Introduction

Paulo Brito
pbrito@iseg.ulisboa.pt

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Object of economic growth theory

- Dynamics of per capita aggregate income across long time, and space.
- Main questions
  - what is the meaning of "long time" (millenia, centuries, decennials) ?
  - what are the main factors explaining economic growth ?
  - why rates of growth differ along historical times ?
  - why the rates of growth differ accross countries ?
  - why countries hold inequalities in the GDP per capita while having similar rates of growth ?

Main takeaways from the course

- There is economic growth only if there is a **reproduction** mechanism that works permanently
  $\Rightarrow$ economic growth has an **exponential** feature

$$y(t) \approx e^{\gamma t}$$

- The observed increase in the GDP per capita is not a reliable measure of economic growth: we should **distinguish the transition from long term** growth rate

$$\left.\frac{\Delta y}{y}\right|_{\text{observed}} = \gamma + \gamma_{\text{transition}}$$

  $\Rightarrow$ we need some **theory** to separate the two

Beyond economic growth

Human impact on Earth's geological phases

The **Anthropocene**:

- consensus: there is a geological impact by human activity
- no consensus: periodization (when did it started ?)
  - around 8000 BCE ? (deforestation, increase in carbon concentration preventing a "natural" reduction in Earth's temperature)
  - around 1600 CE ? (exchange in animal and plant species brought about by human activity)
  - around 1800 CE ? (industrial revolution, increase in earth's temperature)
  - around 1944 CE ? (clear increase in temperature, start of the atomic era)
- see `http://www.anthropocene.info`

Main growth factors

By increasing degree of variability

- Physical and biological environments: geography, size, resources, biology;
- Population: demography, human capital, social capital;
- Technology: capital accumulation, productivity growth (learning by doing, R&D);
- Aggregation: externalities, public goods ;
- Economic institutions: inclusive/exclusive, financial institutions, trade openness, patent protection;
- Political Institutions: in a broad sense (inclusive/exclusive, rule of law, enforcement, accountability) or a narrow sense (government intervention, governance)
- Luck (good or bad)

Phases of economic growth

Secular long run perspective:

- Malthusian trap and first globalization (goods) : (almost) constant rates of growth (6000 BCE to 1700 CE)
- Industrial Revolution: transition with modest increases in the rate of growth
- Modern economic growth and second globalization (goods): rapid economic growth and Great Divergence: post 1820 and until 1990 (according to some authors)
- Great convergence and third globalization (ideas): post 1990
- Nature strikes back: eventual natural limits to growth ?

