W_t + s_t Y_t$
- Future income: $Y_{t+1} = Y_t(1 + g_t)$:

$$\beta_{t+1} = \frac{W_t + s_t Y_t}{Y_t(1 + g_t)} = \frac{\beta_t + s_t}{1 + g_t}$$

Steady-state Wealth-Income ratio

In steady state:

$$\beta_t = \beta_{t+1}, \quad s_t = s_{t+1}, \quad g_t = g_{t+1}$$

Substituting into the dynamic equation:

$$\beta = \frac{\beta + s}{1 + g} \Rightarrow \beta = \frac{s}{g}$$

Numerical illustration and assumptions

Examples:

- If $s = 10\%$ and $g = 3\%$, then $\beta = \frac{10\%}{3\%} = 333\%$
- If $s = 10\%$ and $g = 1.5\%$, then $\beta = \frac{10\%}{1.5\%} = 666\%$

Underlying assumption:

$$W_{t+1} = W_t + s_t Y_t$$

i.e., no capital gains or losses (no asset price effects).

Inequality across households

A short story of the World Inequality Lab

World Top Incomes Database (WTID) - 2011:

- Accessible series on income inequality for over 30 countries
- Relied solely on tax data, with limitations on scope

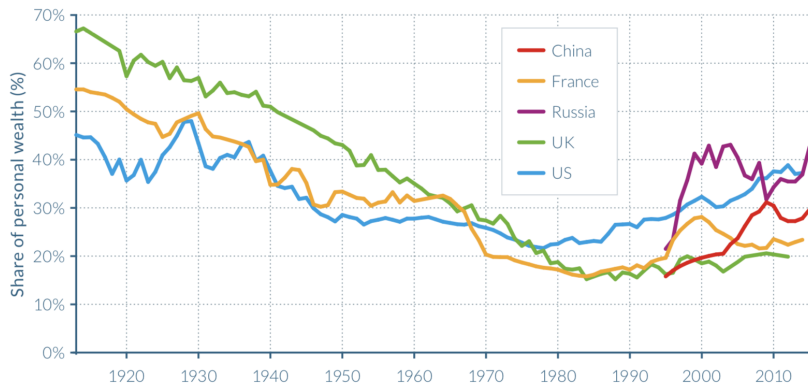
WTID evolves into WID - 2015

- Inclusion of wealth data and extended national income series.
- Adoption of System of National Accounts (SNA)

WID.world - 2017

- Launch of the WID website with advanced data visualization.
- Universal coverage, combining tax data and surveys, and detailed distributional accounts for all income and wealth.
Annual distributional national accounts.

The fall and rise of private wealth concentration



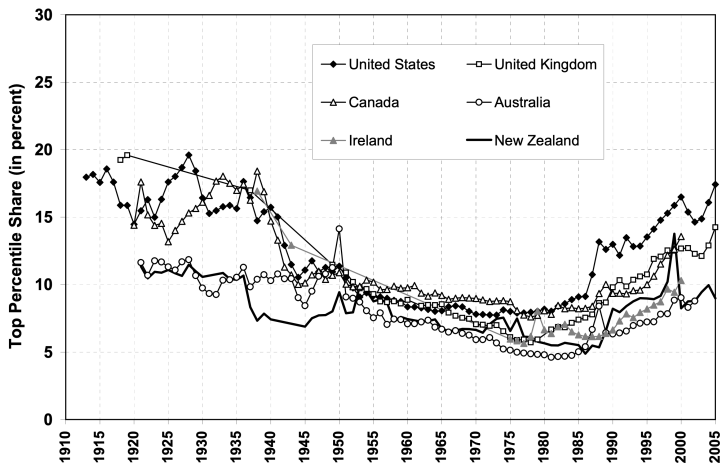
- **Notes.** The share held by the richest 1% of the population follows a U-shaped or L-shaped evolution. Concentration rises at different paces since the 1990s-2000s. Distributional wealth data is scarce. Source: The world inequality report (2022)

Top incomes in the long run

Fiscal income series

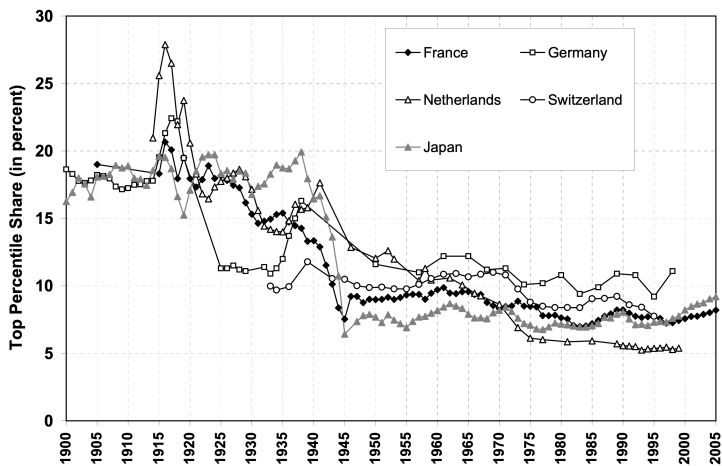
- A mix of administrative sources and national accounts
- Pioneering methods by Kuznets Kuznets and Jenks, 1953; Atkinson and Harrison, 1978; Piketty and Saez, 2003.
- Partial macro-economic consistency, but excellent historical coverage
- Only covers the very top of the distribution

Increasing top 1% in English speaking countries



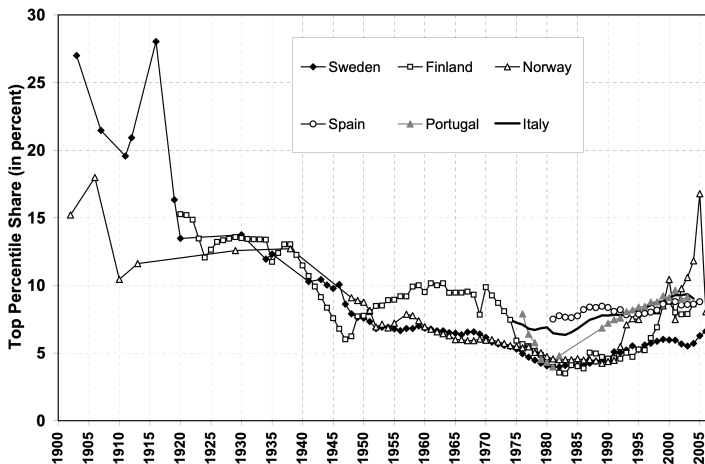
- **Notes.** Income concentration is U-shaped over the last century in English speaking countries. In the 2020s, the USA surpassed its early-1900s levels (see updated plots in [wid.world](#)). Source: Atkinson, Piketty, and Saez, 2011

L-shaped top 1% in Europe and Japan



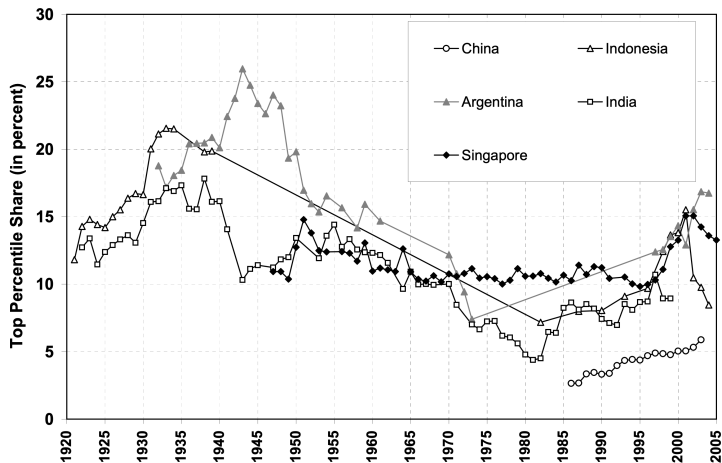
- **Notes.** Some countries experienced an L-shape over the last century with stagnating or slowly increasing level of concentration in recent decades (See France or Japan). Source: Atkinson, Piketty, and Saez, 2011

Top 1% in Northern and Southern Europe



- **Notes.** Scandinavian countries set the low income inequality frontier worldwide, describing an L-shaped pattern too. Some tax code related changes are visible in the data, showcasing potential sensitivity (see Norway). Source: Atkinson, Piketty, and Saez, 2011

Top 1% in developing countries



- **Notes.** The few developing countries with long run fiscal series also seem to have experienced a fall and comeback of inequality during the last century. This includes the giants: China and India. Source: Atkinson, Piketty, and Saez, 2011

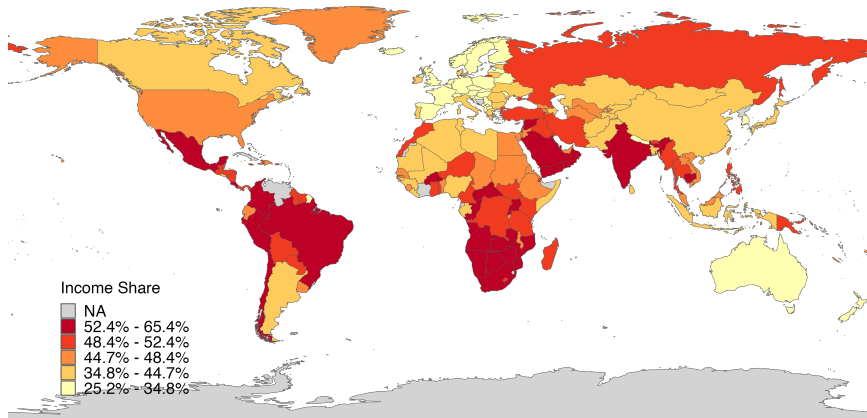
Recent estimates: macro consistency

Distributional National Accounts (DINA)

- In recent years, data availability allows for macro-consistency
- Time coverage is lower than with fiscal income series
- More details of methods and findings in following sections

Present levels of concentration - DINA Top 10%

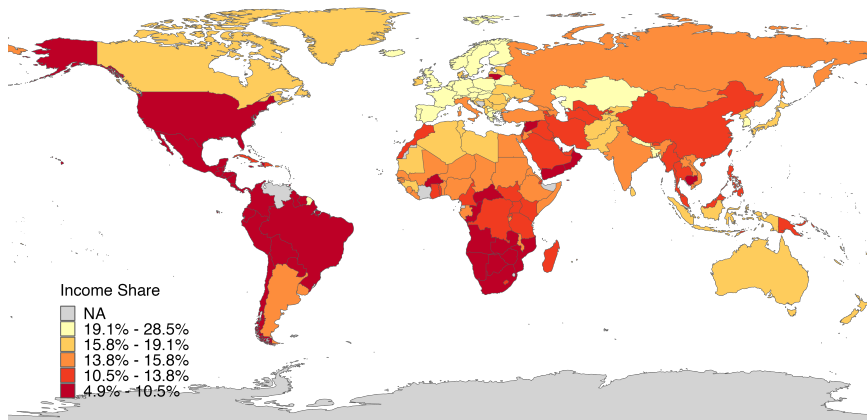
Pre-tax National Income Top 10% Share by Country



- **Notes.** Dark red areas indicate the global top quintile of income concentration, including regions such as Latin America, sub-Saharan Africa, India and the Gulf. The bottom quintile includes western Europe and Scandinavia.

The symmetric Bottom 50% - DINA

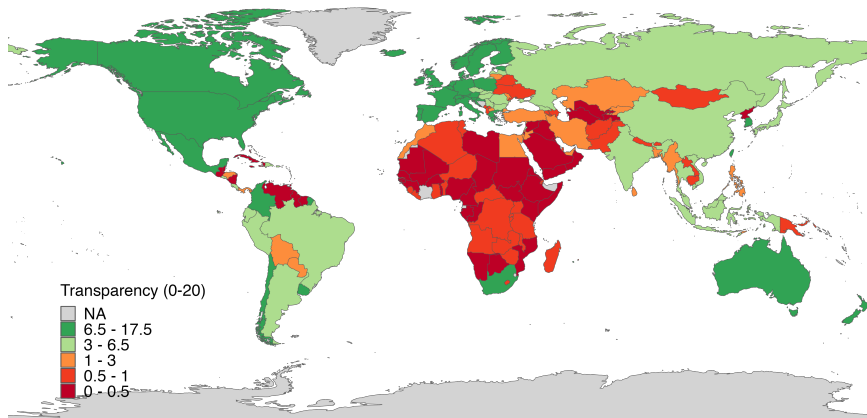
Pre-tax National Income Bottom 50% Share by Country



- **Notes.** Dark red areas indicate a lower share for the bottom half, including regions such as Latin America, sub-Saharan Africa, India and the Gulf. The higher quintile includes western Europe and Scandinavia.

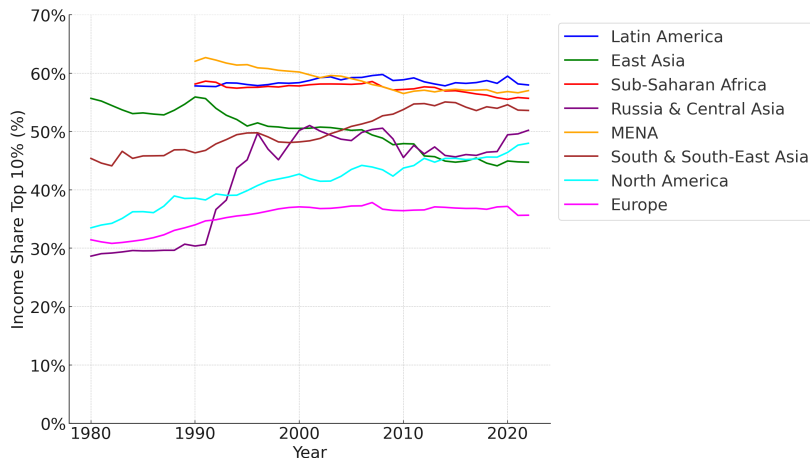
Different levels of data quality

Inequality transparency index by Country



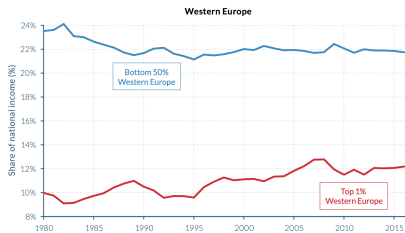
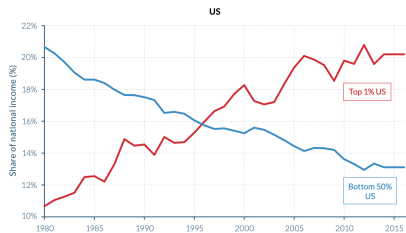
- **Notes.** Transparency levels are heterogeneous across continents. Dark red areas indicate the global bottom quintile, including regions such as sub-Saharan Africa, and MENA. The top quintile, includes scores lower than 10, signaling room for improvement even in Europe.

The great convergence? - Top 10%



- **Notes.** Since 1980, most regions intensified income concentration, yet at different speeds. They are now closer to the extreme inequality frontier, set by Latin America, MENA and sub-Saharan Africa, which have remained more stable.

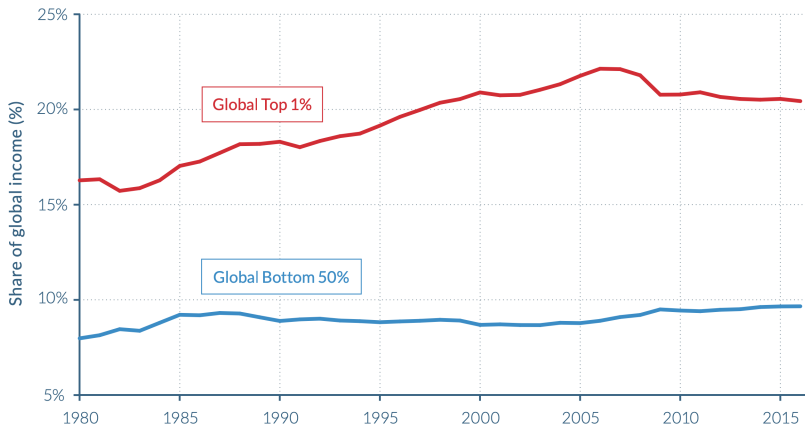
Within-country dynamics: US vs. Europe



- **Notes.** In the US the top 1% share has increased almost as much as the bottom 50% has decreased in their share of national income. In Europe, trends are much flatter, yet mostly going in the same direction

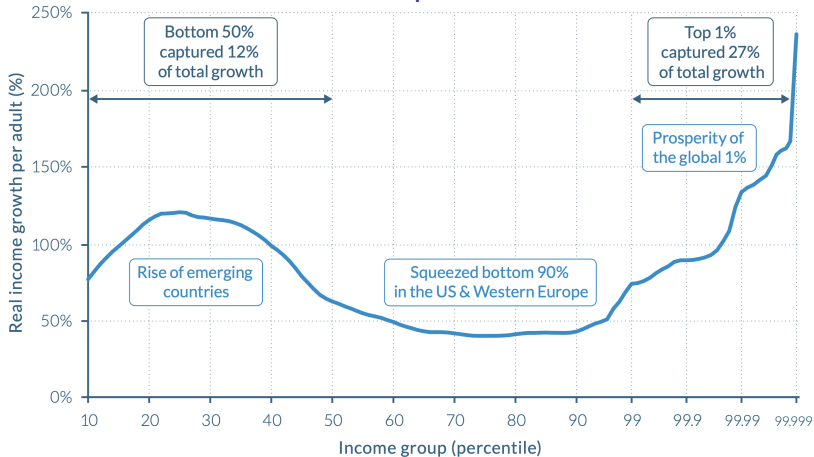
Inequality across borders

"One world" income inequality



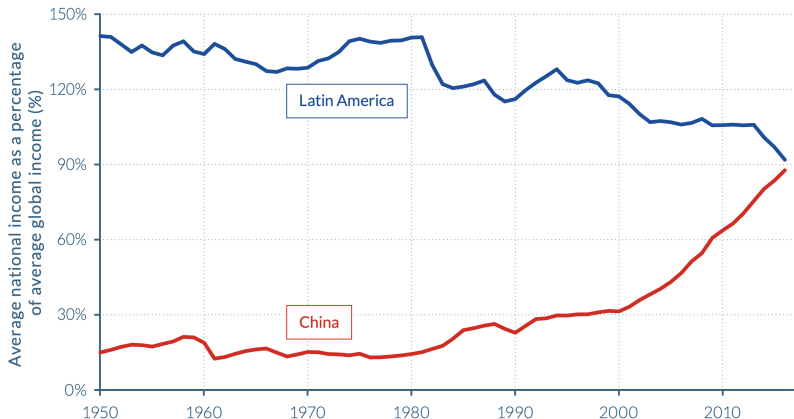
- **Notes.** Representing the world as a single big country, the global top 1% share increased considerably, from $\approx 16\%$ in 1980, to more than 20% in the second half of the 2010s. The bottom 50% experienced an increase, but more moderate in volume. Source: the world inequality report (2022)

