Chapter 1

Malthusian World

Econ 3070: Macroeconomics 2.0

University of Pittsburgh, 2023

Some History

Long-run growth facts

10,000 years ago: all (but a tiny fraction) of humanity was poor

Before 1800: living standards differed little across countries and across time

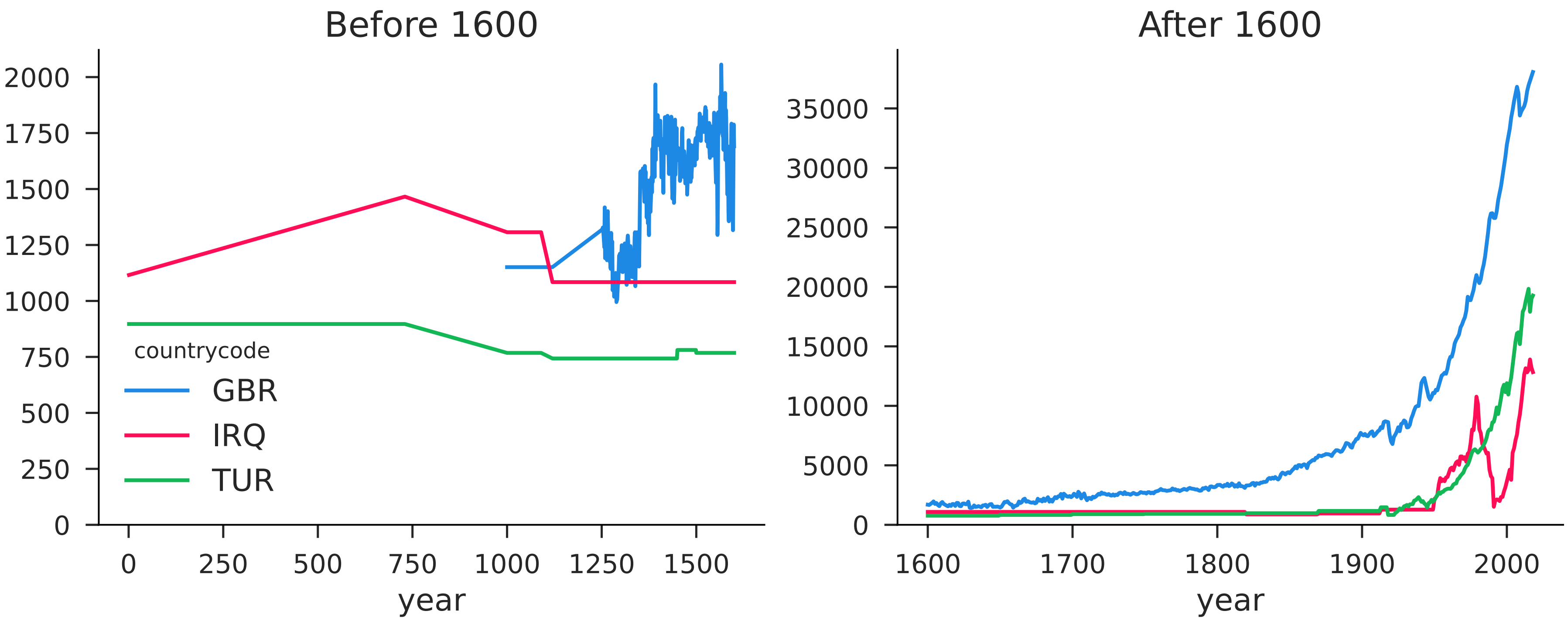
After 1800: while some countries started to double their per capita income every 35 to 40 years, in others income remained stagnant

Reliable data is hard to come by: folks at the Maddison Project have made most comprehensive attempt to catalog this.

— Penn World Tables covers a wide variety of macroeconomic variables from 1950 onwards