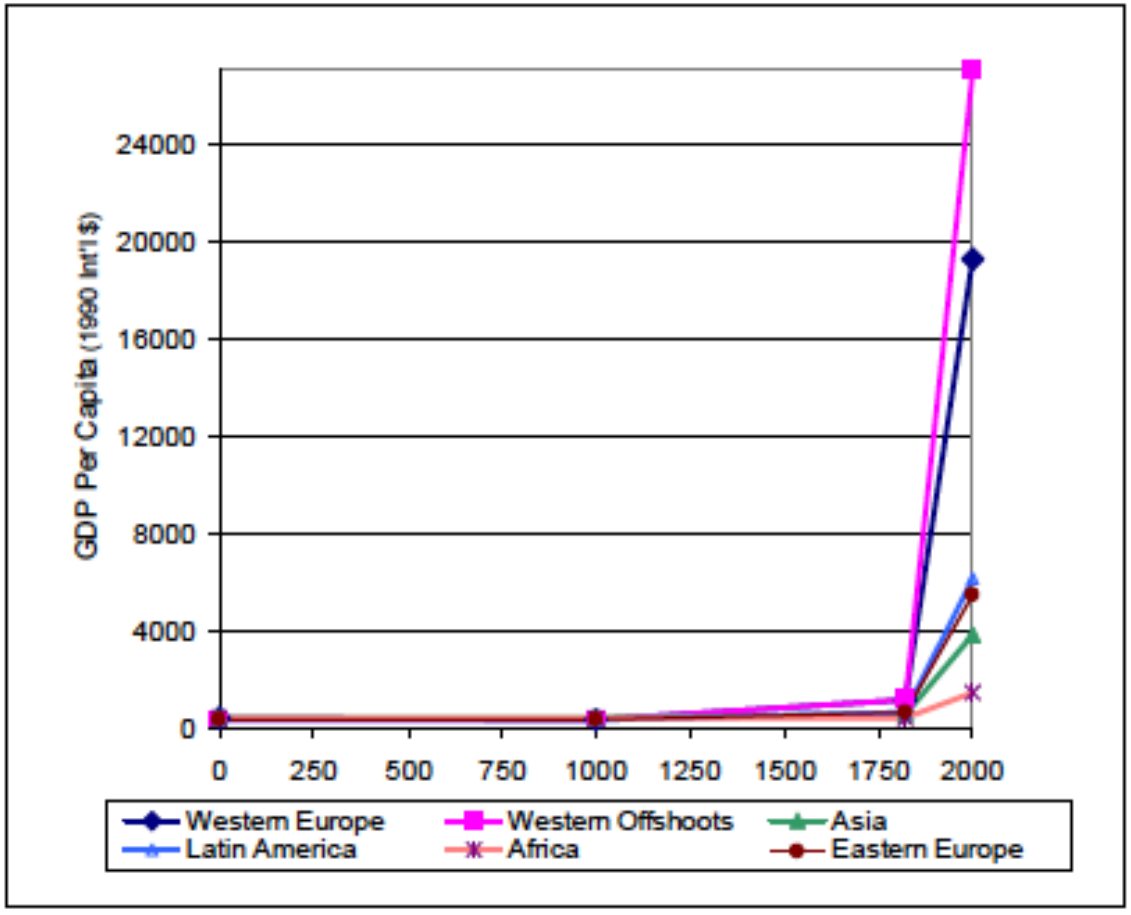

Figure 1: The Evolution of Regional Income Per Capita, 1-2000 CE
(Source: Maddison, 2003)