Growth incidence: the elephant curve



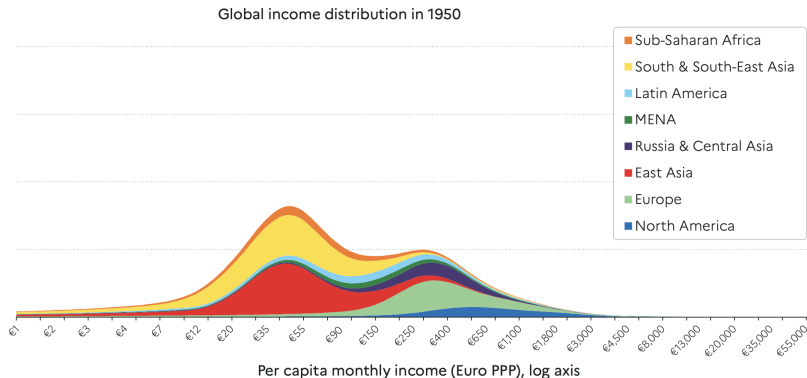
- **Notes.** The bottom 50% of the world's population doubled their incomes between 1980-2016, capturing 12% of total growth (not the same people). The top 1% saw a much faster increase, capturing 27%. Source: The world inequality report 2018. The elephant curve was first shown by using survey data Milanovic, 2016

The Rise of Asia: the Chinese catch-up



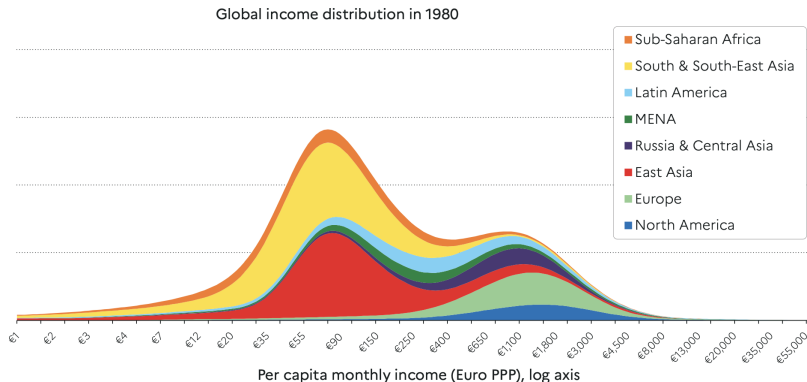
- **Notes.** As seen before, the Chinese economic catch-up is the most accelerated economic growth in the period. It explains most of the increase in the bottom incomes, globally. In 2024, China has already surpassed Latin America. Source: The world inequality report 2018.

The composition of Global Income (1950)



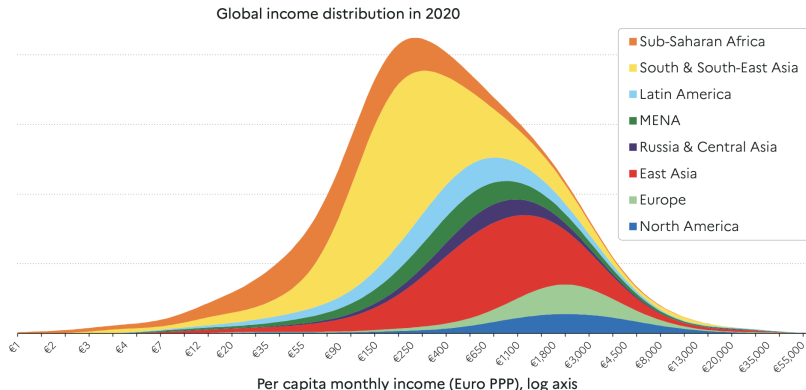
- **Notes.** Areas are proportional to the population. Source: The world inequality report (2022)

The composition of Global Income (1980)



- **Notes.** Areas are proportional to the population. Source: The world inequality report (2022)

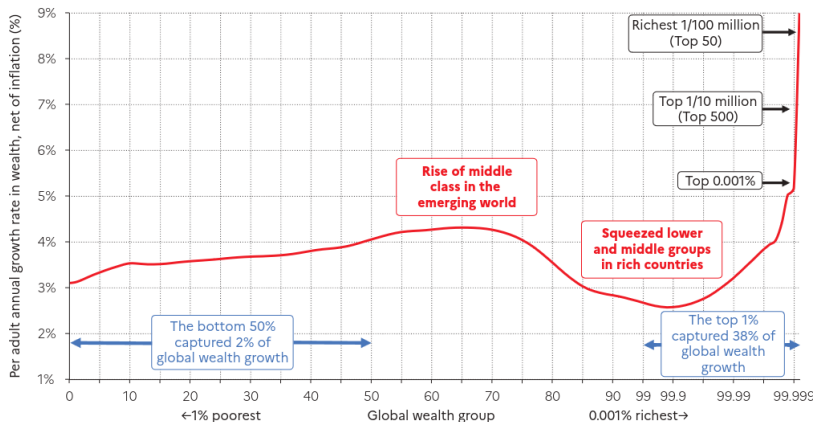
The composition of Global Income (2020)



- **Notes.** Areas are proportional to the population. Source: The world inequality report (2022)

Wealth growth incidence: the elephant(er) curve

Figure 9 Average annual wealth growth rate, 1995-2021



- **Notes.** In recent decades, *wealth* growth has favored the top percentile of the global distribution, capturing 38% of total growth vs 2% for the bottom 50%. Source: The world inequality report (2022)

A step back for perspective

Contents of section 2

2. A step back for perspective

2.1 Theories of wealth inequality

- Modeling individual wealth
- Life-cycle saving vs. bequests
- Dynamic random shock models
- The idea of justice

2.2 Mobility and opportunity

- The great Gatsby curve
- The sticky tails
- Inequality of opportunity

2.3 Climate justice

- Carbon footprint to income elasticity
- The fairness of carbon emissions reduction

2.4 Methodological considerations

- Is there a 'true' level of inequality?
- Inequality of what?
- Summarizing a distribution

Theories of wealth inequality

Modeling individual wealth

Future individual wealth is defined as

$$W_{t+1}^i = (W_t^i + s_t^i Y_t^i) \times (1 + q_t^i)$$

Their present wealth W_t^i , plus present savings $s_t^i Y_t^i$, all of which accrue capital gains at rate q_t^i

The key role of relative saving rates

At steady state, we ignore price effects

$$q_t^i = 0 \quad \text{for all } i, t$$

The share of wealth held by i

$$\sigma_W^i = \sigma_Y^i \cdot \frac{s^i}{s}$$

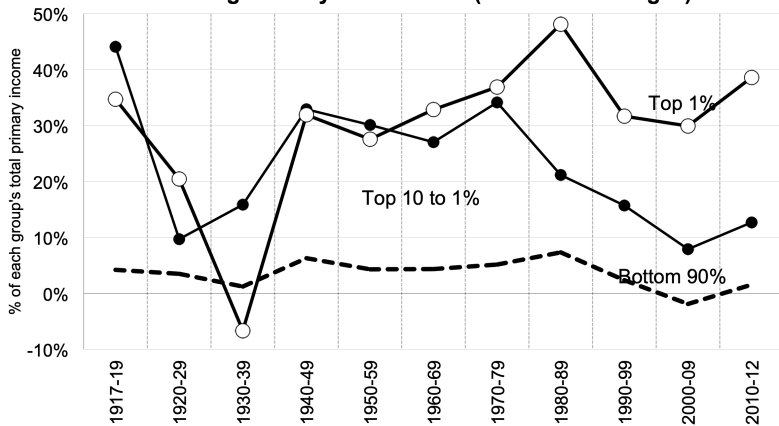
Is their share of income σ_Y^i times the relative saving rate s^i/s

*This generalizes the Harrod-Domar-Solow identity: $\beta = s/g$.
But what defines s ?*

The precautionary saving model

- Uncertain income $\Rightarrow$ individuals save for self-insurance
- Richer individuals need less precautionary saving
- Hence, saving rates should decline with income (not supported by evidence)

Saving rates by wealth class (decennial averages)



The rich save more as a fraction of their income, except in the 1930s when there was large dis-saving through corporations. NB: The average private saving rate has been 9.8% over 1913-2013.

Source: Saez and Zucman (2016)

Life-cycle saving model

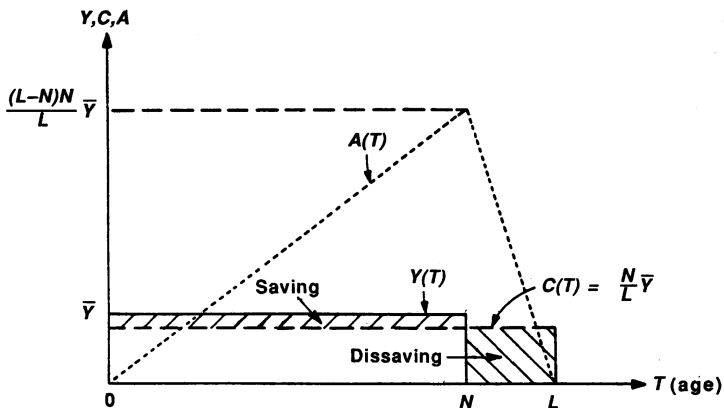
Individuals smooth consumption over the life-cycle

- No growth: $n = g = r = 0$
- Work for N years, retire at age L
- Constant labor income $\bar{Y}$
- Zero bequests: die with $W_L = 0$

Implications:

- Consumption is constant $C = \bar{Y} \cdot N/L$
- Savings during working years: $S = (1 - N/L) \cdot \bar{Y}$
- Dis-savings During retirement: $S = -N/L \cdot \bar{Y}$

Income, consumption, saving and wealth as a function of age

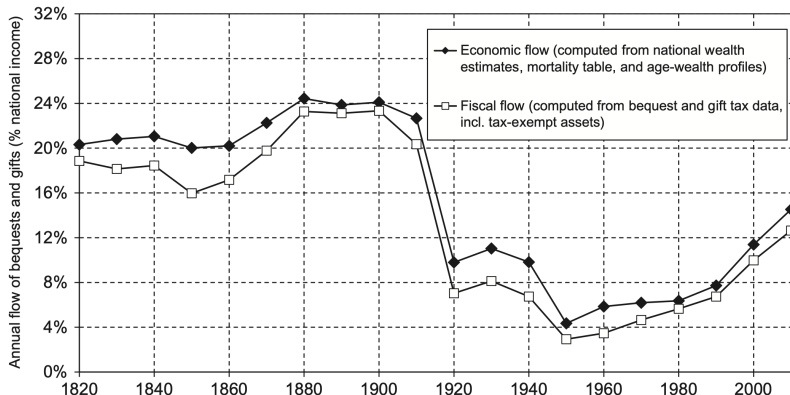


Source. Modigliani, 1986

Limits of the Life-Cycle model

- Public pensions reduce the need to save
- Disagreement on the contribution to aggregate wealth from life-cycle savings and inherited wealth: the Modigliani vs. Kotlikoff-Summers controversy (Kotlikoff and Summers, 1981; Modigliani, 1986)
- The central question is how far the imprint of inheritance extends: only to the original transfer, or also to the capital income it produces.
- **Main limitation:** explains too little wealth inequality
 - ▶ Wealth distribution would mirror income distribution

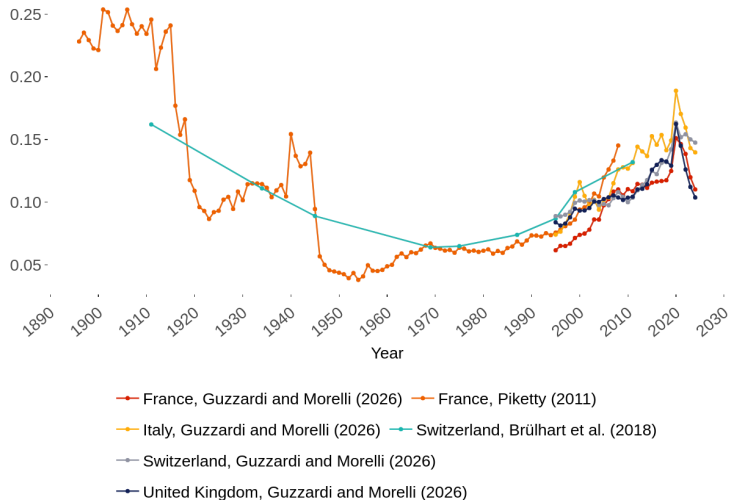
Annual inheritance flow, % NI, France



The annual inheritance flow was about 20–25% of national income during the nineteenth century and until 1914; it then fell to less than 5% in the 1950s and returned to about 15% in 2010

- **Notes.** Piketty and Zucman, 2015 showed how other simple statistics measure the weight of inheritances and bequests, and how they closely follow the dynamics of wealth accumulation.

Annual inheritance flow, % NI, more countries



o from <https://wealthproject.gc.cuny.edu/>

Dynamic random shock models (1/3)

Observed wealth inequality exceeds what is predicted by basic models.

Stochastic wealth process:

$$W_{t+1}^i = \tilde{a}_t^i W_t^i + \tilde{b}_t^i$$

- $\tilde{a}_t^i$: multiplicative shocks (e.g., capital gains, returns)
- $\tilde{b}_t^i$: additive shocks (e.g., labor income)

Example shock-types:

- Heterogeneous rates of return
- N^o of children
- Saving taste

Dynamic random shock models (2/3)

Under a number of assumptions, wealth converges to a steady-state distribution, where the top tail follows a Pareto distribution (Piketty and Zucman, 2015).

- Pareto exponent α determined by $\tilde{a}_t^i$
- Higher $\mathbb{E}(\tilde{a}_t^i) < 1 \Rightarrow$ lower $\alpha \Rightarrow$ higher inequality
- Higher $\text{Var}(\tilde{a}_t^i) \Rightarrow$ lower α

Dynamic random shock models (3/3)

- Latest models consider a variety of factors: (Benhabib, Bisin, and Luo, 2019; Blanchet, 2022):
 - ▶ Inter-generational mobility, savings, heterogeneous rates of return, inheritance, assortative mating, demographic change
- Blanchet, 2022 uses U.S. microdata to estimate his model and finds that the main drivers of rising top 1% wealth share since the 1980s are, in decreasing order of importance:
 - 1 Higher saving rates at the top
 - 2 Higher returns to wealth (especially capital gains)
 - 3 Higher labor income inequality

The role of tax regressivity and increasing returns

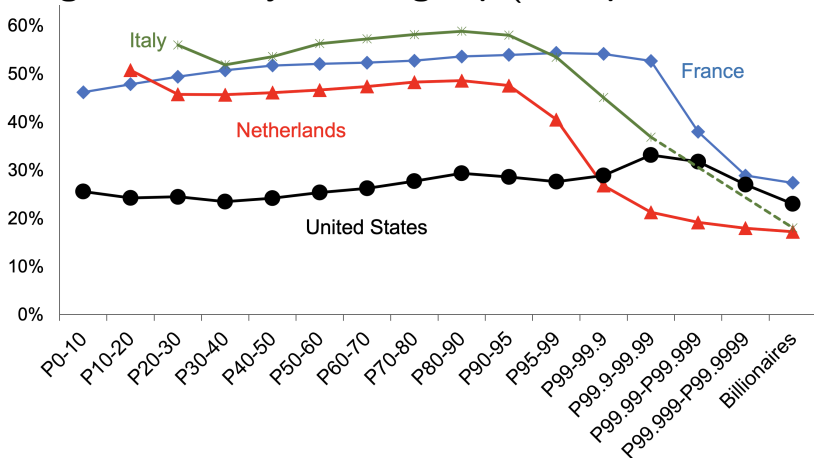
Considering :

$$W_{t+1} = (1 + \tilde{R} - \tau) \cdot W_t + \tilde{b}$$

- $\tilde{R}$: net return on wealth
- τ : effective tax rate on wealth
- $\tilde{b}$: savings from labor income

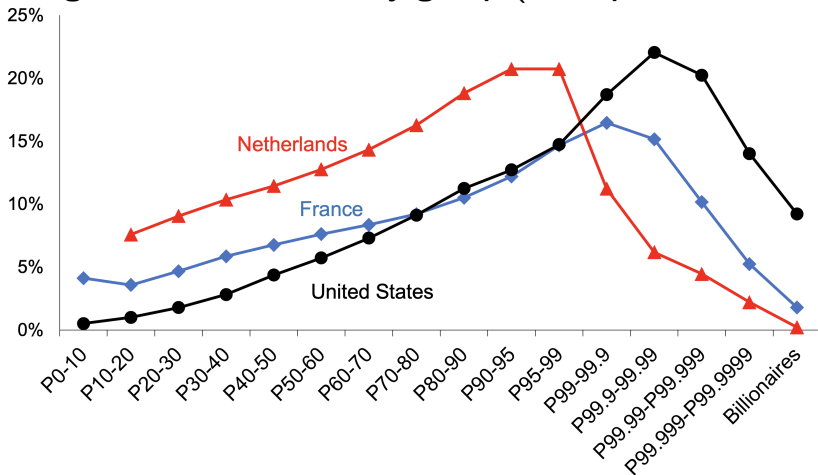
If $\tilde{R}(W) \nearrow$, and $\tau(W) \searrow$, we get explosive dynamics

Average tax rates by income group (% of pre-tax income)



Source. Zucman, 2024

Average income tax rates by group (% of pre-tax income)



Source. Zucman, 2024

The Idea of Justice (Sen, 2009)

Anne, Bob, and Carla, are fighting over a flute

The Idea of Justice (Sen, 2009)

Anne, Bob, and Carla, are fighting over a flute

- Anne is the only one who can play it
- Bob doesn't have any toys
- Carla made the flute with her own hands

The Idea of Justice (Sen, 2009)

Anne, Bob, and Carla, are fighting over a flute

- Anne is the only one who can play it
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- Carla made the flute with her own hands

Each argument is individually compelling, yet they can be contradictory (Utilitarian, egalitarian, and libertarian).