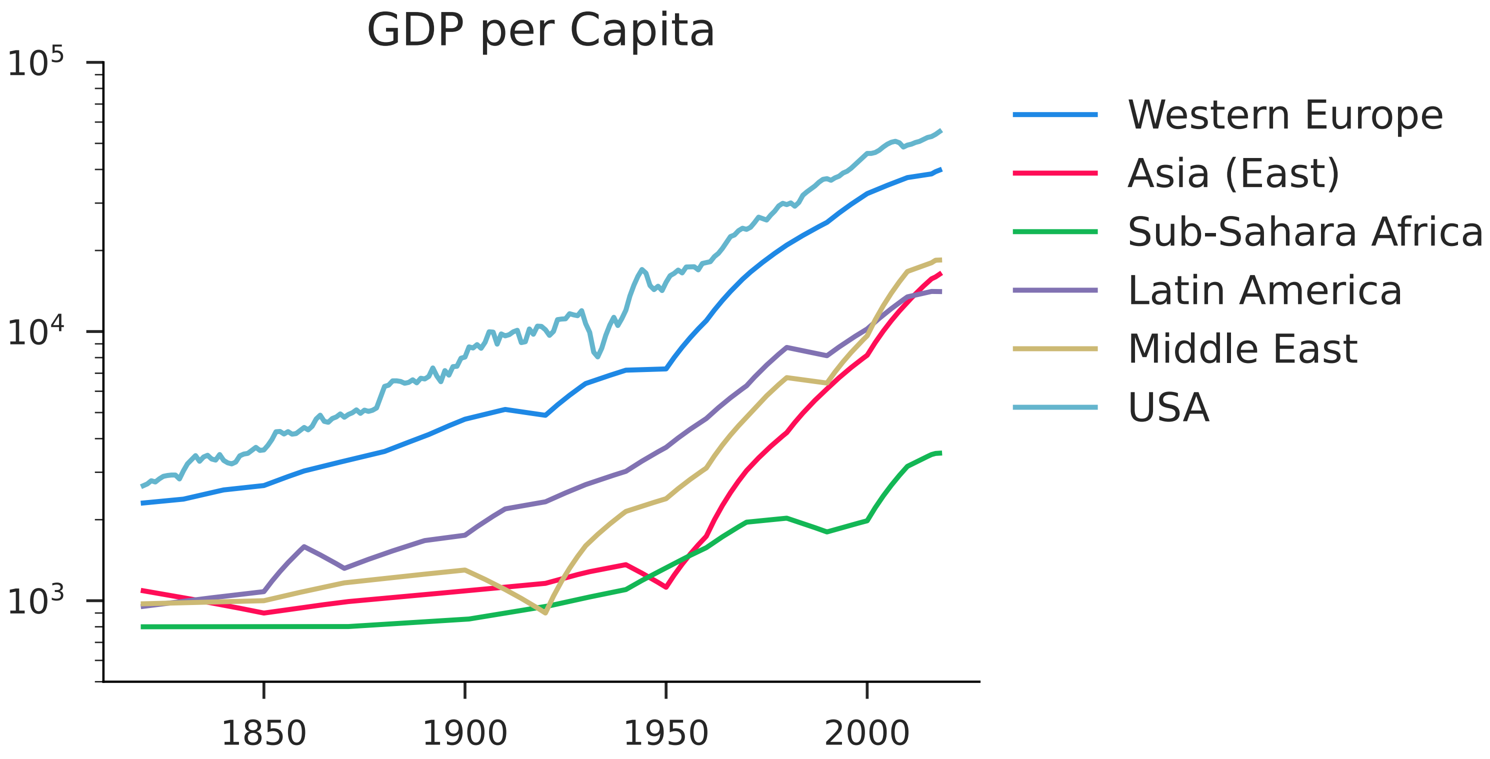
Regional Divergence

Two distinct periods emerge when we look at England versus Mesopotamia before and after roughly 1600