Figure: Maddison on the evolution of income per capita

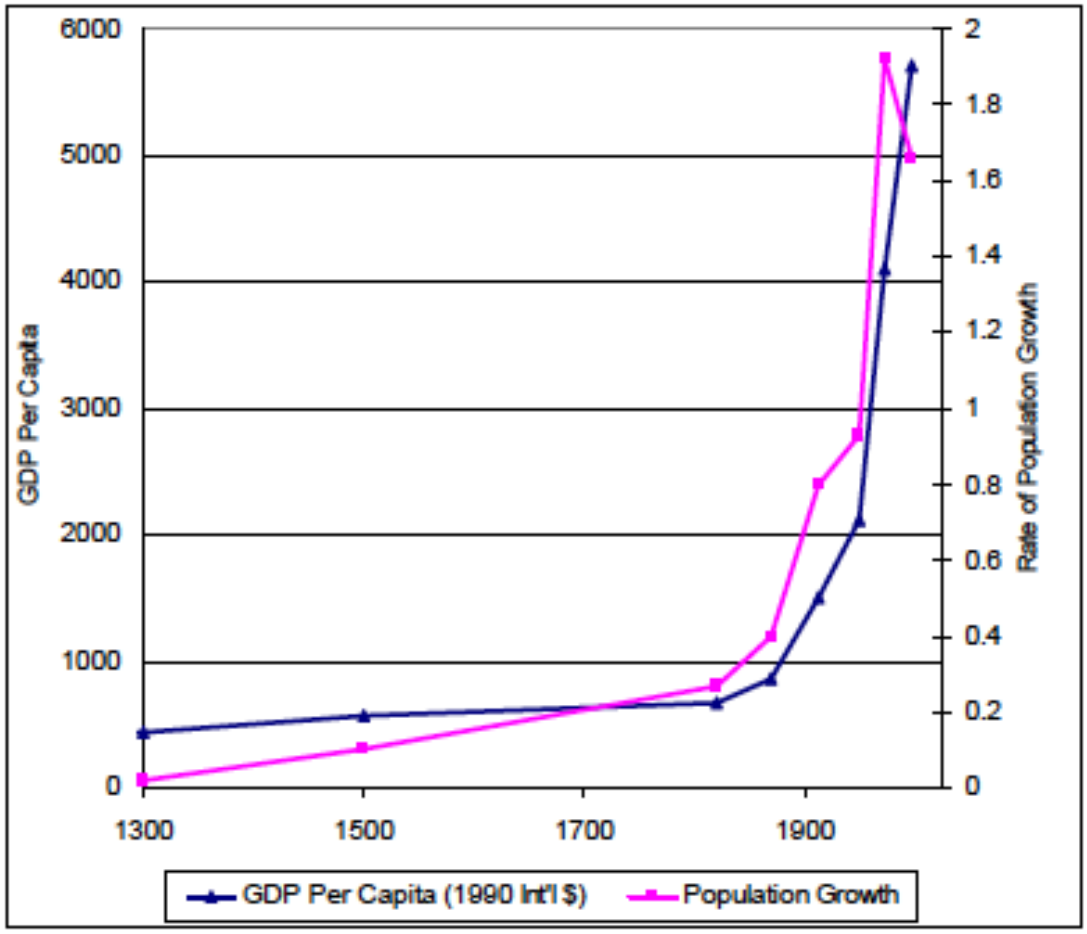

Figure 4: World Population Growth and Income Per Capita
(Source: Maddison, 2001)

Figure: Maddison on the evolution of population

Ancient growth experience

Malthusian trap

- low rates of growth: between 0% and 0.5%
- rises in income implied rises in population (not income p.c.)
- negative correlation between population growth and real wages
- big impact of demographic changes and (ex Black-Death (1347-1350)) and institutions (ex. different responses to it in E. and W.Europe);

Ancient growth experience

Malthusian trap

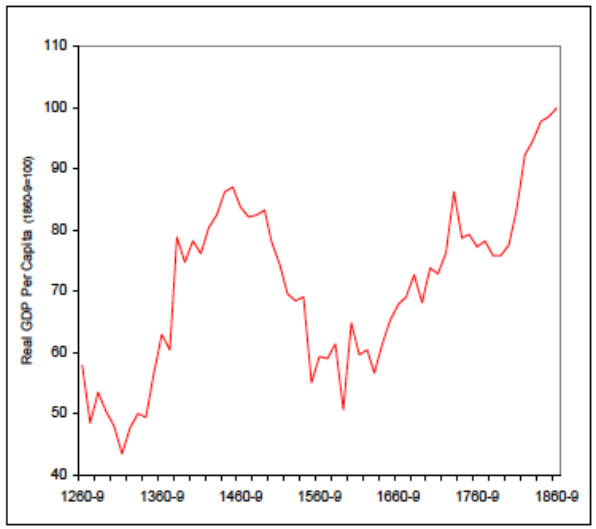

Figure 2: Fluctuations in Real GDP Per Capita in England, 1260-1870 CE
(Source: Clark, 2005)

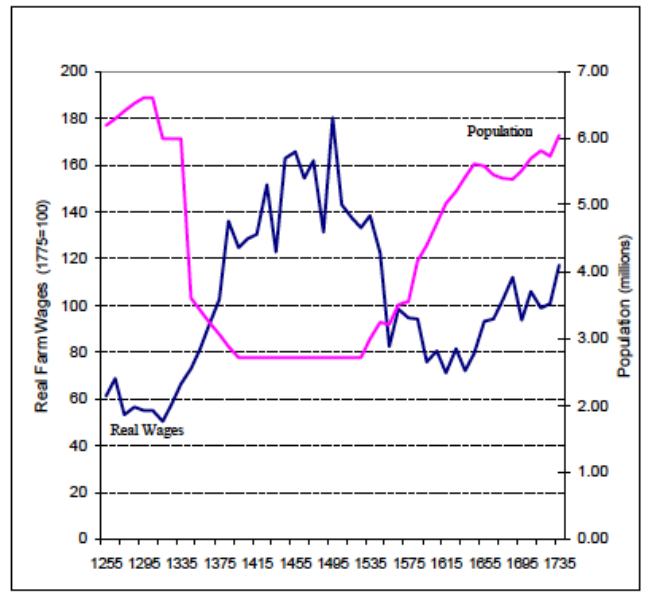

Figure 5: Population and Real Wages in England, 1250-1750 CE
(Source: Clark, 2005)