Finding moral common ground

Some degree of inequality is desirable

- Remuneration of hard work seems natural
- Different individuals have different needs

Some kinds of equality are fundamental

- We are all equal in dignity and before the law
- Smaller groups tend to distribute equally

Equality of opportunity

- Compelling idea to most of the political spectrum
- We all want to see a fair race

Mobility and opportunity

The concept of social mobility

The prospect of upward mobility

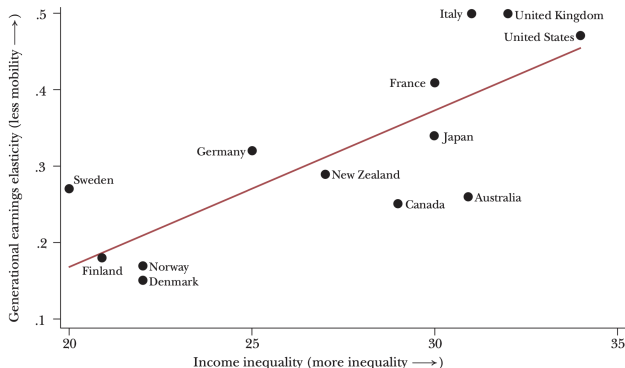
- Higher inequality would me more bearable in the prospect of moving up the ladder (Benabou and Ok, 2001)
- Good news: we can measure this prospect

Intergenerational earnings elasticity (β)

$$\ln(Y_{i,t}) = \alpha + \beta \ln(Y_{i,t-1}) + \epsilon_i,$$

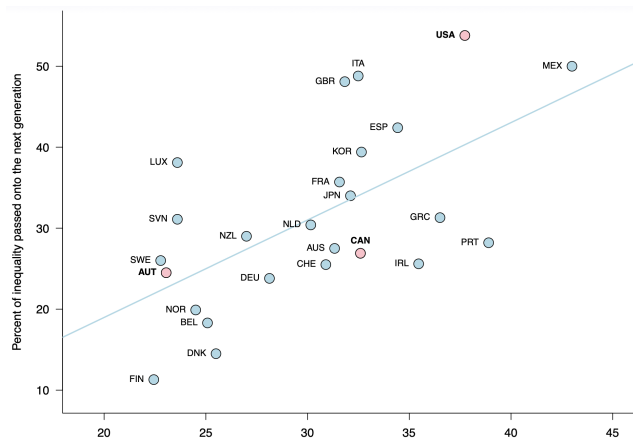
- Y are the earnings of family i across generations t and $t - 1$

The great Gatsby curve



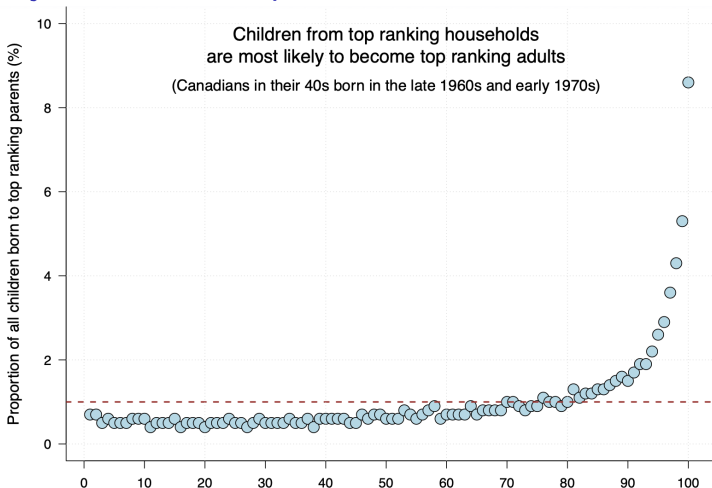
- **Notes.** Higher inequality is associated with lower inter-generational mobility (a lesser prospect of moving up the ladder) in a cross country perspective. Source: Corak (2013)

The Great Gatsby curve (updated)



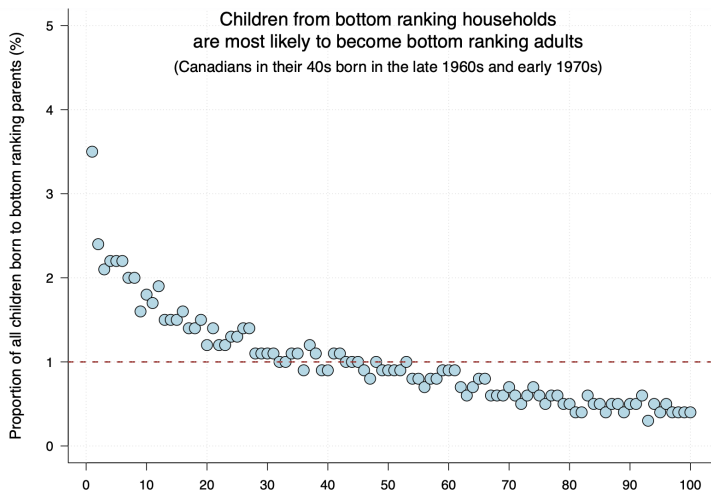
- **Notes.** After collecting more estimates of earnings elasticity, which are work and data intensive, the relation holds. Source: Corak (2013) updated by the author.

Mobility from the top 1%



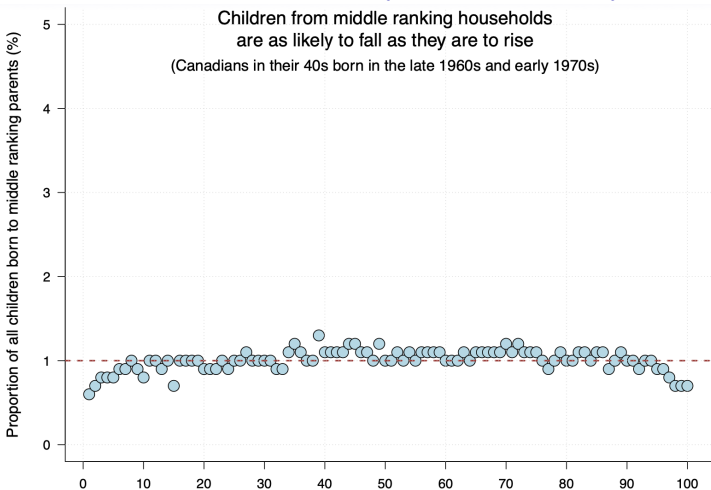
- **Notes.** The top tail of the distribution is very 'sticky'. Children from rich families are most likely to fall in very similar ranks than their parents, they are also very unlikely to fall elsewhere (Corak, 2022).

Mobility from the bottom 5% (Corak, 2022)



- **Notes.** The bottom tail of the distribution is also sticky, even in a country like Canada. Source: Corak, 2022.

Mobility from the median (Corak, 2022)



- There is greater mobility in the middle, which could also be interpreted as instabile or uncertain. A kid with median income parents can end up almost anywhere in the distribution.

Why are the tails so sticky?

Determinants

- Family (heritage, education, skills, networks), institutions (tax system, public education), market dynamics
- Economic connectedness (Chetty et al., 2022a; Chetty et al., 2022b)

Is mobility desirable per se?

- Random mobility is not the goal
- Work ethic and skill can be transmitted through generations

Can you measure inequality of opportunity?

Inequality of opportunity

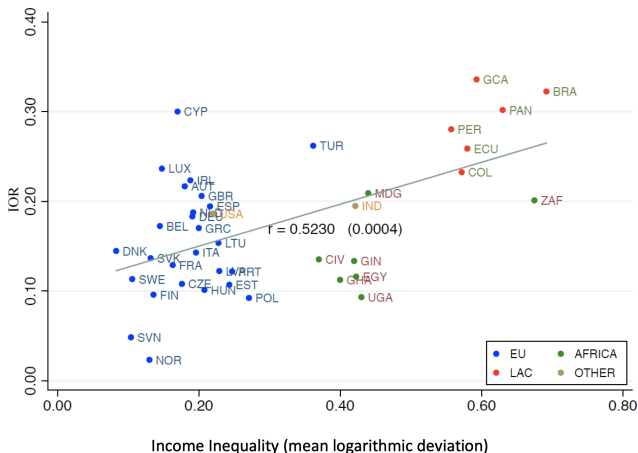
Isolating the effect of involuntary factors

- Individual i has an outcome (i.e., income, education, health):

$$y_i = f(C_i, E_i, \epsilon_i)$$

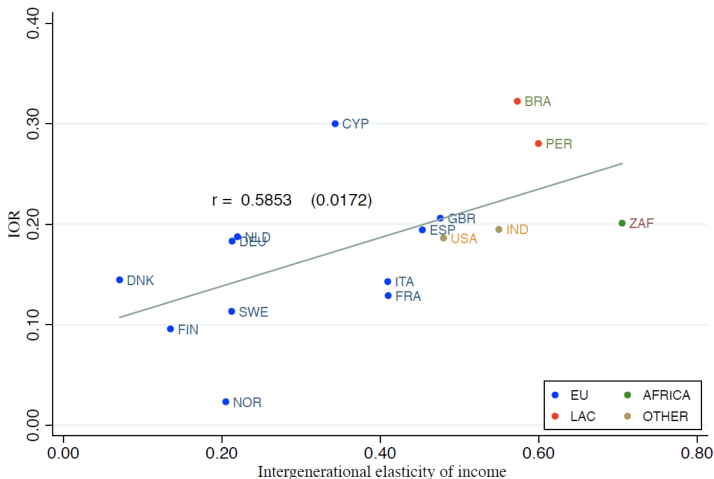
- C_i are individual sets of circumstances (family background, ethnicity, gender, birthplace), E_i is effort (years of schooling, work hours), and ϵ_i is luck
- What is not captured by C_i is attributed to effort, which is affected by circumstances, so the effect of C_i is often considered a lower bound (Ferreira and Gignoux, 2011), but there might be contradicting effects (Roemer and Trannoy, 2016)
- Identification is tricky, several sources of endogeneity.

Inequality of opportunity and income inequality



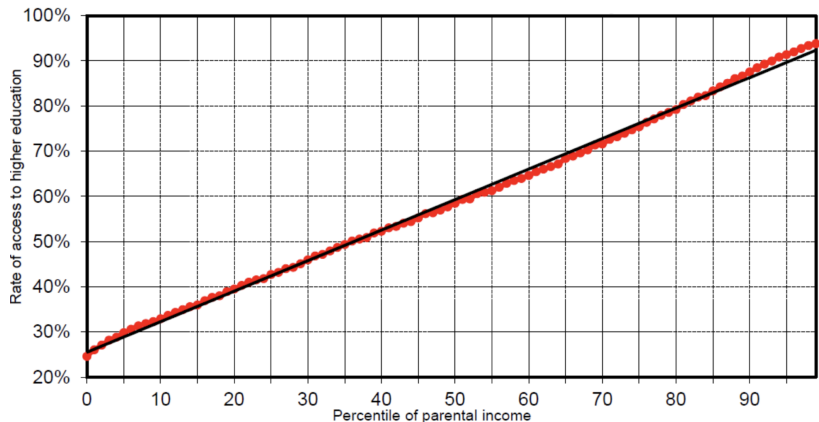
- **Notes.** Despite data limitations, inequality of opportunity can be approximated and summarized into an index (the part of the distribution explained by involuntary factors), which is tightly correlated with overall income inequality. Source: Brunori, Ferreira, and Peragine, 2013

Inequality of opportunity and social mobility



- **Notes.** Measured inequality of opportunity is also tightly correlated with inter-generational elasticity of income. Source: Brunori, Ferreira, and Peragine, 2013

Inequality in access to education, US 2014



- **Notes.** In the United States, administrative data on income tax declarations allows studying families over generations. Only 25% of the children of parents in the first centile access higher education, while over 90% of the children in the top centiles access it. Source: Chetty et al., 2020

Top income shares vs poverty rates

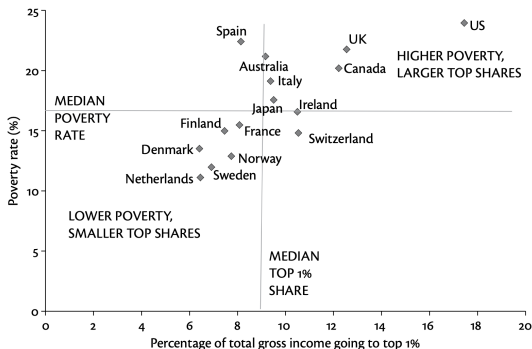


FIGURE 1.4: Poverty and top income shares in selected countries, c. 2010

In the US in 2010 the relative poverty rate (percentage living on incomes below 60 per cent of the median) was 24.7%, and the share of total gross income going to the top 1% (excluding capital gains) was 17.5%.

- **Notes.** Poverty rates are positively correlated with top income shares, suggesting that what happens at the top might not be independent from what happens at the bottom. Source: Atkinson, 2015

Today's outcomes are tomorrow's opportunities

We should not ignore events “after the gun is fired”

- Strong link between outcomes, mobility and opportunity
- Some runners might trip and fall into poverty
- We want a fair race because prizes are unequal, yet the prize structure is largely a social construct

Other instrumental concerns

- Inequality is tightly linked to lack of social cohesion, increased crime, ill-health, teenage pregnancy, obesity, and a whole range of social problems (Wilkinson and Pickett, 2010; Stiglitz, 2012)

...This gives us a direction of change

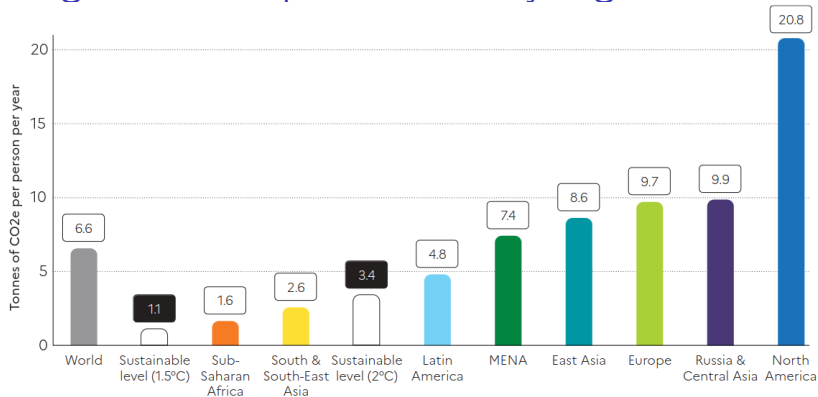
Climate justice

Income, consumption and the carbon footprint

The elasticity of the carbon footprint w.r.t income

- When incomes increase, consumption tends to increase too, although not linearly (diminishing propensity to consume)
- Consumption-related emissions are thus linked to inequality
- The footprint-to-income elasticity is < 1 (Pottier, 2022)

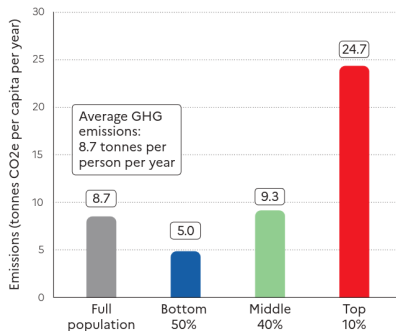
Average carbon eq. emissions by region, 2019



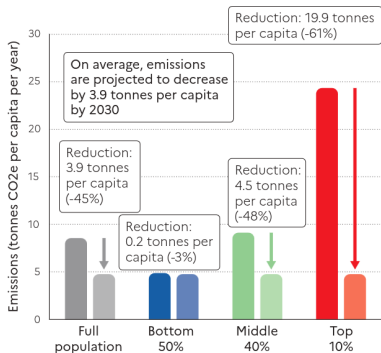
- **Notes.** Average emission-levels across regions are distributed very similarly to income. Sustainability levels call for drastic reductions in emissions, but who should reduce and at what rate? Values include emissions from domestic consumption, public and private investments as well as imports and exports. Sustainable level correspond to an egalitarian distribution of the remaining carbon budget until 2050. Source: The world inequality report 2022.

Who has the right to pollute?

Per capita emissions by income group in France,
2019 estimates



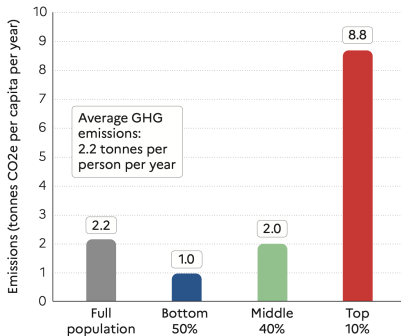
Emissions reduction requirement
to meet Paris Agreement 2030 targets in France



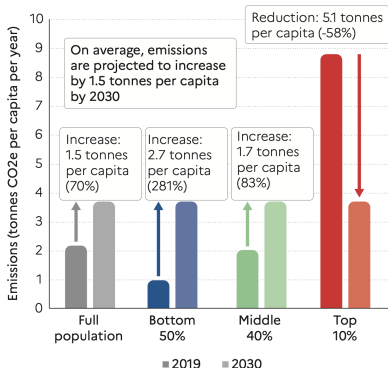
- **Notes.** In France, the 2030 agreement imposes a reduction of 45% in national emissions. Who should bear that weight? Everyone at the same proportion? What about the bottom 50%, who is already close to the target, should they make an effort?

