

# Introduction

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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 time ?
  - ▶ why the rates of growth differ among countries ?
  - ▶ why countries hold inequalities in the GDP per capita while having similar rates of growth ?

# Main takeaways of the course

- ▶ There is economic growth only if there is a **reproduction** mechanism that works permanently  
⇒ 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

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

⇒ 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

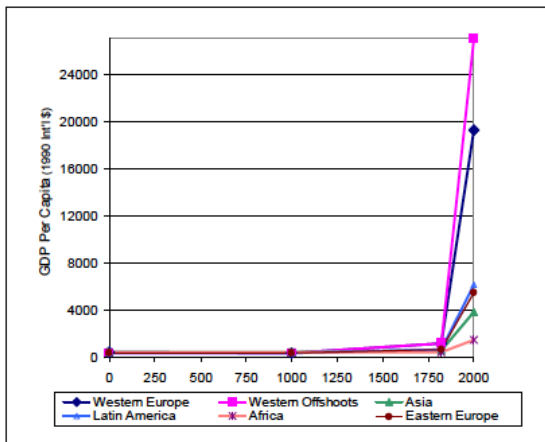
By increasing degree of variability

- ▶ Physical and biological environments: geography, size, resources, biology;
- ▶ Population: demography, human capital, social capital;
- ▶ Technology: learning by doing, R&D (as an independent activity);
- ▶ 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

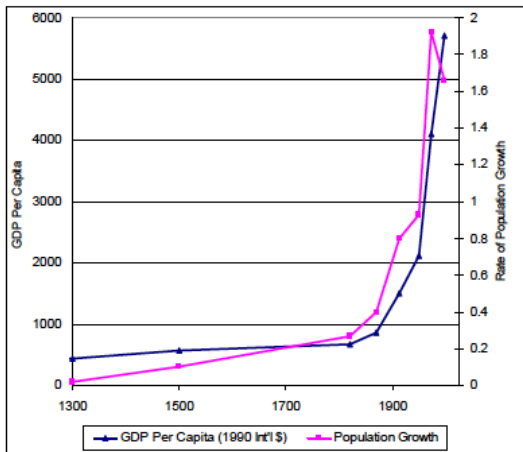
Secular long run perspective:

1. Malthusian trap and first globalization (goods) : (almost) constant rates of growth (6000 BCE to 1700 CE)
2. Industrial Revolution: transition with modest increases in the rate of growth
3. Modern economic growth and second globalization (goods): rapid economic growth and Great Divergence: post 1820 and until 1990 (according to some authors)
4. Great convergence and third globalization (ideas): post 1990
5. 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

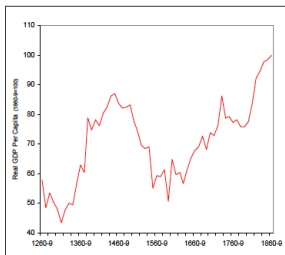


Figure 2: Fluctuations in Real GDP Per Capita in England, 1260-1870 CE  
(Source: Clark, 2005)

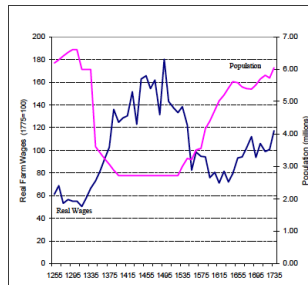


Figure 5: Population and Real Wages in England, 1250-1750 CE  
(Source: Clark, 2005)

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 not a large difference of GDP per capita around 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. Asia was richer (see ?)
- ▶ 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
- ▶ unprecedented accumulation of human capital: schooling and knowledge (scientific revolution)
- ▶ social capital: institutions (protection of property rights, contract enforcement, reduction of transactions costs, reduction of 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**
- ▶ 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 is the structure underlying (almost) all growth theories