Figure: Clark on the UK's population and real wages

Ancient growth experience

Limits to growth

- labor was the main factor of production
- land had an impact on growth because of decreasing returns;
- there were some gains in productivity, although not related to a purposeful activity as R&D;

Ancient growth experience

First globalization

- there was a small difference in GDP per capita across the world (Eurasian continent)

Table: Ratio richest to poorest region: before the great divergence

1000	1500	1820
1.1:1	2:1	3:1

- E. and SW. Asia were richer (see Frankopan (2016))
- first globalization: a first decoupling between production and consumption took place with trade in a small number of (luxury) goods (Silk road)
- physical distance was a major factor

Modern economic growth

Main features

- modern economic growth: permanent positive rates of growth;
- it may have started in the UK around 1800;
- it was contemporaneous with a demographic revolution, but growth became independent from the growth population;
- non-Malthusian features: rise in wages and almost stationary rate of return of capital

Modern economic growth

Main factors

- two driving forces: increases in productivity and capital accumulation (physical, human, social)
- physical capital accumulation: massive, helped by the development of financial system
- technologic progress: rise in productivity as a purposeful activity, huge reduction in transport costs;
- unprecedented accumulation of human capital: schooling and knowledge (Scientific Revolution)
- social capital: institutions (protection of property rights, contract enforcement, reduction of transactions costs, reduction in uncertainty, etc)
- non-renewable natural resources: no decreasing returns ?

Modern economic growth

Great divergence

- *The Great divergence*:

Table: Ratio richest to poorest region: after the great divergence

1820	1870	1913	1950	2001
3:1	5:1	9:1	15:1	18:1

- increase in disparities and change of the economic center
- second globalization (inter-industrial trade): huge reduction in transport costs lead to an increase in the trade in **goods** and the Ricardo comparative advantage mechanism start working massively;
- relative free capital movement re-inforced this movement and lead to an international alignment of interest rates;
- increasing agglomeration of economic activity in a few centers (at national and international levels)

Present epoch: a new phase ?

Great convergence

- technical progress: driven by IT lead to a reduction of costs in the movement of **ideas**, robotization;
- third globalization (intra-industrial trade): a large part of international trade is related to the supply chains of some multinational corporations;
- allowed high increases in wages in a few (7) countries (technology from the "North" and wages from the "South") and competition between countries for parts of the supply chains;
- institutional consequences: rebalances of the inclusive/exclusive attitudes around the world ?
- limits to growth as a result of the environmental impact of human activity ?

Growth theory: Some puzzles

Puzzle 1: on the exponential structure of growth

- Long run growth arises only for a very particular mathematical structure:
- Let

$$\dot{y} \equiv \frac{dy(t)}{dt} = \mu(y)$$

  - logistic growth: $\mu(y) = \alpha y(\beta - y)$,
  - exponential growth: $\mu(y) = \gamma y$,
  - power law growth: $\mu(y) = y^{\phi}$ for $\phi > 1$,
- razor edge property of growth models: although the exponential case is very particular it this the structure underlying (almost) all growth theories