Is progressive taxation part of climate justice?

Per capita emissions by income group in India,
2019 estimates



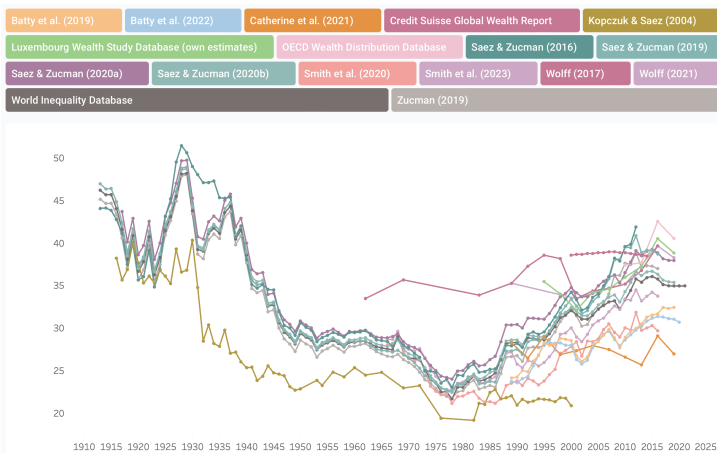
Emissions reduction requirement
to meet Paris Agreement 2030 targets in India



- **Notes.** In India, the 2030 target leaves room for an increase of emissions, since the national level is internationally low and living standards have room for improvement. But what about the top 10%, causing emissions comparable to the French middle class?

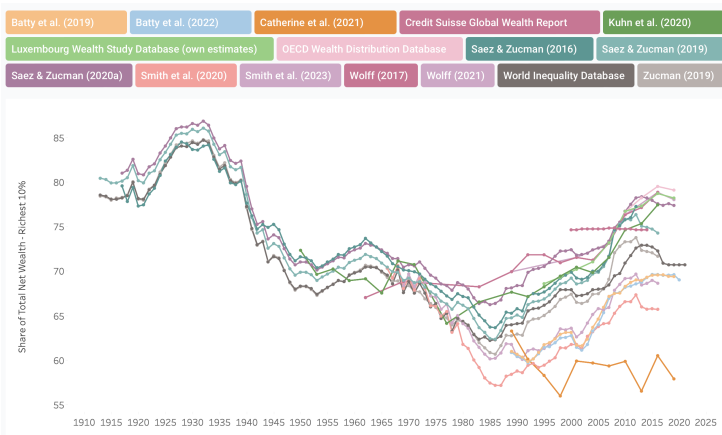
Methodological considerations

What is the true level of inequality? The top 1%



Notes: All the series in this graph estimate the same statistical object, the top 1% share of income. What explains the apparent diversity? Source: The GC Wealth Project (<https://wealthproject.gc.cuny.edu>)

What is the true level of inequality? The top 10%



Notes. Sources, methods and assumptions matter. More details on this later, but keep in mind to always acknowledge sources. Source: The GC Wealth Project (<https://wealthproject.gc.cuny.edu>)

Inequality of what?

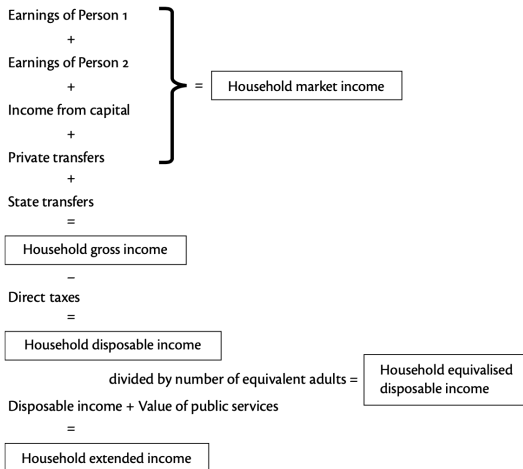
Types of Income

- Definition varies by source (surveys, administrative data, national accounts).
- Pre or post tax, including or including in kind spending? Social security contributions?
- Composition matters (e.g., wage income, mixed income, property income, social transfers, pensions, undistributed profits, imputed rents).

Type of Wealth

- Wealth (Book Value vs. Market Value)
- Including or excluding pension assets

Decomposing household income



Inequality among whom?

Measurement units

- What reference population? Total population, adults, economically active, Households.
- Within household assumptions: per capita, equal distribution among adults, per adult-equivalent, equal distribution between partners.
- Factoral Distribution of Income (Capital vs. Labour)

How to summarize a distribution

Inequality indices must satisfy conditions

- Anonymity, invariant to proportional transformation of income or population, Pigou-Dalton transfer principle

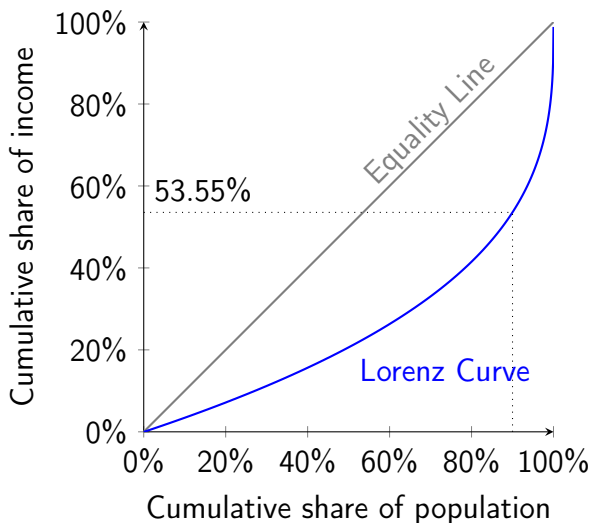
Implicit well-being functions (Atkinson, 1970)

- Gini (more weight to middle incomes), Atkinson (parametric), S.D.(linear), S.D logs (concave)

Concentration and dispersion

- Top Shares (10%, 1%, 0.1%, 0.01%)
- D9/D1

The Swiss knife of inequality measurement



We need good measurement

- For a long time, discussions on these topics were mostly theoretical and inconclusive.
- Good data helps avoid ideological debates and study causes and consequences of inequality, which are fundamental to understand and make judgements on current situations

The challenge of measurement

Contents of section 3

3. The challenge of measurement

3.1 The mathematics of extreme events

- The essence of power laws
- The fractal nature of power laws
- Pareto's version of a power law

3.2 Sources of information

- National Accounting
- Households surveys
- Administrative data

3.3 The inequality toolbox

- Pareto interpolations
- Microdata combination

3.4 Measuring national wealth

- Taking stock: aggregate wealth
- Direct and indirect measurement methods

The mathematics of extreme events

Modelling extreme events

Many models assume that random variables behave normally:

$$X \sim \mathcal{N}(\mu, \sigma^2).$$

- Extreme deviations from the mean are unlikely.
- Averages stabilize with growing samples (LLN).

But many natural and social systems behave very differently:

$$P(X > x) \propto x^{-\alpha}.$$

- Where a small number of observations can dominate totals.
- And the mean or variance may not even exist.

Power laws describe such systems.

Power Laws in Nature (I): Biology & Ecology

Kleiber's Law (Metabolism).

Metabolic rate scales with body mass across species. This pattern is often linked to the fractal structure of vascular networks and resource distribution. (Kleiber, 1932; West, Brown, and Enquist, 1997)

Forest Patch Sizes.

The distribution of forest patch areas and fire sizes follows a heavy-tailed pattern. (Malamud, Morein, and Turcotte, 1998)

Power Laws in Nature (II): Earth & Space

Earthquakes (Gutenberg–Richter Law).

The frequency of earthquakes declines as a power of their magnitude: large events are rare but far more common than under thin-tailed models. (Gutenberg and Richter, 1944)

Initial Mass Function of Stars (Salpeter IMF).

The masses of newly formed stars follow a power-law tail, with a small number of very massive stars contributing disproportionately to total stellar mass. (Salpeter, 1955)

Power Laws in Society

City Size Distributions (Zipf's Law).

City sizes follows a Zipf law. This regularity appears across many countries and time periods. (Zipf, 1949)

Firm Sizes.

Firm employment and sales exhibit a Pareto-like upper tail. (Axtell, 2001)

Income and Wealth Distributions.

The upper tails of income and wealth follow Pareto laws: a small fraction of individuals holds a large share of aggregate resources. (Pareto, 1897; Gabaix, 2009; Benhabib, Bisin, and Zhu, 2011)

Power Laws and Fractals

If a system has no characteristic scale (self-similar), then many observables must transform in a simple multiplicative way (Mandelbrot, 1982). This leads to relationships of the form

$$P(X > x) \propto x^{-\alpha},$$

Fractals describe the *geometry* of self-similar structures; power laws describe the *statistics* of their sizes and events.

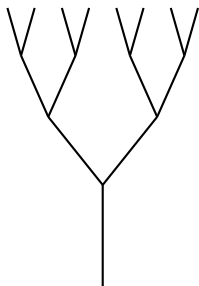
Power Laws and Fractals

Self-similarity.

Fractals are objects that look “similar” at different magnifications: zooming in reveals structures that resemble the whole.

Scale invariance and power laws.

In scale-free systems, there is no characteristic size: rescaling distances simply multiplies observables by a constant factor.



A simple fractal-like tree: zooming in repeats the same pattern.

Defining power laws

A power law is a functional relationship of the form:

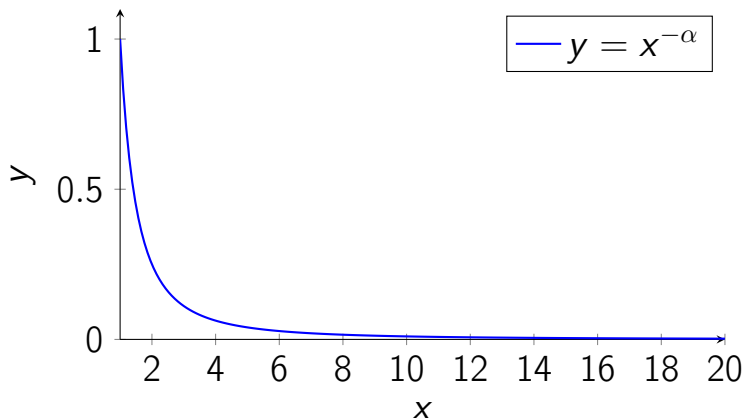
$$y = Cx^{-\alpha}, \quad C > 0, \alpha > 0.$$

Taking logarithms:

$$\log y = \log C - \alpha \log x,$$

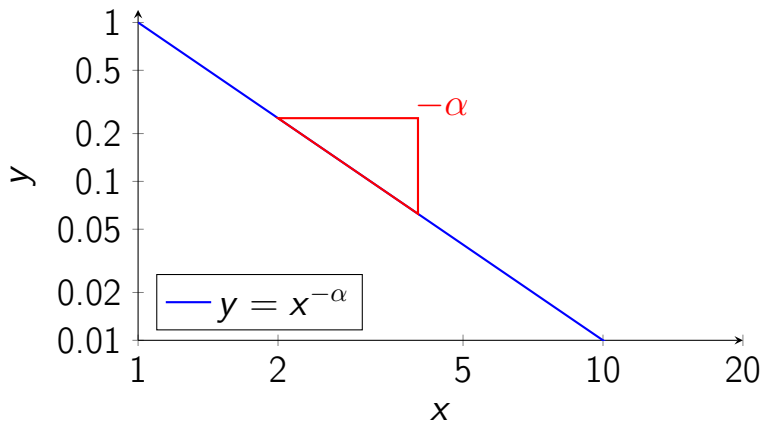
which is a straight line on log-log scales.

Power laws on linear scale ($\alpha = 2$)



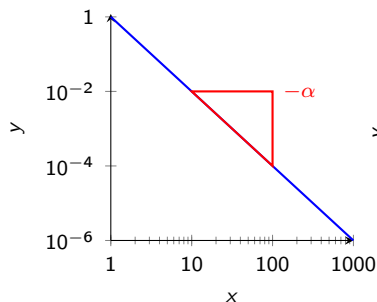
Power laws decay slowly: the tail remains thick for large x .

Power laws on log-log scale ($\alpha = 2$)

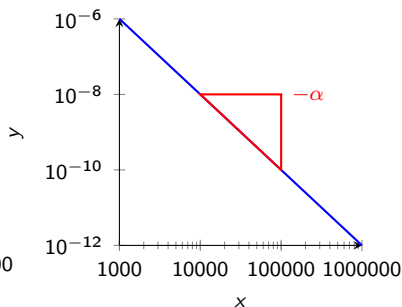


It becomes straight in logarithmic coordinates.

Power laws are fractal in nature (self-similarity)



Global view (1 to 10^6)



Zoom on the tail

A power law is scale-free: zooming in preserves its shape.

Pareto's version of a power law

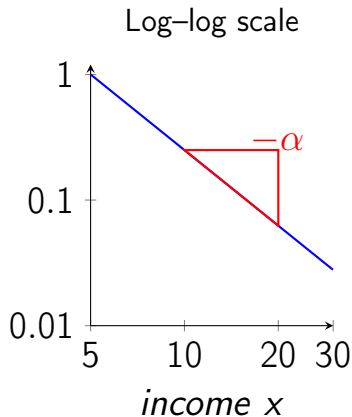
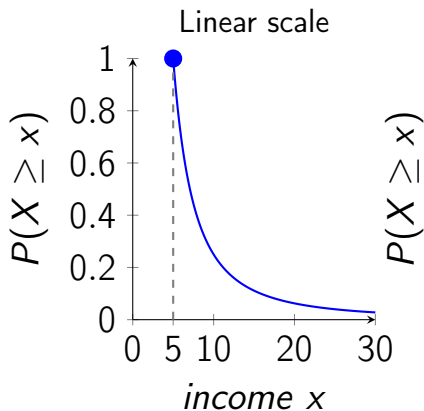
- Pareto, 1897: the upper tail of income follows a power law.
- He expressed this through the survival function (complementary CDF). Defining the fraction of people who earn at least x as:

$$P(X \geq x) = \left(\frac{x_{\min}}{x} \right)^{\alpha}, \quad x \geq x_{\min}, \alpha > 0.$$

This is a direct application of the power-law form:

$$P(X \geq x) = Cx^{-\alpha}, \quad C = x_{\min}^{\alpha}.$$

Example ($\alpha = -2$, $x_{min} = 5$)



In the Pareto distribution, the constant C becomes x_{min}^α , with the α exponent ensuring $P = 1$ at $x = x_{min}$, effectively shifting the distribution across incomes.

The Pareto Distribution

Moments:

$$\mathbb{E}[X] = \begin{cases} \frac{\alpha x_{\min}}{\alpha-1}, & \alpha > 1, \\ \text{undefined}, & \alpha \leq 1, \end{cases}$$

$$\text{Var}(X) = \begin{cases} \frac{\alpha x_{\min}^2}{(\alpha-1)^2(\alpha-2)}, & \alpha > 2, \\ \text{infinite}, & 1 < \alpha \leq 2. \end{cases}$$

Thus:

- Mean exists only if $\alpha > 1$.
- Variance exists only if $\alpha > 2$.

Sources of information

Making sense of contradicting sources

- **Observation:** Large discrepancies across sources (trends, levels, compositions)
- **Problem:** Can we make meaningful comments on the inequality-growth relation if we only capture a fraction of growth?
- **Challenge:** Find a way to use the strengths of each source to compensate for the weaknesses of others

National Accounts

Pros

- The main reference for macroeconomic statistics
- Accounts for the whole economy and its sectors
- Multiple sources consistently combined
- International standard

Cons

- Only reports aggregates, no granular distribution (yet)
- The level of detail is often lower in developing countries

The distribution of primary income, Households

Uses			Resources		
		B2n	Operating surplus, net		69
		B3n	Mixed income, net		53
D4	Property income	41	D1	Compensation of employees	1154
D41	Interest	14	D11	Wages and salaries	954
D45	Rents	27	D12	Employers' social contributions	200
			D4	Property income	126
			D41	Interest	14
			D42	Distributed income of corporations	20
			D43	Reinvested earnings on foreign direct investment	3
			D44	Other investment income	30
			D441	Investment income attributable to insurance policyholders	20
			D442	Investment income payable on pension entitlements	8
			D443	Investment income attributable to collective investment fund share holders	2
			D45	Rents	21
				Income from offshore tax havens	3
B5n	Primary income, net	1361			

- **Notes.** Each sector's resources are recorded at the right hand. They follow the sequence from income generation to savings and capital formation.