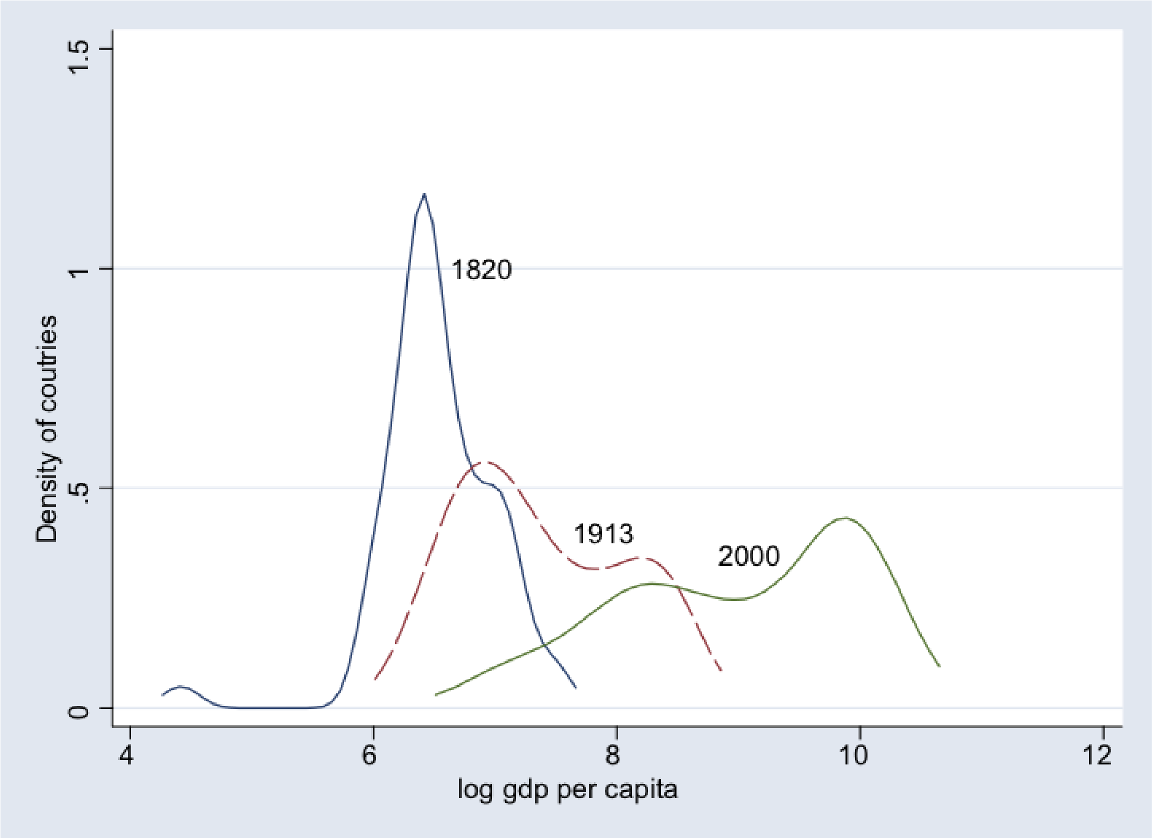
World GDP History

Substantial growth across all regions, but large disparities persist