Growth theory: Some puzzles

Puzzle 1: on the exponential structure of growth

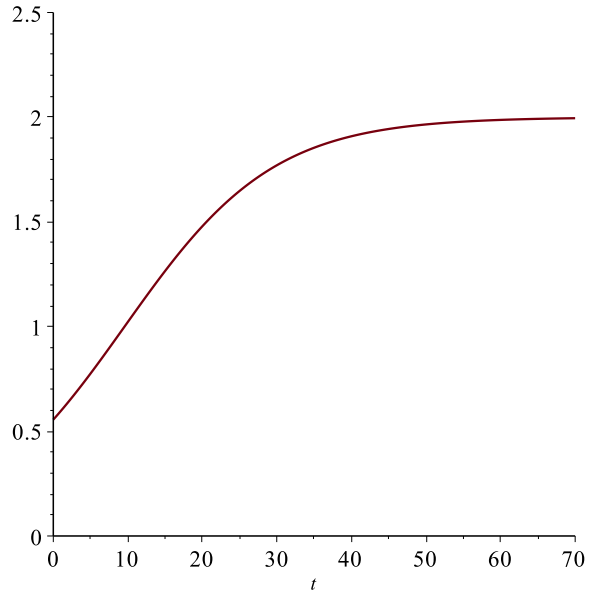

Figure: Logistic growth $\mu(y) = \alpha y(\beta - y)$

- there is short run (transition) growth
- but there is no long-run growth

Growth theory: Some puzzles

Puzzle 1: on the exponential structure of growth

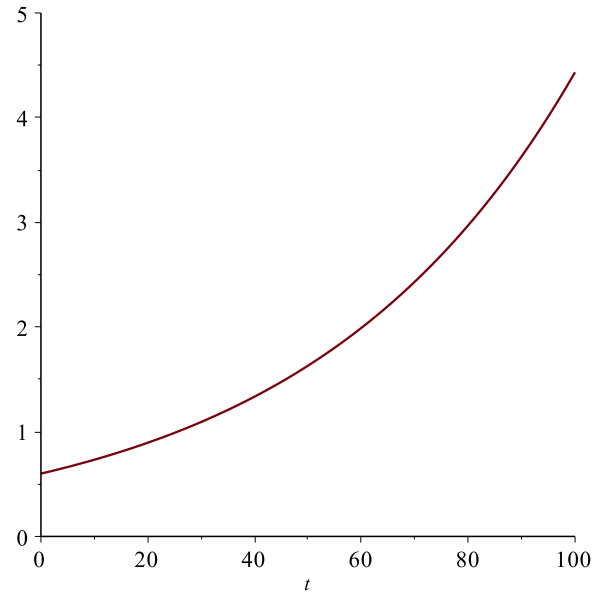

Figure: Exponential growth $\mu(y) = \gamma y$

- there is no short run (transition) growth
- but there is long-run growth
- gdp becomes infinite ($y(t) \to \infty$) in **infinite** time

Growth theory: Some puzzles

Puzzle 1: on the exponential structure of growth

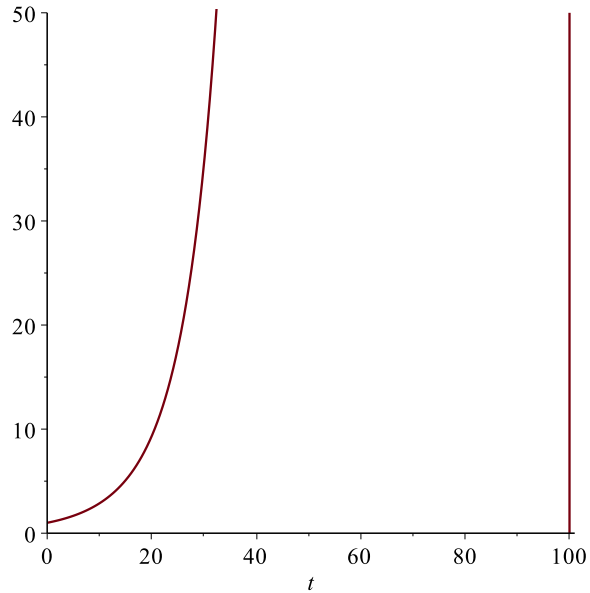

Figure: Power law growth $\mu(y) = y^{\phi}$ for $\phi > 1$

- gdp becomes infinite ($y(t) \to \infty$) in **finite** time
- and collapses afterwards