Source adapted from the SNA 2008

The secondary distribution of income

Uses			Resources		
		B5n		Primary income, net	1361
D5	Current taxes on income, wealth, etc.	178	D62	Social benefits other than social transfers in kind	384
D61	Net social contributions	333	D621	Social security benefits in cash	53
D611	Employers' actual social contributions	181	D6211	Social security pension benefits	45
D6111	Employers' actual pension contributions	168	D6212	Social security non-pension benefits in cash	8
D6112	Employers' actual non-pension contributions	13	D622	Other social insurance benefits	279
D612	Employers' imputed social contributions	19	D6221	Other social insurance pension benefits	250
D6121	Employers' imputed pension contributions	18	D6222	Other social insurance non-pension benefits	29
D6122	Employers' imputed non-pension contributions	1	D623	Social assistance benefits in cash	52
D613	Households' actual social contributions	129			
D6131	Households' actual pension contributions	115			
D6132	Households' actual non-pension contributions	14			
D614	Households' social contribution supplements	10			
D6141	Households' pension contribution supplements	8			
D6142	Households' non-pension contribution supplements	2			
B6n+D7	Secondary income, net	1234			

- **Notes.** Income taxes, contributions and social transfers are recorded at this stage. Source adapted from the SNA 2008

Household surveys

Pros

- Rich micro-level source with an array of variables
- Less than 1 pct of the population sampled
- Comparability increased over time, since 1960s
- Harmonized sources available (EU-SILC, LIS, WIID)
- Somewhat captures the informal economy

Cons

- Subject to both sampling and non-sampling biases
- Captures a fraction of national income at best

Household survey limitations

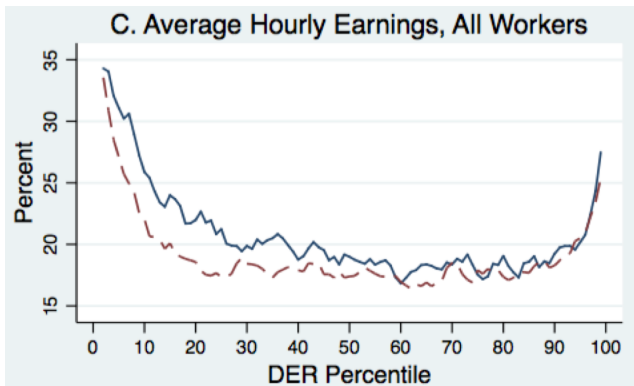
Sampling

- ▶ Small sample bias (Taleb and Douady, 2015)

Non-Sampling

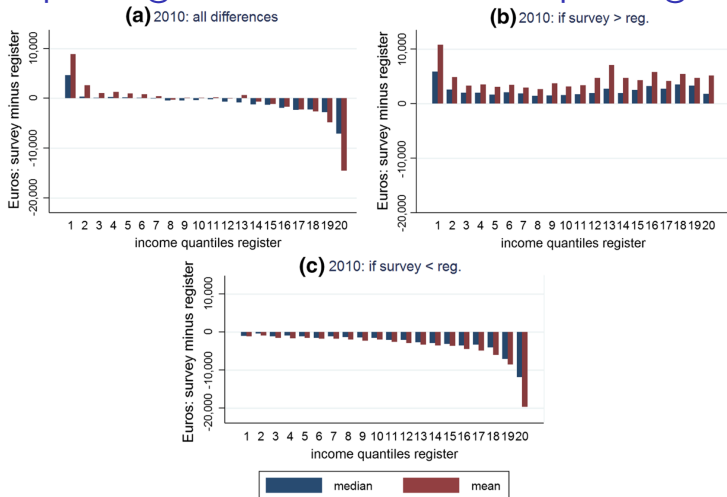
- ▶ Misreporting (Bound and Krueger, 1991; Bollinger, 1998; Paulus, 2015; Angel, Heuberger, and Lamei, 2018)
- ▶ Heterogeneous response rates across the income distribution (Korinek, Mistiaen, and Ravallion, 2006; Johansson and Klevmarken, 2007; Bollinger et al., 2014; Chenevert, Klee, and Wilkin, 2016)

U-shaped nonresponse



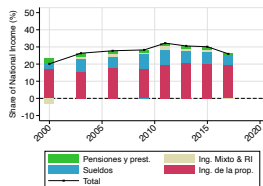
- **Notes.** Men are in blue and women in red. (Bollinger et al., 2019). Compares declared incomes in the CPS and Social Security records in the US. Accounting for 1/3-1/2 of the measured gap in inequality

Over-reporting bottom and under-reporting top

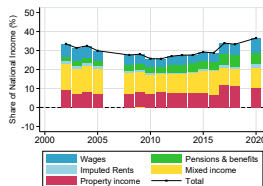


- **Notes.** Misreporting is mean reverting but non deterministic. Austrian SILC (survey), individually matched to income tax declarations. Source: Angel, Heuberger, and Lamei, 2018

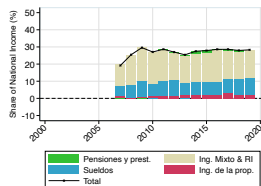
Aggregate income under-coverage in surveys



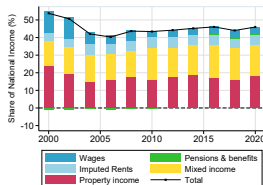
(a) Chile



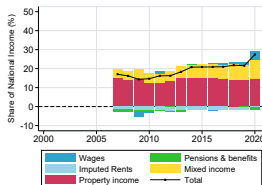
(b) Colombia



(c) Ecuador



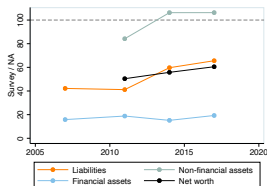
(d) México



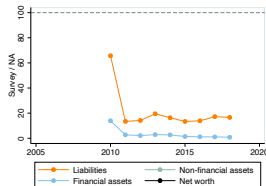
(e) Perú

- **Notes.** Comparing Latin American surveys to national accounts aggregates unveils large gaps, especially in capital income measurement, which are particularly relevant for inequality analysis. Source: Alvaredo et al. (2022)

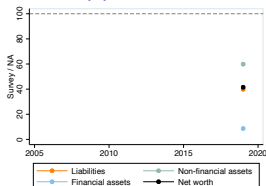
Aggregate wealth survey under-coverage



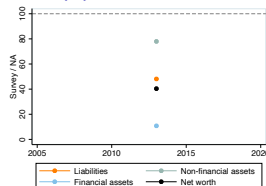
(f) Chile



(g) Colombia



(h) Mexico



(i) Uruguay

- **Notes.** A similar phenomenon is observed in wealth surveys, where gaps are even larger. Financial wealth is measured with the largest discrepancy across sources. Source: Carranza, De Rosa, and Flores (2023)

Administrative data (1/2)

Pros

- Used historically to estimate income proportions of affluent groups (Pareto, 1896; Kuznets and Jenks, 1953; Atkinson and Harrison, 1978, Alvaredo et al., 2013)
- High time coverage, and precision at the very top
- Direct measurements from the universe, rarely sampled
- Enforced by law

Cons

- Limited population coverage in developing countries and in historical series
- Changes in the tax code can influence measurement
- Economic incentives to under-declare

Administrative data (2/2)

Practical considerations

- Tax return information is confidential, with strict security.
- Data aggregation is common to protect individual privacy.
- Interpolation techniques are needed.

Applications in Developing Countries

- They rarely provide complete population coverage.
- Research focuses on estimating top income shares.
- Methodological challenge: low coverage and large informality.
- Importance of publishing data for greater fiscal transparency.

Brazilian administrative data

Figure: Brazilian income tax declarations - 2020 - tabulated format



Tabela 9 - Resumo das Declarações Por Faixa de Rendimentos Totais (em salários-mínimos)

Valores em R\$ milhões

Faixa SM Mensal	Qtde Declarantes	Rendim. Tribut.	Rendim. Tribut. Exclús.	Rendim. Isentos	Imposto Devido	Dedução de Incentivo	Imposto Devido 1	Imposto a Pagar	Doações Efetuadas
Até 1/2	1,604,246	1,110.77	146.77	263.62	0.02	0.00	0.02	0.01	957.11
De 1/2 a 1	578,381	4,975.59	242.51	699.00	0.15	0.00	0.15	0.08	184.88
De 1 a 2	2,755,245	43,655.42	1,623.49	6,499.02	1.13	0.00	1.13	0.61	562.12
De 2 a 3	5,014,845	135,856.84	8,796.73	15,271.23	404.80	0.00	404.80	83.86	872.45
De 3 a 5	8,262,962	322,633.21	26,223.85	54,106.30	6,348.92	0.43	6,348.49	1,014.70	1,783.86
De 5 a 7	4,316,910	245,948.76	22,023.01	50,870.07	12,338.48	1.73	12,336.75	1,923.85	1,759.58
De 7 a 10	3,219,144	249,138.21	24,438.66	62,356.49	22,211.34	5.88	22,205.47	3,468.77	31,466.02
De 10 a 15	2,526,189	269,857.80	29,508.51	85,199.97	35,293.13	18.76	35,274.37	4,368.64	2,858.15
De 15 a 20	1,167,190	165,207.33	20,683.24	66,463.50	26,005.52	23.44	25,982.07	2,616.15	2,245.76
De 20 a 30	1,073,869	197,198.67	28,396.73	100,128.29	34,473.24	44.63	34,428.62	2,954.61	3,728.53
De 30 a 40	462,066	110,538.55	18,533.01	70,142.24	20,747.34	37.83	20,709.51	1,698.10	28,512.49
De 40 a 60	340,832	94,559.36	21,735.02	88,543.26	18,465.74	41.61	18,424.13	1,764.24	8,756.65
De 60 a 80	117,987	35,199.37	12,391.79	53,803.75	7,119.31	18.50	7,100.81	896.25	97,696.69
De 80 a 160	122,641	42,143.33	21,567.30	102,302.42	8,894.52	25.53	8,868.98	1,487.84	5,081.24
De 160 a 240	30,762	13,990.22	10,278.35	50,327.53	3,038.27	11.36	3,026.91	682.28	3,046.41
De 240 a 320	13,567	7,779.53	7,135.74	31,942.87	1,710.26	7.54	1,702.72	422.01	1,915.07
Mais de 320	28,007	35,640.27	77,873.98	257,190.17	7,784.50	75.42	7,709.08	1,880.57	24,834.56
Total	31,634,843	1,975,433.24	331,598.71	1,096,109.71	204,836.68	312.66	204,524.02	25,262.58	216,261.57

- **Notes.** Observations are not accessible at the individual level (unless you work at the tax agency). The level of detail varies across countries and time, both in observations and in the composition of declared incomes/assets.

The inequality toolbox

A truncated distribution - Chilean tax data

Año Comercial	Tramo de Rentas	Consolidado			p	thr	bracketavg
		N° de Personas	Renta Determinada	Impuesto Determinado			
2019	Tramo 1 - 0 a 13,5 UTA (Exento)	7 749 288	23 169 595	9 861	0,45423	0	3139515
2019	Tramo 2 - 13,5 a 30 UTA (Tasa 4%)	1 761 945	20 501 037	252 113	0,859628	8038926	12209919
2019	Tramo 3 - 30 a 50 UTA (Tasa 8%)	499 887	11 301 031	383 221	0,951524	17864280	23729774
2019	Tramo 4 - 50 a 70 UTA (Tasa 13,5%)	183 369	6 412 004	374 275	0,977634	29773800	36805552
2019	Tramo 5 - 70 a 90 UTA (Tasa 23%)	89 156	4 189 123	369 942	0,987234	41683320	49826944
2019	Tramo 6 - 90 a 120 UTA (Tasa 30,4%)	67 326	4 133 703	537 303	0,991909	53592840	66006266
2019	Tramo 7 - Más de 120 UTA (Tasa 35%)	86 178	12 155 716	3 040 973	0,99544	71457120	1,56E+08

- **Notes.** Tabulations give precise estimates of cumulative densities at arbitrary points in the distribution. But how can we get a smooth Lorenz curve with that information?

Connecting the dots (1/3)

Simple Pareto Interpolation

- The Pareto distribution follows a power law density function.
- The shape parameter (α) defines the slope at the top.
- Higher α value suggests more equitable income distribution.
- Smooths income distributions with continuous estimates from aggregated data, allowing estimation at specific brackets.

Density Function

$$f(x) = \frac{\alpha x_0^\alpha}{x^{\alpha+1}}$$

- x_0 is the minimum value. α is the shape parameter.

Connecting the dots (2/3)

Cumulative Distribution Function

$$1 - F(x) = \left(\frac{x_0}{x}\right)^\alpha \quad \text{where } x_0 > 0, \alpha > 1$$

From Atkinson, Piketty, and Saez (2011):

- Constant relation between a value x and the average above it.

$$\frac{x^*(x)}{x} = \beta, \quad \text{where } \beta = \frac{\alpha}{\alpha - 1}$$

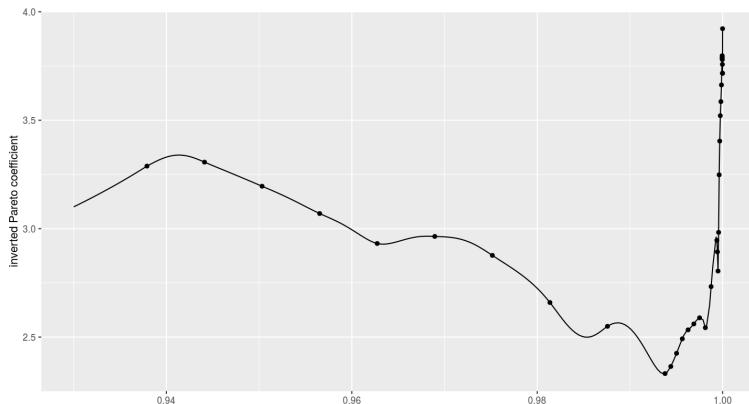
- β is an intuitive alternative to α .
- If $\beta = 2$, the average income above \$100,000 is \$200,000.

Connecting the dots (3/3)

Generalized Pareto interpolation (Blanchet, Fournier, and Piketty, 2022)

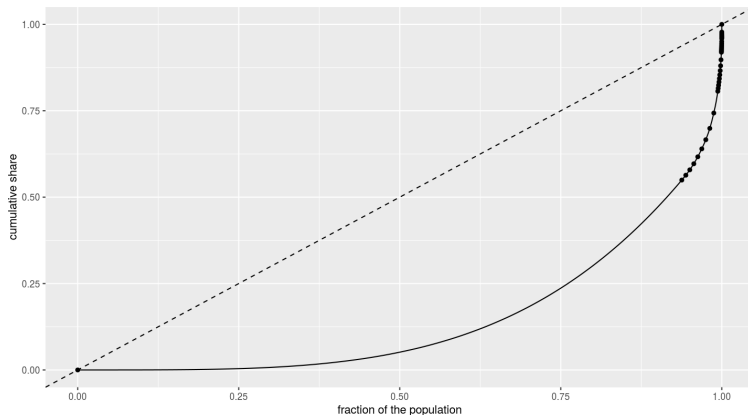
- Atkinson (2017) and Jenkins (2017) note potential inaccuracies with simple interpolations, especially with the lower bound selection.
- Key feature: Adjusts the β coefficient along the distribution.
- Captures heterogeneity more effectively.
- Tested with microdata from the US and France (1962-2014).
- Reduces error rate, especially at the top.

U-shaped Beta coefficients - Brazil 2000



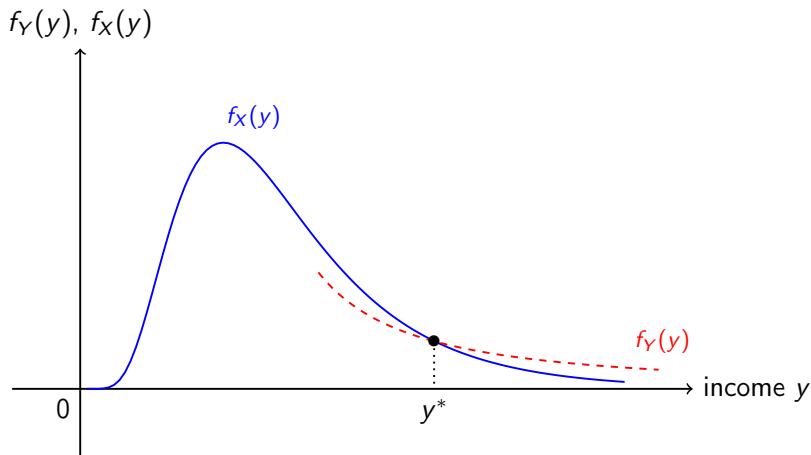
- **Notes.** A higher Beta coefficient implies higher inequality within a given bracket. When data are sufficiently detailed, the coefficients often increase sharply at the top

Interpolated Lorenz curve - Brazil 2000



- **Notes.** The top section of the Lorenz curve ($\approx$ top 10%) was successfully, by overlapping sections of Pareto distributions between actual observations of cumulative densities. Extrapolations are also possible, yet they rest on more acrobatic assumptions

Comparing sources: a stylized view



- **Notes.** The blue solid line represents the distribution in a household survey, theoretically covering the whole distribution (log-normal). The red dashed line represents the top tail of the distribution, as captured by income tax records (Pareto). Source: Blanchet, Flores, and Morgan, 2022

Understanding the differences: a formal approach

Non-Response

$$\triangleright f_Z(y) = f_Y(y)\theta(y) \Rightarrow \theta(y) = f_Z(y)/f_Y(y)$$

Misreporting

$$\triangleright f_Z(y) = f_Y(y)(1 - p(y)) + f_M(y)\bar{p}$$

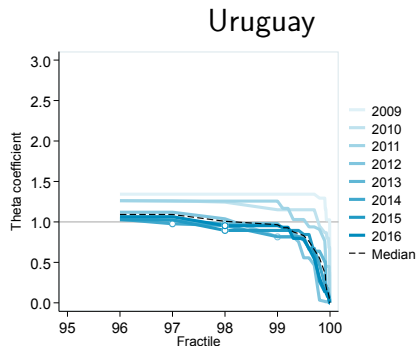
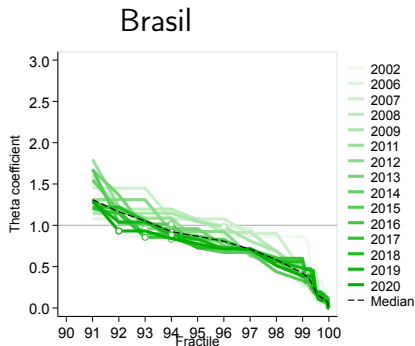
Non-Response & Misreporting

$$\triangleright f_Z(y)/f_Y(y) = \theta(y)(1 - p(y)) + f_M(y)/f_Y(y)\bar{p}$$

Conclusions

- ▶ If both biases exist, they are indistinguishable *ex-post*.
- ▶ Misreporting only can be solved by matching declarations at the individual level

The Θ coefficient



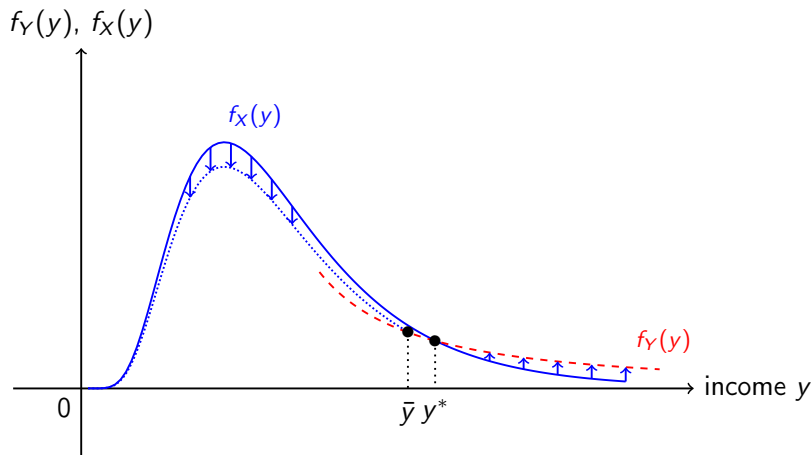
- **Notes.** θ coefficients measure the discrepancy of densities between surveys and a reference distribution. The underestimation of richer populations seems to aggravate with time (more examples in the paper). Source: De Rosa, Flores, and Morgan, 2022

The BFM approach: theoretical requirements

Two assumptions

- Income tax declarations are a lower bound of frequencies
- We can trust self declared items in the survey

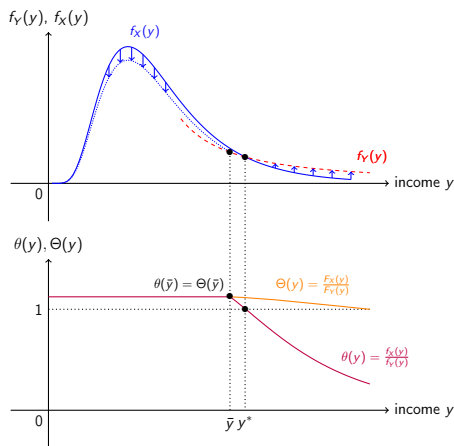
The BFM approach: Intuition (1/2)



- **Notes.** The adjustment consists in adjusting the weights of observations with income $> \bar{y}$ to fit the red dashed line. Observations below that point will be lowered proportionally to keep the total population unchanged.