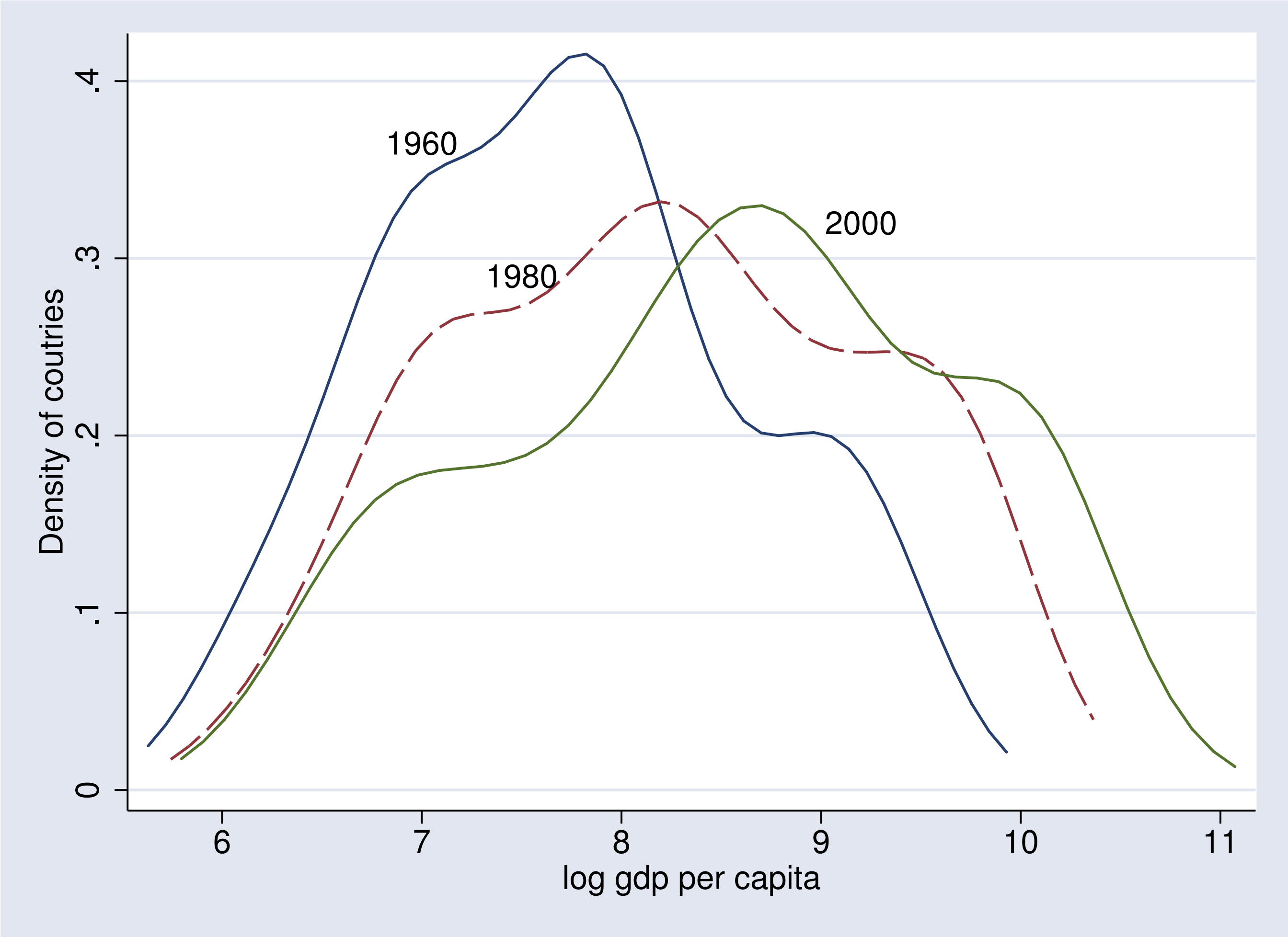


Evolution of GDP distribution

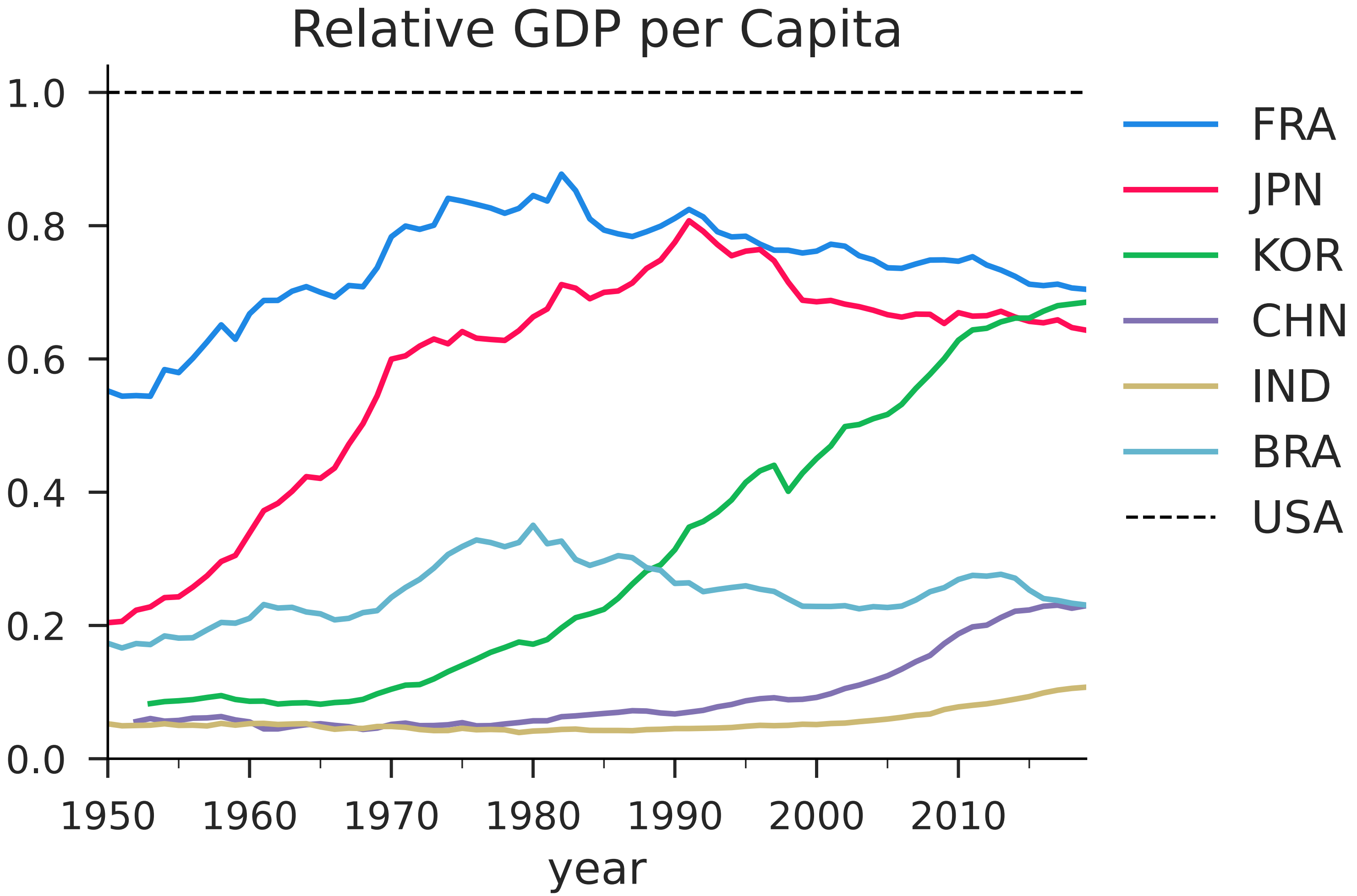
Evolution of density of *countries* (not people)