Some puzzles

Puzzle 2: growth and distribution

- Consider the former equation

$$dy(t) = \mu(y)\,dt$$

- let $\rho(y,t)$ be the density of population having the income $y \in [y_0(t), y_1(t)] \in (0,\infty)$, such that

$$\int_0^\infty \rho(y,t)\,dy = 1,$$

- the dynamics of the distribution is given by

$$\frac{\partial \rho(y,t)}{\partial t} + \frac{\partial}{\partial y}\left(\mu(y)\rho(y,t)\right) = 0$$

Some puzzles

Puzzle 2: growth and distribution

We can determine

- the average per capita income

$$\bar{y}(t) = \int_0^\infty \rho(y,t)\, y dy$$

- its variance

$$\sigma(t) = \int_0^\infty \rho(y,t)(y - y(t))^2 dy$$

- the Gini index

$$G(t) = \frac{1}{\bar{y}(t)} \int_0^\infty R(y,t)(1 - R(y,t))\, dy \in (0,1)$$

where $R(x,t) = \int_0^x \rho(y,t)\, dy$

Some puzzles

Puzzle 2: growth and distribution

- there are four important properties that interest us
  - long run growth: does $\lim_{t\to\infty} y(t) = \infty$?
  - ergodicity: does $\lim_{t\to\infty} \sigma(t) = \bar{\sigma}$ finite and constant (independent from the initial distribution) ?
  - dispersion: does $\sigma(t) = 0$ or $\lim_{t\to\infty} \sigma(t) = 0$?
  - inequality: does $G(t) \in (0, 1)$ stays stationary, increases, decreases, f or $\lim_{t\to\infty} \sigma(t) = 0$?

Some puzzles

Puzzle 2: growth and distribution

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  - dispersion: does $\sigma(t) = 0$ or $\lim_{t\to\infty} \sigma(t) = 0$? or $\lim_{t\to\infty} \sigma(t) = +\infty$?
  - inequality: does $G(t) \in (0, 1)$ stays stationary, increases, decreases, f or $\lim_{t\to\infty} \sigma(t) = 0$?
- examples, starting from an initial heterogeneous distribution:
  - case1: logistic $\mu(k) = ay(b - y)$
  - case 2: constant $\mu(k) = \bar{\mu}$
  - case 3: exponential $\mu(k) = \gamma k$
- can we have long-run growth without an increase in inequality ?

Some puzzles

Puzzle 2: growth and distribution

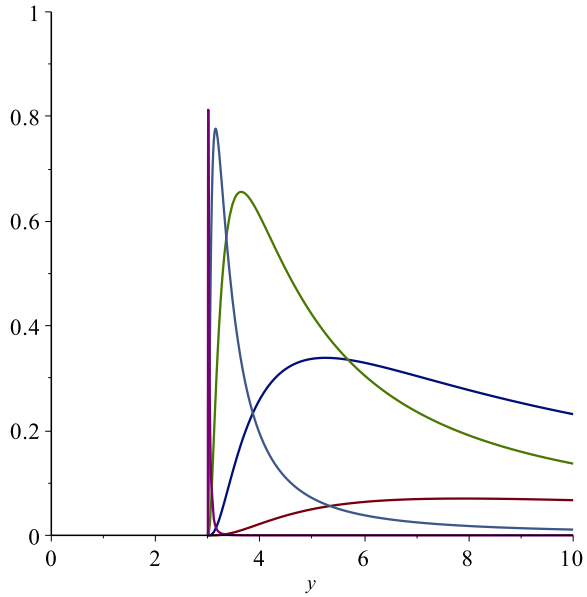

Figure: case 1: ergodicity, long run equality, but no growth (obs: increasing time moves distribution to the left)