Source: Blanchet, Flores, and Morgan, 2022

The BFM approach: Intuition (2/2)



- **Notes.** The merging point is defined in $\bar{y}$, not in y^* , to preserve the continuity of density functions. It is defined as the point where θ and Θ meet. Source: Blanchet, Flores, and Morgan, 2022

Survey calibration

- Traditional methodology (Deville and Särndal, 1992)
- Survey variable $x_1, \dots, x_n$, with *design weights* $d_1, \dots, d_n$
- We need a new set of weights $w_1, \dots, w_n$ consistent with totals from external sources:

$$\sum_{i=1}^n w_i x_i = T$$

- Condition: minimize the distance between original and adjusted weights:

$$\min_{w_1, \dots, w_n} \sum_{i=1}^n \frac{(w_i - d_i)^2}{d_i}$$

⇒ The solution is interpreted as a model of *non-response*.

Alternative methods

○ Reweighting

⇒ Korinek, Mistiaen, and Ravallion (2006); Hlasny and Verme (2017; 2018); Alvaredo (2011, for Argentina)...

○ Replacing

⇒ Burkhauser et al. (2016); Piketty, Yang, and Zucman (2017); Chancel and Piketty (2017); Czajka (2017); DWP (2015); Alvaredo (2011, for U.S.); Burkhauser et al. (2018); Jenkins (2017)...

○ Hybrids

⇒ Bourguignon (2018); Medeiros et al. (2018)

○ Optimal transport

⇒ Each observation from database A is matched one-to-one with an observation in another one, while minimizing the sum of distances over overlapping variables between matched observations. (Blanchet, Saez, and Zucman, 2022)

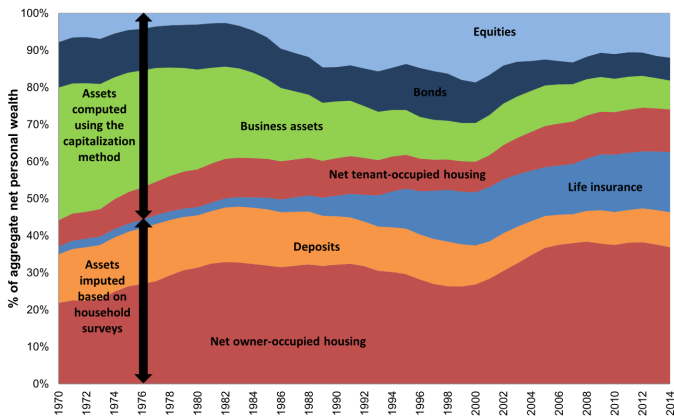
Measuring national wealth

The balance sheet

	Gross personal wealth	4689
AN, S14	Non-financial assets owned by households	1429
	<i>Housing assets of households</i>	1174
AN111, S14	<i>Dwellings owned by households</i>	681
AN2111, S14	<i>Land underlying dwellings owned by households</i>	493
	<i>Business and other non-financial assets of households</i>	255
AN2112, S14	<i>Agricultural land of households</i>	23
	<i>Other domestic capital of households</i>	232
AF, S14	Financial assets owned by households	3260
AF2+AF3+AF4+AF7+AF8, S14	<i>Currency, deposits, bonds and loans of households</i>	1120
AF5, S14	<i>Equity and investment fund shares of households</i>	1749
AF6, S14	<i>Life insurance and pension funds of households</i>	391
AF, S14	Minus: Liabilities of households	189
	Equals: Net personal wealth	4500

- **Notes.** As happens for income, wealth aggregates are also recorded in the national accounting system, this time as a stock instead of a flow. Data is much scarcer in developing countries, especially for non-financial wealth

Wealth composition in France 1970-2014



- **Notes.** Modern national accounting systems report long series with detailed compositions. In France, we can observe the surge of financialization since the 1980s. Equity, and life insurance increased as a share of personal wealth with respect to business assets. Land prices explain most of the surge of housing value. Source: Garbinti, Goupille-Lebret, and Piketty, 2021

Wealth distribution: direct methods

Wealth taxes

- Wealth taxes generate administrative data on individual wealth holding (Norway, Spain, Switzerland)
- Only a few countries have them, and most of those who have them have started dismantling them (France).
- The taxable population might be limited

Wealth surveys

- Subject to the same limitations than income surveys (tend to underestimate financial wealth), but they are less common
- In theory, they cover the whole population

Wealth distribution: indirect methods

Estate multiplier

- Uses inheritance data to study the wealth of the deceased
- Assumes dead population of a given year is a sample of the living. Weights are adjusted to represent different probabilities of dying, given socio-economic factors (i.e., age, gender).
- Might be sensitive to assumptions on randomness of mortality rates (conditional on demographics) and extreme cases

Capitalization method

- Uses capital income reported and information on asset-specific returns to compute the underlying asset behind the flow.
- Biased if taxable rates of return vary with wealth

Empirical insights on accumulation dynamics

Contents of section 4

4. Empirical insights on accumulation dynamics

4.1 Taxes and redistribution

- Tax incidence
- The role of redistribution

4.2 Financial assets and pensions

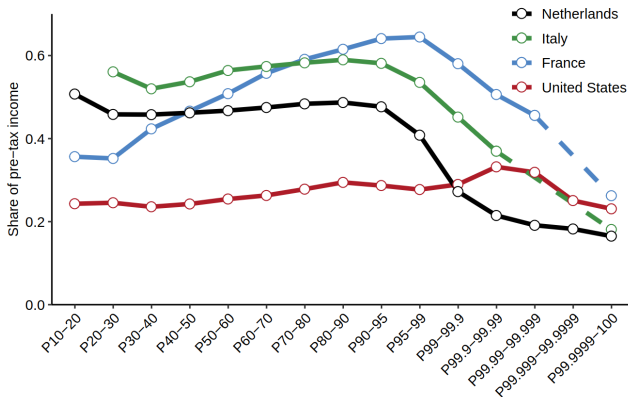
- Financial assets other than pensions
- Pension assets and augmented wealth

4.3 Non-financial assets

- Real estate
- Asset composition across the wealth distribution

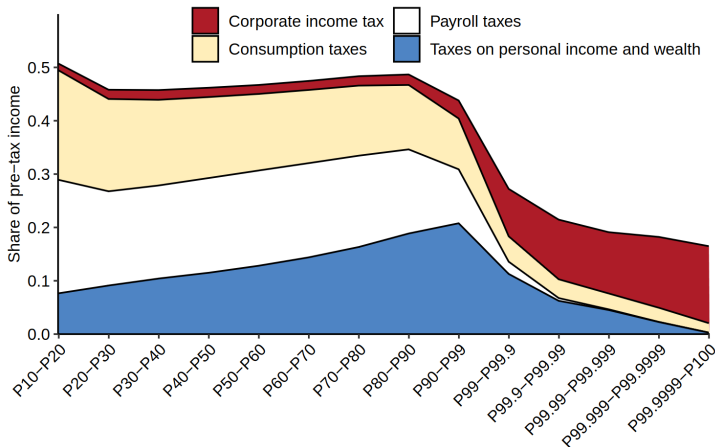
Taxes and redistribution

Regressive tax systems in Europe



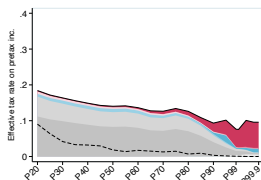
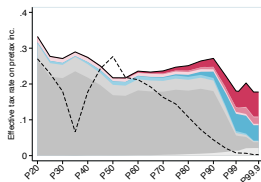
- **Notes.** Effective tax rates, divide all taxes paid (incl, PIT, CIT, Indirect taxation) and divide it by total income (incl. personal incomes and incomes retained in corporations). The often increase from the middle to the middle-high incomes, until they drop at the very top of the distribution. Source: Bruil et al., 2022

Zoom on the Netherlands 2016

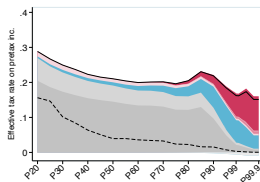


- **Notes.** Consumption taxes are more important for those with lower saving rates. Progressive taxation on personal income and the corporate income tax combined are not enough to render the system progressive. Source: Bruil et al., 2022

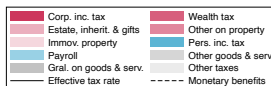
Similar patterns in the global south



(e) Mexico 2018



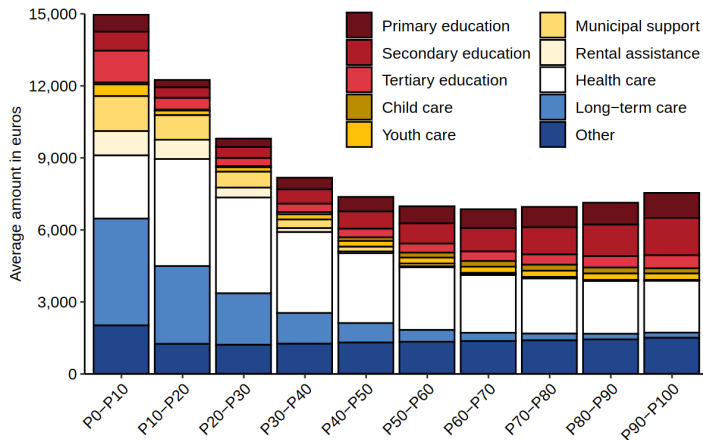
(d) Chile 2017



(f)

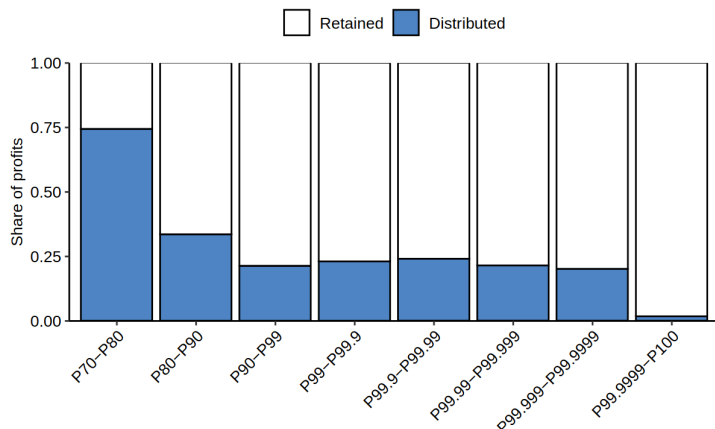
- **Notes.** Although tax levels are lower, the large reliance on indirect taxation in Latin America and tax exemptions result in regressive systems. Source: De Rosa, Flores, and Morgan (2022)

Zoom on in kind spending, Netherlands 2016



- **Notes.** Linked administrative sources allow for a careful incidence analysis of in kind spending. Here, it is mostly targeted to lower deciles. Source: Bruil et al., 2022

Retained vs. distributed profits



- **Notes.** Retained profits, as opposed to distributed profits, have become increasingly relevant worldwide. Profit retention is also more present in top rankings, likely for tax purposes. This also complicates wealth inequality estimates, such as those based on the capitalization method, which relies on distributed profits. Source: Bruil et al., 2022

Financial assets and pensions

Return rates differ substantially across households

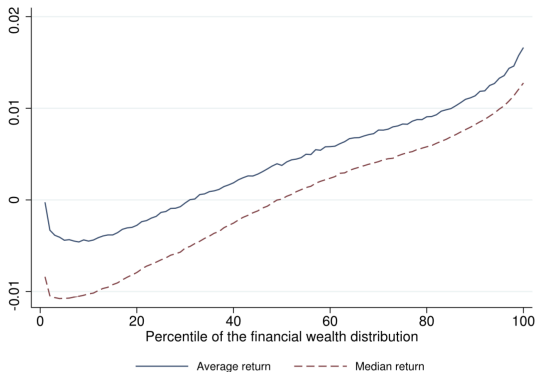


Figure: Fagereng et al., 2020 (Norwegian data)

- Positive correlation with wealth, differences can compound in time
- Gradient confirmed in other contexts (Smith, Zidar, and Zwick, 2023 for the US; Bach, Calvet, and Sodini, 2020 for Sweden)

Why might richer households earn higher returns?

The gradient is well documented, but what are the mechanisms?

Candidates:

- **Risk:** riskier portfolios earn higher expected returns.
- **Access:** reduced participation costs to high-yielding assets.
- **Skill/information:** some make better investment choices.
- **Entrepreneurship:** business can yield high returns.

Interpretation depends on modeling choices



Figure: Fagereng et al., 2020

- Fagereng et al. (2020) emphasize persistent heterogeneity in realized gains after controlling for risk, favoring skill/information
- Bach, Calvet, and Sodini (2020) uses risk modeling to argue that most of the gradient reflects *systemic* risk exposure ($\neq$ idiosyncratic)

Implications for inequality

For inequality dynamics

Faster wealth reproduction at the top accelerates wealth concentration.

- *"returns explain most of the historical increase in top wealth shares"* (Bach, Calvet, and Sodini, 2020)

For inequality measurement

- Wealth is often inferred by capitalizing income: $\widehat{W}_i = \frac{Y_i^K}{r}$.
- Return r is common within asset classes, so positive gradient overstates top wealth (Smith, Zidar, and Zwick, 2023).
- Yet, this do not eliminate the rise in US top wealth shares.

Pension funds and "augmented wealth"

Only privately owned pension funds are counted as private wealth in standard definitions. So depending on institutions, pension funds can be (*or not be*) part of the total

- Individual capitalization funds are tractable
- But entitlements in pay-as-you-go systems don't have a sock-counterpart
- This has distributional consequences and blurs comparisons

So should we include the capitalized present value of pension entitlements in household wealth?

Pension funds and rights matter quantitatively

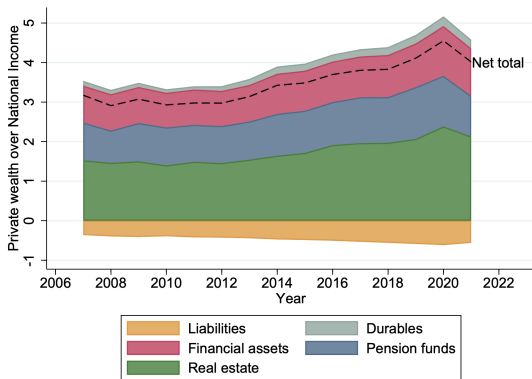
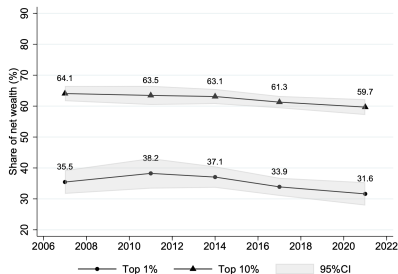


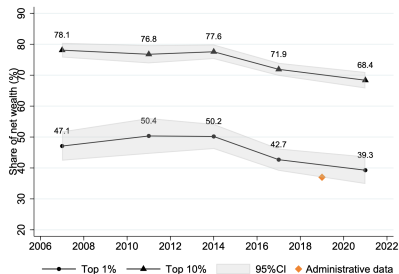
Figure: From Nofal, Flores, and Cubillos, 2026

- In Chile (fully privatized system), pension funds $\approx 1/4$ of national assets, nearly as much as other financial assets.

Wealth inequality with and without pensions



(a) Including pension funds



(b) Excluding pension funds

Figure: Nofal, Flores, and Cubillos, 2026 (Chilean data)

- o Including pensions funds from top means a difference in the top 10% wealth share of 18 points in the latest year

Distributional consequences of augmented wealth

- Pension wealth is usually more equally distributed than marketable wealth, reducing measured wealth inequality.
- Augmented wealth adjustments –including health and pension– typically lower measured inequality (Feldstein, 1976; Wolff, 1996; Davies and Shorrocks, 2000)

Change in wealth Gini (2013)

Country	Net wealth	Augmented wealth	Difference
United States	0.892	0.701	-0.191
Germany	0.765	0.511	-0.254

Source: Bönke et al., 2020, augmented wealth includes the present value of pension entitlements in this case

Augmented measurement challenges

Estimating the present value of future benefits requires assumptions about:

- retirement age;
- survival probabilities (mortality heterogeneity);
- real discount rates (very sensitive);
- future earnings and contribution histories;
- pension rules;

Also, should we count entitlements accumulated so far, or expected entitlements too?