Recent evolution of GDP distribution

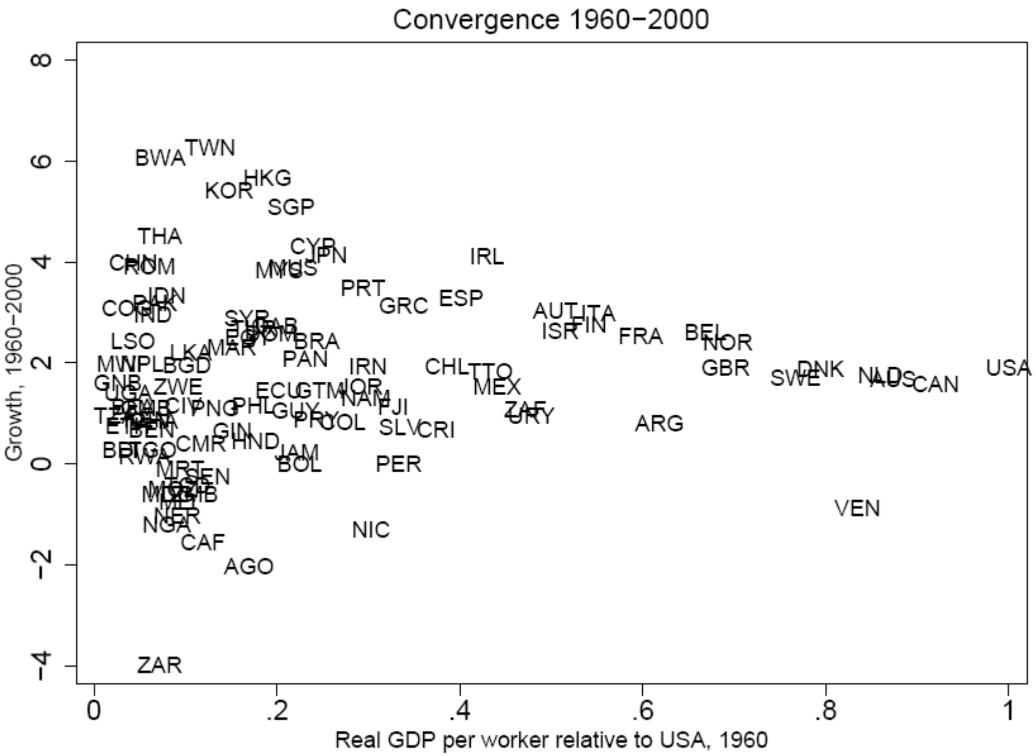


Major country dynamics

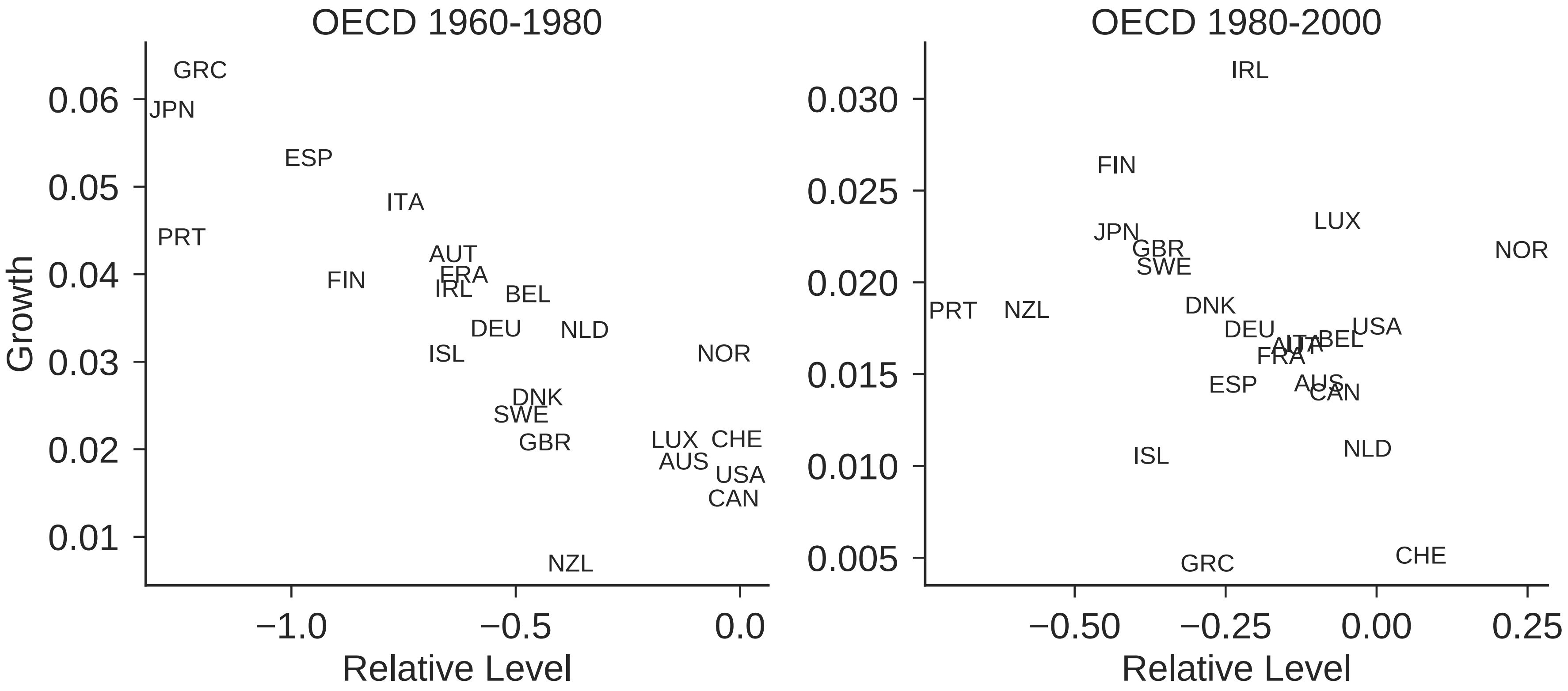


Lack of convergence

Figure 3: Growth Versus Initial Income: 1960-2000



Club convergence



"Old" Theory

Malthusian World

Assumption 1: There is a fixed amount of land, but population can grow

Assumption 2: Population growth $\propto$ standard of living

Assumption 3: Production utilizes only land and labor (agrarian society)

$\longrightarrow$ Standard of living and population stagnate

Simple Model

Let output (GDP) be Y and population be L

Assume higher standard of living (Y/L) leads to higher population growth

$$\frac{\dot{L}}{L} = h\left(\frac{Y}{L}\right) \equiv \theta \cdot \left(\frac{Y}{L} - \bar{y}\right)$$

Here θ and $\bar{y}$ are positive constants and $\dot{L} = \frac{dL}{dt}$

Constant population ($\dot{L} = 0$) implies

$$\frac{Y}{L} = h^{-1}(0) = \bar{y}$$

Equilibrium

Population and land (K) are combined to produce output

$$Y = F(z, K, L) \equiv zK^{\alpha}L^{1-\alpha}$$

Here z is overall productivity. Thus the standard living is

$$\frac{Y}{L} = z\left(\frac{K}{L}\right)^{\alpha}$$

Combining with previous slide

$$\bar{y} = z\left(\frac{K}{L}\right)^{\alpha} \quad \Rightarrow \quad L = K\left(\frac{z}{\bar{y}}\right)^{\frac{1}{\alpha}}$$

Technology

What happens after an improvement in technology? In the short run we will have

$$\frac{Y}{L} > \bar{y} \quad \rightarrow \quad \frac{\dot{L}}{L} > 0$$

But over time, population growth will dissipate these gains until we return to the original standard of living

This result is called **Malthusian stagnation**: one-off improvements in technology will not change the long-run standard of living

Continual Growth Not enough

For there to be constant population growth, we need Y and L to grow at the same rate. From the standard of living function, we can see that this require $g_z = \alpha g_L$, so that

$$g_L = \frac{g_z}{\alpha} = \theta\left(\frac{Y}{L} - \bar{y}\right) \quad \Rightarrow \quad \frac{Y}{L} = \frac{g_z}{\alpha\theta} + \bar{y}$$

So even continual, exponential improvements in technology only yield a slight increase in the standard of living

— turns out the fixed factor (land) is a big deal!