Some puzzles

Puzzle 2: growth and distribution

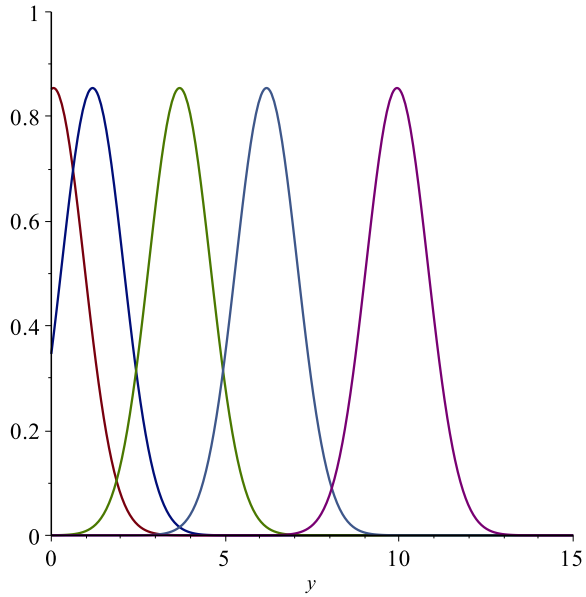

Figure: case 2: permanent ergodicity and dispersion and growth: $\mu(k) = \bar{\mu}$

Some puzzles

Puzzle 2: growth and distribution

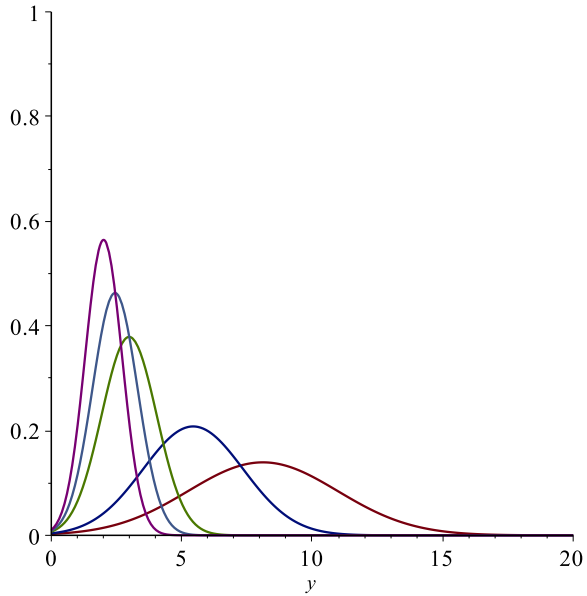

Figure: case 3: no ergodicity, increasing dispersion, permanent inequality and growth: $\mu(k) = \gamma k$

Some historical facts

Inequality

- Inequality in the very long run: Scheidel (2017) and Milanovic (2016)

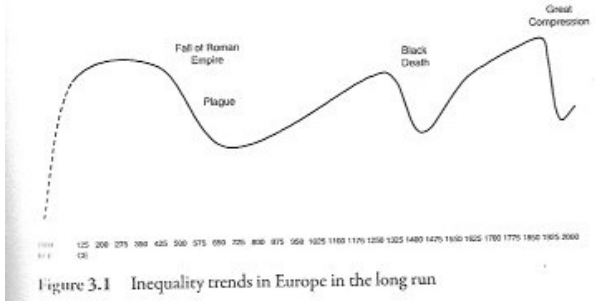

Figure 3.1 Inequality trends in Europe in the long run

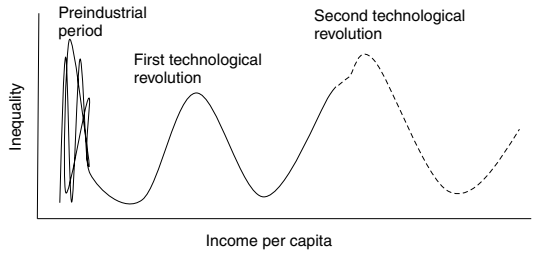

FIGURE 2.4. Expected pattern of changes in inequality versus income per capita from the preindustrial through the postindustrial period and into the future (dotted line)

- Pre IR: compression (short) and distension (longer) periods
- Post IR: distension (IR - WWI, 1970 - present) and compression (WWI- 1970)

References

- Anthropocene: Lewis and Maslin (2018)
- Long-run growth facts: Maddison (2007)
- Stylized facts on economic growth: (Acemoglu, 2009, ch. 1, 2) , (Barro and Sala-i-Martin, 2004, ch. 10,11,12)
- Pre-modern and modern economic growth: (Galor, 2011, ch 2)
- Inequality: Milanovic (2016), Scheidel (2017)

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