Consequences for inequality

For inequality measurement

- Institutional choices matter for measurement
- Conceptual distinctions are not always sharp
- International comparisons must be done with attention to detail
- Pension systems are generally great equalizers

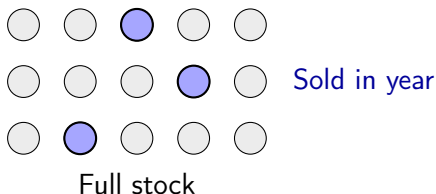
For conceptual debates

○

Non-financial assets

The problem of stock valuation at market prices

- We want to **value the entire stock of assets** (e.g. housing, unlisted firms).
- But market prices are only directly observed when assets are sold.
- In any period, **sales are only a fraction** of the universe.
- Moreover, sales are not representative of the full stock.



Hedonic pricing as the bridge

- Goods are bundles of characteristics. For housing, for example:

$$z_i = (\text{size}_i, \text{location}_i, \text{amenities}_i, \dots)$$

- The market maps each bundle of characteristics into a price:

$$p_i = p(z_i)$$

- So the price is not only the price of the house as a unit; it embeds the market valuation of its attributes (Rosen, 1974)

Implicit prices and the hedonic gradient

- The marginal implicit price of characteristic z_k is the derivative of the hedonic price function:

$$p_k(z) = \frac{\partial p(z)}{\partial z_k}$$

which is the market price of a marginal increase in characteristic k , holding other characteristics fixed.

- The hedonic function is an **equilibrium price schedule**.
- The slope of the hedonic price function equals the marginal willingness to pay of the marginal household (Rosen, 1974).
- So the hedonic price function is not simply a statistical association. It aims to measure the observed equilibrium.

Empirical implementation

- A typical empirical hedonic specification is:

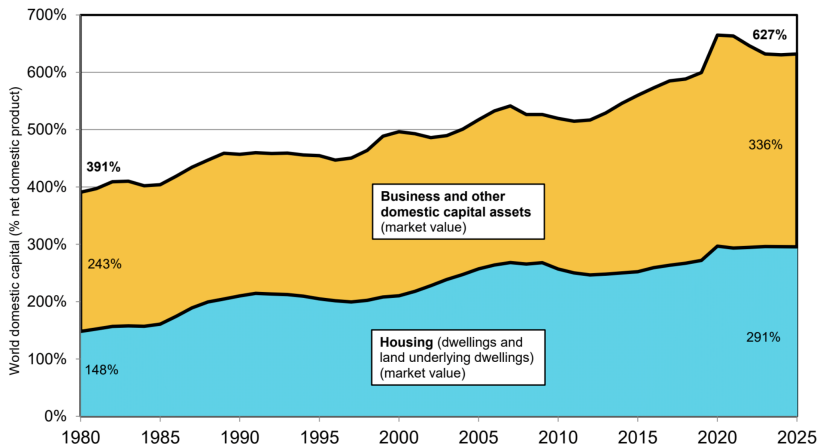
$$\log p_i = \alpha + \beta_1 \log(\text{size}_i) + \beta_2 \text{pollution}_i + \beta_3 \text{distance}_i + X_i' \gamma + \varepsilon_i$$

- X_i includes other housing, and location controls, for example:

$$X_i = (\text{rooms}_i, \text{age}_i, \text{floor}_i, \text{school quality}_i, \text{municipality}, \text{year})$$

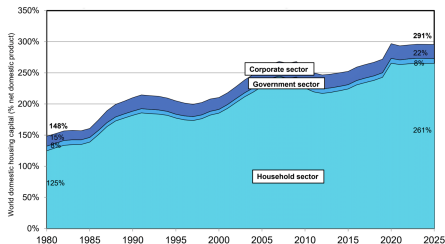
- Implementation decisions matter: functional form, controls, interactions, fixed effects, and omitted variables

The world capital stock 1980-2025

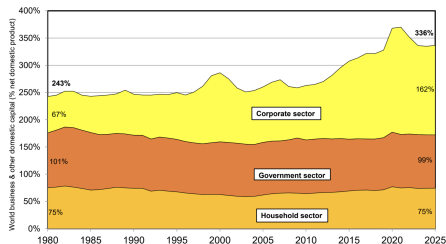


- Despite measurement challenges and assumptions, the global wealth to income ratio seems to rise remarkably between 1980-2025, from 391% to 627% (Bauluz et al., 2025).

Both housing and business assets increased



(a) Domestic housing capital



(b) Business and other domestic

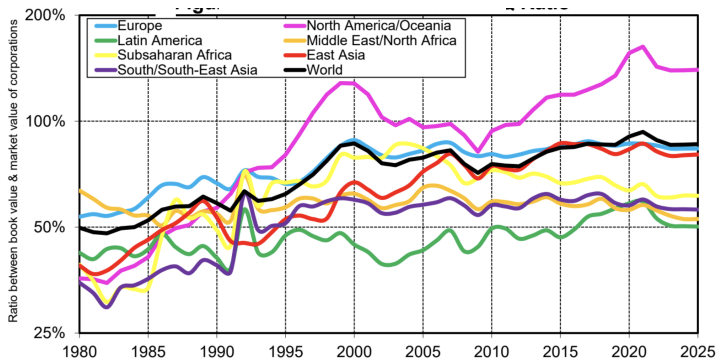
- Both asset types contributed to the increase (Bauluz et al., 2025). But can we disentangle saving-led accumulation from price effects at this level?

Savings vs. price effects in Bauluz et al., 2025

- Accumulated wealth grew faster (4%) than income flows (2.8%)
- From an accounting perspective, savings could only explain up to 2.1% of that growth
- The rest (1.9%) must come from variations in prices

Roughly, the trend is half savings, half asset-price revaluation.

The evolution of business assets

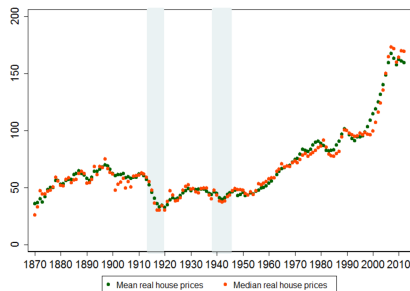


- A large revaluation of business assets is measured by Tobin's Q (market / book-value of firms) in most regions.

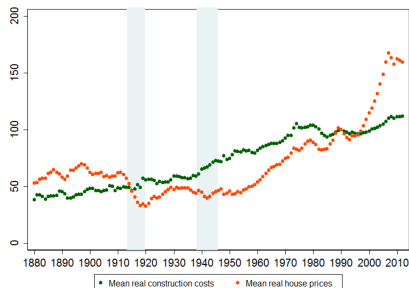
Housing is an important part of the story

- Housing capital: 148% → 291% of world NDP (Bauluz et al., 2025)
- The housing share of domestic capital also rose: 38% → 46%
- Other studies confirm this trend over an even longer period (Knoll, Schularick, and Steger, 2017)
- The key driver seems to be the value of land: scarcity, location, amenities, and urban demand.

A focus on housing: rising land prices



(a) Mean and median house prices



(b) Costs vs house prices

- Knoll, Schularick, and Steger, 2017 show that construction costs cannot explain the historical rise of housing prices, pointing to an increase in the value of underlying land. Source: Data is aggregated for 14 countries. Index base 100 in 1990. WW1 and WW2 are shaded.

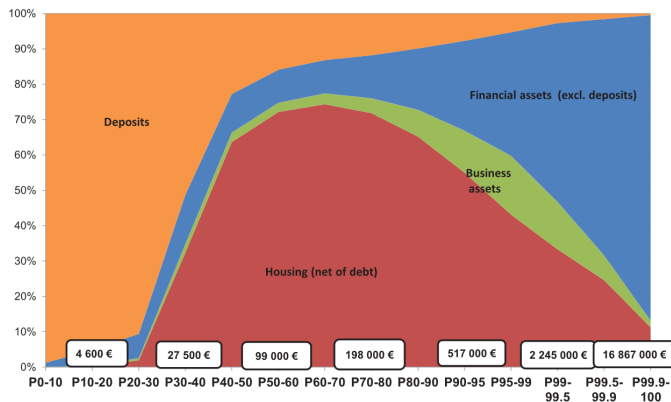
Consequences for inequality: are housing assets equalizing?

- Housing is the single largest component of household wealth in most OECD countries (Causa, Woloszko, and Leite, 2019)
- The middle class holds a disproportionate share of its wealth in owner-occupied housing

Distributional implication:

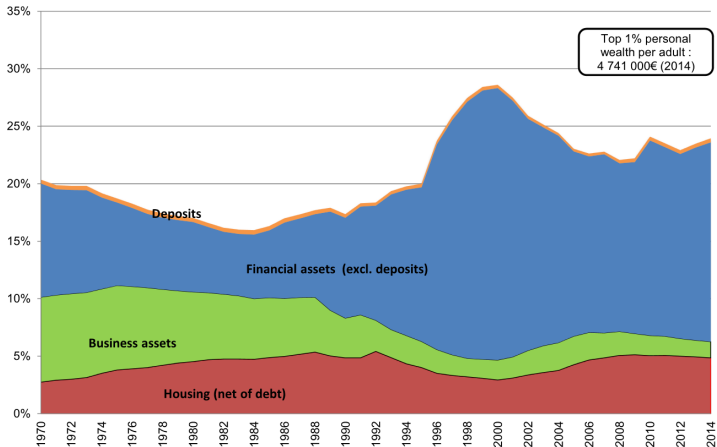
- High homeownership → tends to compress wealth inequality.
- Rising house prices with limited access → amplifies inequality between owners and non-owners.

Wealth types by percentile: France



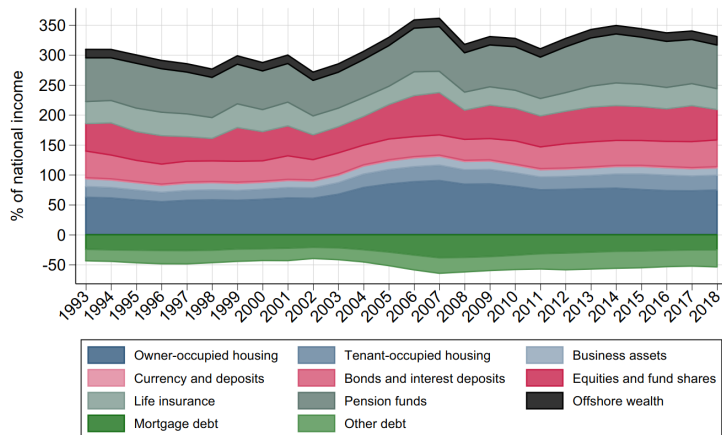
- **Notes.** Large heterogeneity in composition across the wealth distribution. Lower ranking households mostly keep wealth as cash and bank deposits. The middle classes mainly hold wealth through housing assets, while richer households mainly hold financial assets. Source: Garbinti, Goupille-Lebret, and Piketty, 2021

Top 1% composition across time: France



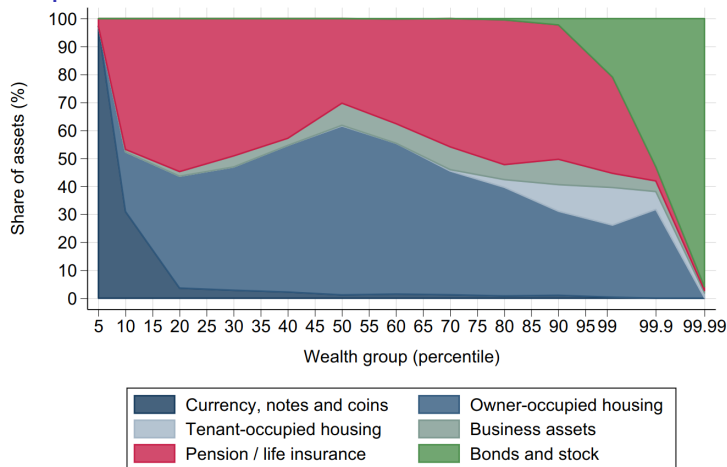
- **Notes.** The composition of wealth within the top 1% varies, especially since the 1990s, financial assets are now largely the dominant asset-type. Source: Garbinti, Goupille-Lebret, and Piketty, 2021

Wealth composition in South Africa



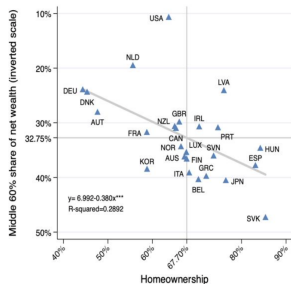
- **Notes.** Similar patterns are observed in –the few– developing countries with data, yet for shorter time-spans. Source: Chatterjee, Czajka, and Gethin, 2022

Similar patterns across countries: South Africa

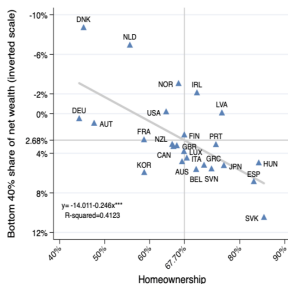


- **Notes.** Similar to France, both ends of the distribution hold diametrically different forms of wealth. In countries with more privatized pension systems, pension funds are also an important part of the wealth of the middle class. Source: Chatterjee, Czajka, and Gethin, 2022

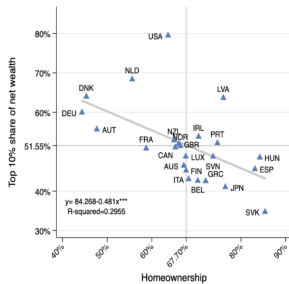
Home-ownership % tends to lower wealth inequality



(a) Middle 60%



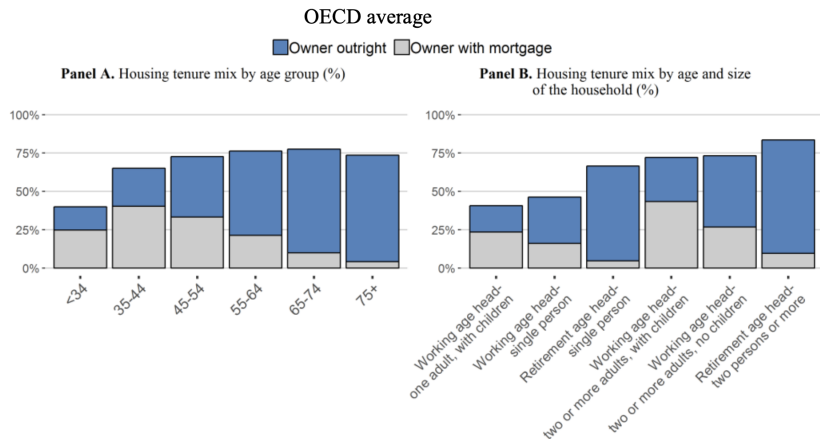
(b) Bottom 40%



(c) Top 10%

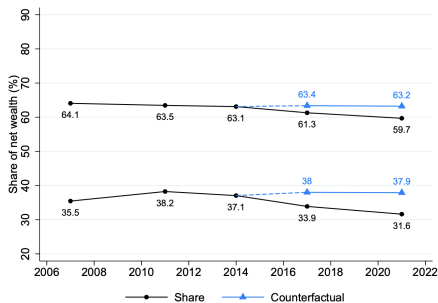
- Using the OECD Wealth Distribution Database, Causa, Woloszko, and Leite, 2019 Find a cross-country (-) correlation between top 10% shares and homeownership, and a (+) correlation with middle and bottom shares (inverted y-axis in figures).

Household characteristics and household tenure

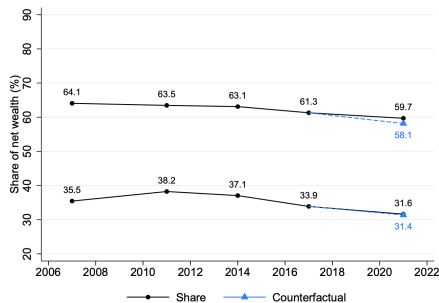


- The same source finds that ownership follows a clear demographic profiling.

The equalizing effect of housing in Chile



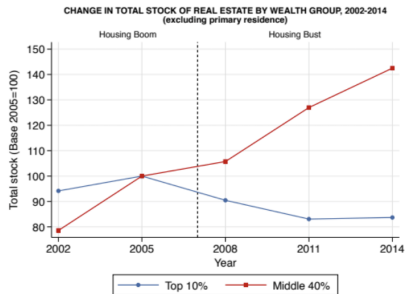
(a) Only real estate



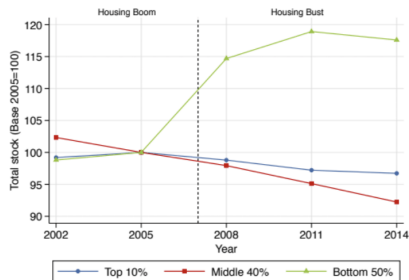
(b) Only pension funds

- The housing VAT introduced in 2016, provoked a soaring increase in housing prices. The counterfactual analysis suggests that top shares would have remained stable or even increased without it. (see Nofal, Flores, and Cubillos, 2026)

Housing bursts are also redistributive



(a) Change in total housing stock
(excl. 1ry residence)



(b) Change in stock of owner
occupied residences

- Martínez-Toledano, 2020 Finds evidence of portfolio reshuffling with housing booms and bursts (Spain). The richer dis-save rental investments, while the bottom 50% can benefit from lower prices in access.

Housing booms: equalization and exclusion

Equalizing channel

- Middle-class holds housing.
- Mortgage leverages gains.
- Prices raise net worth.

Exclusion channel

- Prices raise entry costs.
- Down-payment constraints.
- Renters/young fall behind.

Housing is a democratic asset only for who can enter the market.