# Growth theory: Some puzzles

## Puzzle 1: on the exponential structure of growth

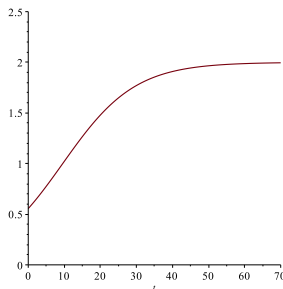


Figure: Logistic growth  $\mu(y) = \alpha y(\beta - y)$

- ▶ 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

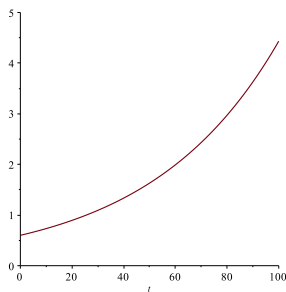


Figure: Exponential growth  $\mu(y) = \gamma y$

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

# Growth theory: Some puzzles

## Puzzle 1: on the exponential structure of growth

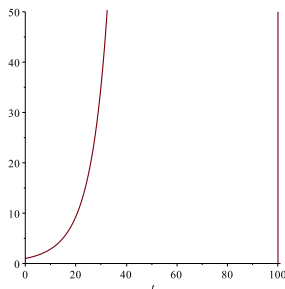


Figure: Power law growth  $\mu(y) = y^\phi$  for  $\phi > 1$

- ▶ gdp becomes infinite ( $y(t) \rightarrow \infty$ ) 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

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

# 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

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

- ▶ 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  $\lim_{t \rightarrow \infty} y(t) = \infty$  ?
  - ▶ **ergodicity**: does  $\lim_{t \rightarrow \infty} \sigma(t) = \bar{\sigma}$  finite and constant (independent from the initial distribution ) ?
  - ▶ **dispersion**: does  $\sigma(t) = 0$  or  $\lim_{t \rightarrow \infty} \sigma(t) = 0$  ?
  - ▶ **inequality**: does  $G(t) \in (0, 1)$  stays stationary, increases, decreases, f or  $\lim_{t \rightarrow \infty} \sigma(t) = 0$  ?

# Some puzzles

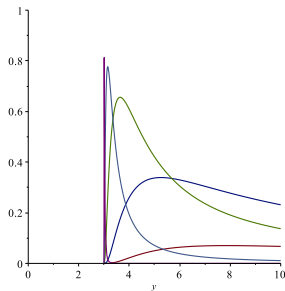
## Puzzle 2: growth and distribution

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- ▶ 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

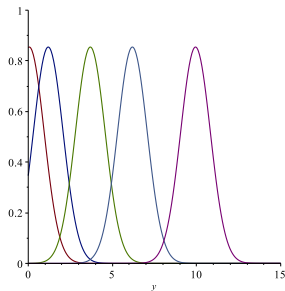
## Puzzle 2: growth and distribution



**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

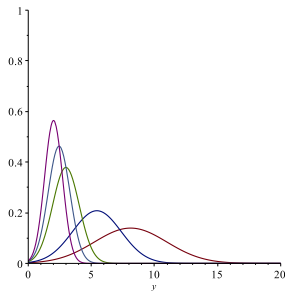


**Figure:** case 2: permanent ergodicity and dispersion and growth:

$$\mu(k) = \bar{\mu}$$

# Some puzzles

## Puzzle 2: growth and distribution

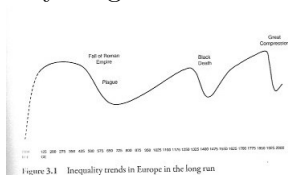


**Figure:** case 3: no ergodicity, increasing dispersion, permanent inequality and growth:  $\mu(k) = \gamma k$

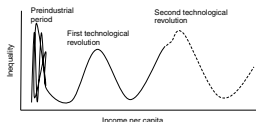
# Some historical facts

## Inequality

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



Milanovic (2016)



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

# References

- ▶ Anthropocene: ?
- ▶ Long-run growth facts: ?
- ▶ Stylized facts on economic growth: (?, ch. 1, 2) , (?, ch. 10,11,12)
- ▶ Pre-modern and modern economic growth: (?, ch 2)
- ▶ Inequality: ?, ?

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