Growth + Demographic Transition

Malthusian world arises because of fixed factor (land) and increasing population growth

— giving up on either of these assumptions opens up new possibilities

What if population growth had some natural maximum?

$$\frac{\dot{L}}{L} = \min\left\{\theta\left(\frac{Y}{L} - \bar{y}\right), n\right\}$$

If technology (z) grows fast enough, it can continually outpace effects of population growth (n)

Advanced Theories

The Three Horsemen of Riches: Plague, War, and Urbanization in Early Modern Europe

NICO VOIGTLÄNDER
UCLA Anderson School of Management and NBER
and
HANS-JOACHIM VOTH
ICREA CREI, Barcelona GSE, and Department of Economics, Universitat Pompeu Fabra

The Three Horsemen of Riches: Plague, War, and Urbanization in Early Modern Europe (by Voigtländer and Voth, 2012)

Income and Urbanization

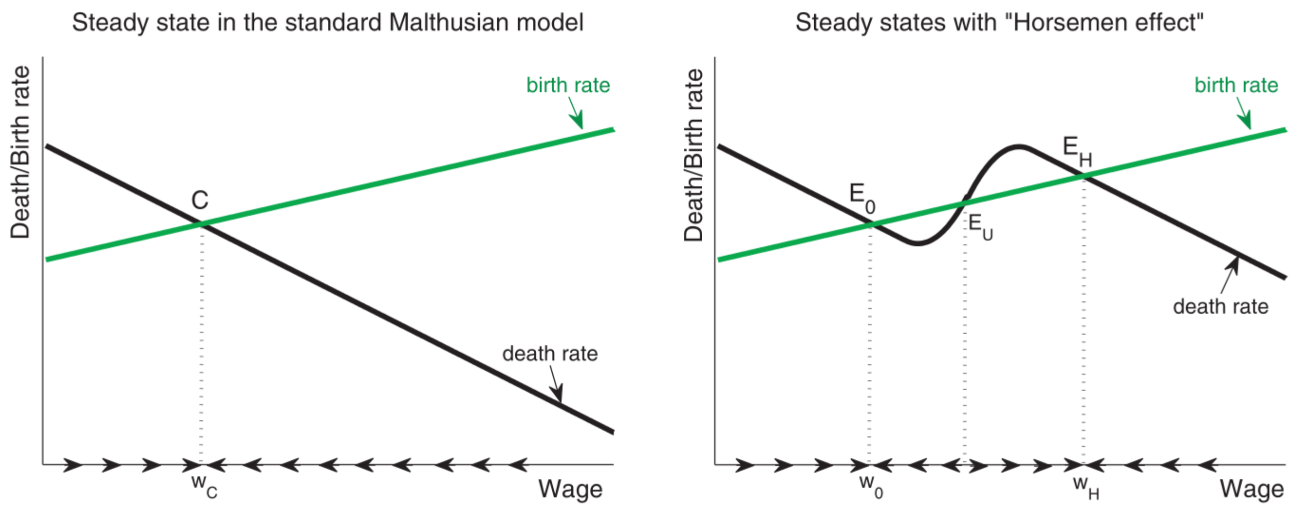
These authors propose an enrichment of the standard Malthusian model that still features birth rates that are increasing as a function of income

However, while death rates are generally decreasing in income, there is an income region where death rates actually increase with income

- They propose that this increase in death rates is driven by urbanization

These are the three horsemen: urbanization and hence plague are fairly direct, while the capacity to wage war often rises with income

Enhanced Malthus



These represent generalizations of the simple demographic model from earlier

$$\frac{\dot{L}}{L} = b(y) - d(y)$$

Multiple Equilibria

Their model features multiple equilibria: one high income and one low income

— This type of explanation is useful for cases where we wish to explain differences in countries that appear otherwise similar early on

They focus in particular on the Black Death as a driving factor and identification point for their analysis

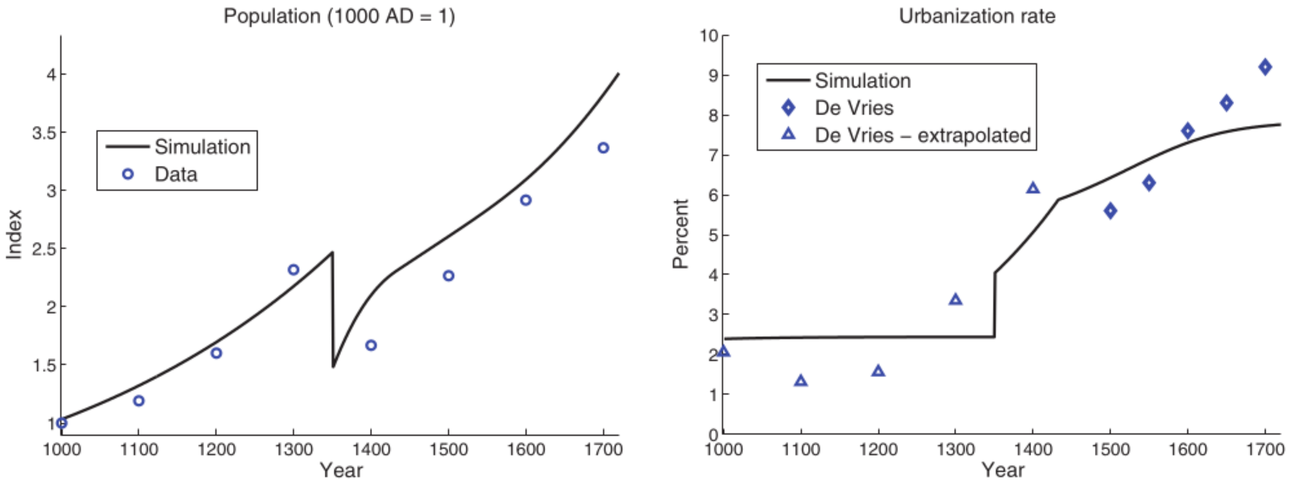
— This addresses the question of why the plague, which also impacted China did not induce the same effects (slightly lower income or lower plague deaths overall)