From wealth inequality to ownership inequality

A central divide is increasingly:

- owners versus renters
- older owners versus younger entrants
- high-demand locations versus peripheral

Homeownership rates determine which force dominates through:

- Credit access
- Housing supply
- Taxation (on property, capital gains, inheritance)

A flavor of current research

A defining feature of economic development

Economic growth has paired with the *consolidation of agricultural production* worldwide

- Productivity gains have met the demands of a fastly growing population over the XXth century (Borlaug, 2007)
- But productivity has stagnated at the frontier for decades
- The same production model has come a great ecological expense and now faces climate change first in line (Ortiz-Bobea et al., 2021)

We ask: Does the same model that boosted agricultural productivity come with a hidden cost? Does it also increase vulnerability to heat-shocks?

Mostly uncharted territory

Little evidence connecting agricultural inequality to productivity:

- Negative relation at the international cross-sectional level (Vollrath, 2007)

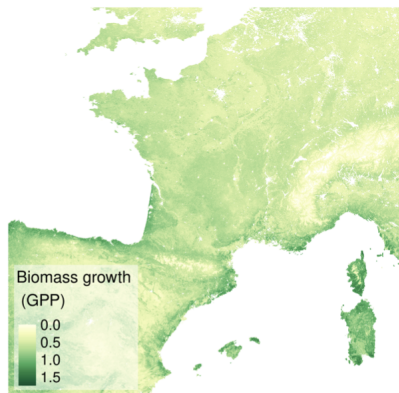
The climate-adaptation literature:

- Part of the literature focuses of quantifying the damage of climate change, and agriculture is expected to suffer great losses (Bilal and Känzig, 2024)
- 20% of damages have been avoided by crop-level technological adaptation since 1960 in the US (Moscona and Sastry, 2023; Moscona and Sastry, 2025)

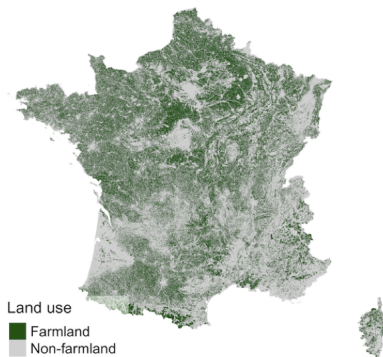
Many studies analyze productivity levels, but less so their variance

- The century-old puzzle of the inverse relation between farm size and productivity is related but inconclusive
- With increasing farm size labor and land productivity go in opposite directions (Foster and Rosenzweig, 2022)

France as unique data opportunity



(a) Yearly land productivity, 2021



(b) Exhaustive farm information

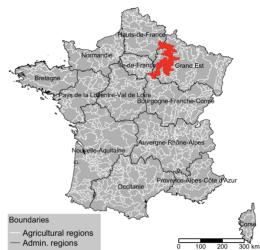
- We combine satellite spectrometry for productivity with within plot-level cadastral data

GPP: a biologically-grounded measure of productivity

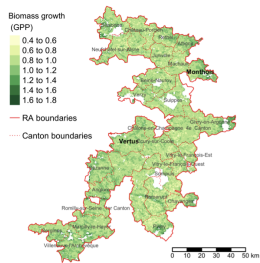
Gross Primary Productivity (GPP)

- Captures the biological base of agricultural production rather than revenue or profit.
- Measures the growth of biomass every 8-days in C.kg /m^2
- Based on fluorescence from photosynthesis
- Resolution: 0.5km pixels
- Credits to Running and Zhao (2019)

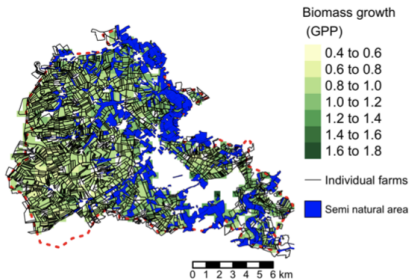
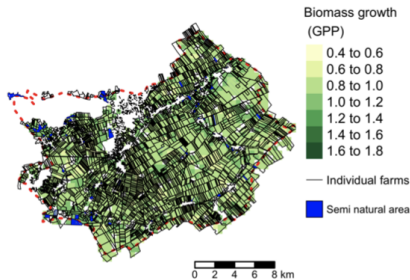
Data snapshots



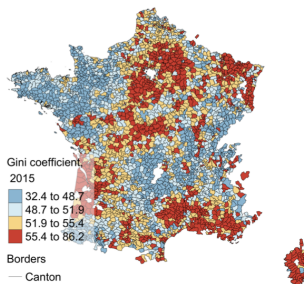
(a) Champagne-Crayeuse (Agricultural region)



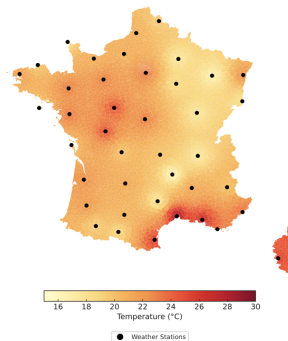
(b) Yearly production in 31 cantons



Building the panel



(c) Land Gini coefficient



(d) Midsummer temperatures, 2021 (°C)

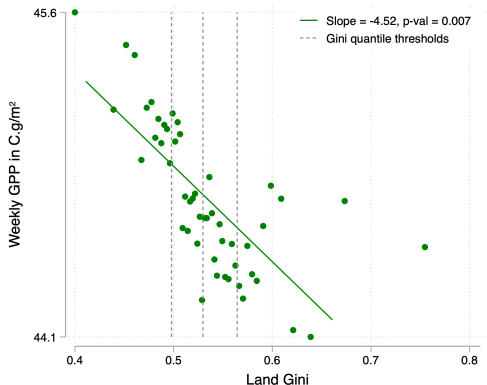
- The full panel is comprised of 2,485 cantons observed over seven years with each year nesting 45 quasi-weeks. They are nested in ≈ 400 agricultural regions
- Temperatures are observed several times a day, but exposure is summarized at the weekly level

Two margins of agricultural production

Total output combines two margins:

- Inequality is associated with lower intensive margins but larger cropped areas
- The net effect on totals can be positive even as per-hectare crop performance declines.

More unequal farmland has lower GPP per hectare



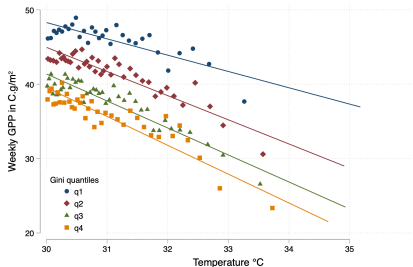
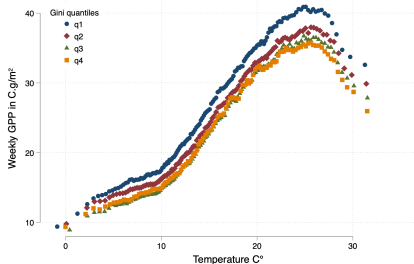
- At the intensive margin, higher land inequality is associated with lower crop biomass production per square meter during the main growing season.

Different plants have different needs

Crop	Max. temp (°C)	Land share	Cumulative	Reference
Winter wheat	32	34.5	34.5	Gammans et al. (2017)
Corn/Maize	32	17.4	51.9	Hawkins et al. (2013)
Winter barley	33	7.4	59.3	Gammans et al. (2017)
Rapeseed	27	6.1	65.4	Pollowick and Sawhney (1988)
Sunflower	35	4.3	69.8	Rondanini et al. (2003)
Grapevine	30	3.6	73.3	Imputed
Spring barley	32	3.3	76.6	Gammans et al. (2017)
Alfalfa	30	2.8	79.5	Murata et al. (1965)
Beetroot	30	2.6	82.1	Imputed
Potato	30	1.1	83.2	Imputed
Soybean	30	1.0	84.1	Schlenker and Roberts (2009)
Spring wheat	33	0.2	84.3	Gammans et al. (2017)
Other (<1%)	30	15.6	100.0	Imputed

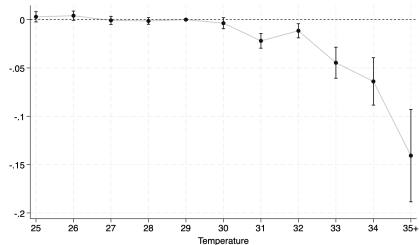
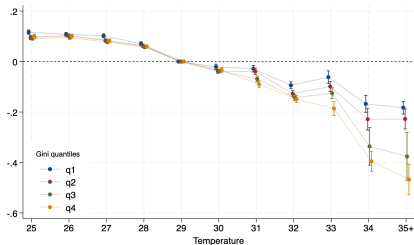
Notes. Compiled by the authors based on Cadastral data and references.

Inequality matters most in the tail

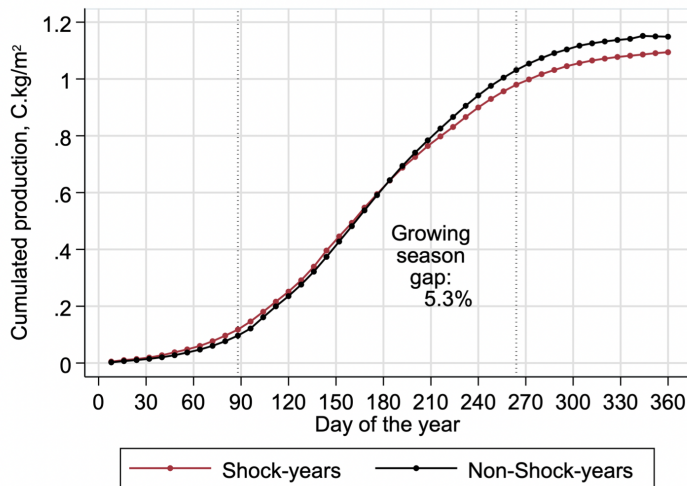


- Across ordinary temperatures, the gradient is modest; above roughly 30°C , high-Gini places exhibit steeper biological losses.

Heat losses are larger where land is concentrated



The average heatshock



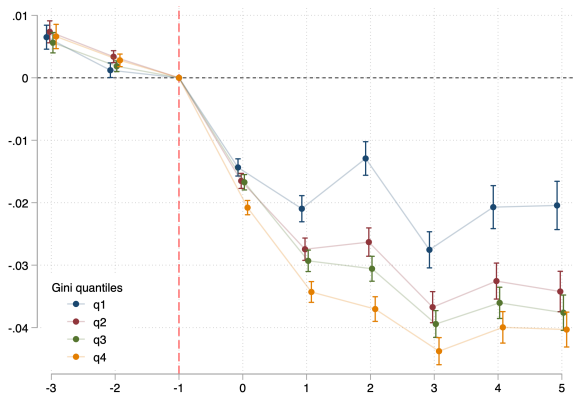
TWFE Regression results

Table 4: Generalized heat shock TWFE impact estimates

Dep. Variable: logGPP	(1)	(2)	(3)	No post-shock weeks (4)	Absorbing shock (5)
Panel (a): ATE and linear Gini					
Shock	-0.196*** (0.003)	-0.183*** (0.003)	-0.187*** (0.003)	-0.184*** (0.003)	-0.088*** (0.002)
Shock x Gini st	-0.021*** (0.004)	-0.018*** (0.004)	-0.019*** (0.004)	-0.030*** (0.003)	-0.015*** (0.002)
Panel (b): ATE by Gini quantile					
q1	-0.167*** (0.006)	-0.164*** (0.005)	-0.167*** (0.005)	-0.134*** (0.006)	-0.044*** (0.007)
q2	-0.188*** (0.006)	-0.180*** (0.005)	-0.182*** (0.005)	-0.182*** (0.006)	-0.092*** (0.005)
q3	-0.199*** (0.006)	-0.181*** (0.005)	-0.186*** (0.005)	-0.189*** (0.006)	-0.102*** (0.004)
q4	-0.227*** (0.007)	-0.208*** (0.006)	-0.215*** (0.006)	-0.226*** (0.006)	-0.104*** (0.004)
p-val equal	0.0000	0.0000	0.0000	0.0000	0.0000
R-sq.	0.723	0.812	0.825	0.819	0.824
N	355024	355024	355024	330067	355024
Canton x Year FEs	✓	✓	✓	✓	✓
Gini x Week FEs	✓				
Gini x AR x Week FEs		✓			
Canton x Week FEs			✓	✓	✓

Notes. Estimated heat shock effects and inequality heterogeneity by log of land Gini (a) and by quantile of the land Gini (b) from baseline models B.4 and B.5, respectively. (1-3) include all weeks in prime season in which shock indicator can turn on and off. (4) drops shocked cantons post initial shock week. (5) Absorbing shock. Standard errors are clustered at the canton. * $p < .1$, ** $p < .05$, *** $p < .01$.

Losses accumulate into persistent production losses



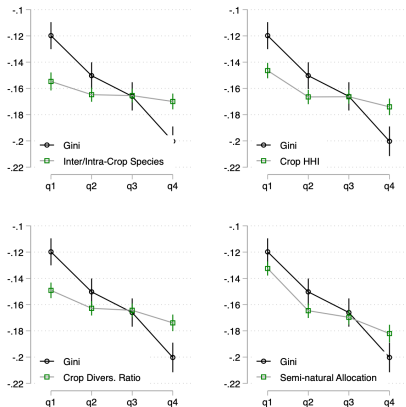
- Cumulative GPP effects map onto year-end agricultural yield outcomes.

Land-use decisions as mechanisms

Leading candidates:

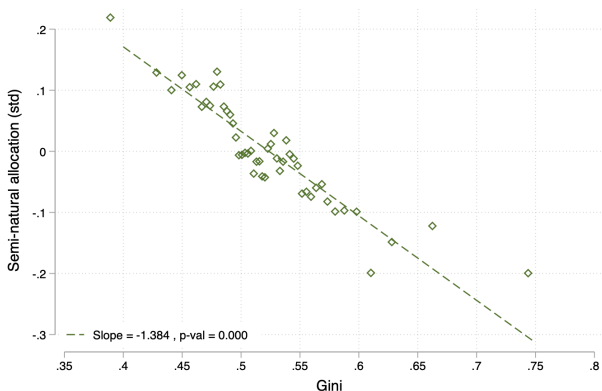
- Crop diversification strategies (Abson et al., 2013; Renard and Tilman, 2019)
- Seminatural ecosystem integration within farmland (Altieri et al., 2015; Rolo et al., 2023; Burgess et al., 2022).

Testing potential predictors



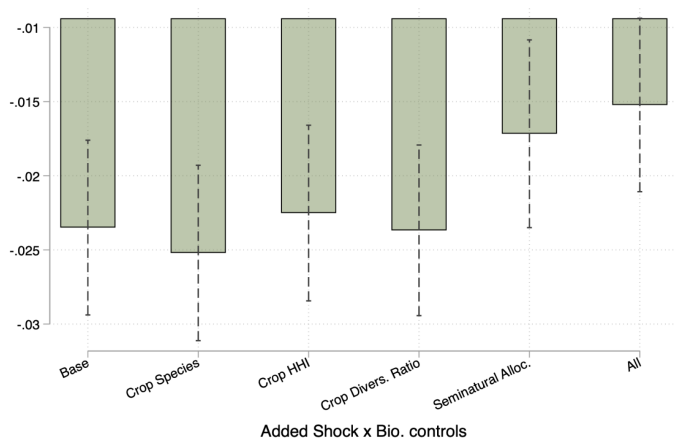
- Crop diversification matters less for the inequality gradient than protective seminatural ecosystems embedded in agricultural landscapes.

Tight correlation with ecological buffers



- High-Gini places allocate less to seminatural area.
- Crop diversification matters less for the inequality gradient than protective seminatural ecosystems embedded in agricultural landscapes.

Controlling for bio-moderators



Comparing with actual aggregate yields

	Yearly log(Crop Yield (C.t/ha.))						log(Cum. GPP (C.t/ha.))		
	Department-level ATE			Dosage ATE per nested canton			Week 6 of exposure Het. Rob. ATE		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Shock	-0.0637*** [0.0076]	-0.0519*** [0.0065]	-0.0523*** [0.0065]	-0.0121*** [0.0016]	-0.0124*** [0.0017]	-0.0126*** [0.0015]	-0.0350*** (0.0008)	-0.0350*** (0.0008)	-0.0351*** (0.0008)
Shock x Gini st	-0.0162*** [0.0060]		-0.0142*** [0.0050]	-0.0018** [0.0009]		-0.0012* [0.0006]	-0.0042*** (0.0008)		-0.0030*** (0.0009)
Shock x Seminatural st		0.0347*** [0.0079]	0.0333*** [0.0084]		0.0044*** [0.0015]	0.0041*** [0.0016]		0.0032*** (0.0007)	0.0018** (0.0008)
N	22183	22183	22183	22183	22183	22183	355024	355024	355024
Canton FEs	✓	✓	✓	✓	✓	✓			
Year FEs	✓	✓	✓	✓	✓	✓			

Notes. (1-3) Crop yields correspond to marketable food crops transformed as the log of metric tons per hectare for each French *département* for years 2015-2021 by the French Agricultural Ministry. (4-6) Yield canton dosage effects per *département* by scaling (1-3) by the proportion of shocked cantons for each year. (7-9) Dynamic heterogeneity robust event study estimates on (log) cumulative GPP at treatment week six (w+5) using our preferred specification (model 3 of Table 5. Model (7) estimates correspond to the last bars in Figure 7b. Standard errors in brackets indicate clustering at the *département* while those in parentheses indicate clustering at the canton. * $p < .1$, ** $p < .05$, *** $p < .01$.

Modeling our findings

In the paper, we write a simple production technology showing:

- Scale economies raise the opportunity cost of maintaining non-yield-producing ecological buffers.
- The result is systematic under-provision of ecological protection in high-inequality landscapes.
- Uniform per-hectare subsidies are not equally effective across landscapes (Protection among small and mid-sized farms, but may fail among large farms)

Concluding remarks

Global income and wealth

- Are extremely concentrated and connected through foreign investment
- Recent literature has improved our understanding of historical processes but warrants better data and measurement
- Macroeconomic consistency is key to base discussions in growth distribution into solid empirical ground

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