Acemoglu and Robinson call these types of events *critical junctures* in their work

— They also cite the Black Death but focus on differences between eastern and western Europe induced by feudal structure

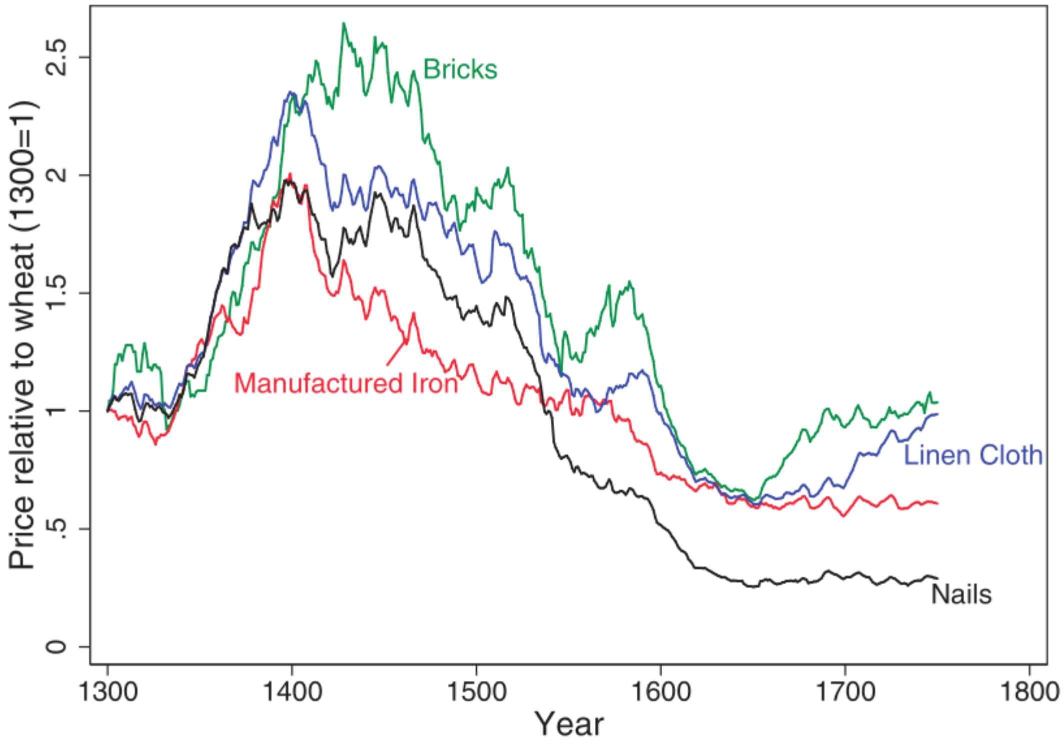
Matching the Data

Using a fairly complex model of demographics, and urbanization, they are able to match the historical account quite well



Shift to Manufacturing

The role of urbanization in mediating a permanent shift towards manufacturing can be seen better in the price data



Unified Models

POPULATION GROWTH AND TECHNOLOGICAL CHANGE: ONE MILLION B.C. TO 1990*

MICHAEL KREMER

The nonrivalry of technology, as modeled in the endogenous growth literature, implies that high population spurs technological change. This paper constructs and empirically tests a model of long-run world population growth combining this implication with the Malthusian assumption that technology limits population. The model predicts that over most of history, the growth rate of population will be proportional to its level. Empirical tests support this prediction and show that historically, among societies with no possibility for technological contact, those with larger initial populations have had faster technological change and population growth.

Population Growth and Technological Change: One Million B.C. to 1990 by Michael Kremer (1993)

Long-run Population Figures

Includes a plot of population levels and growth rates going back tens to hundreds of thousands of years

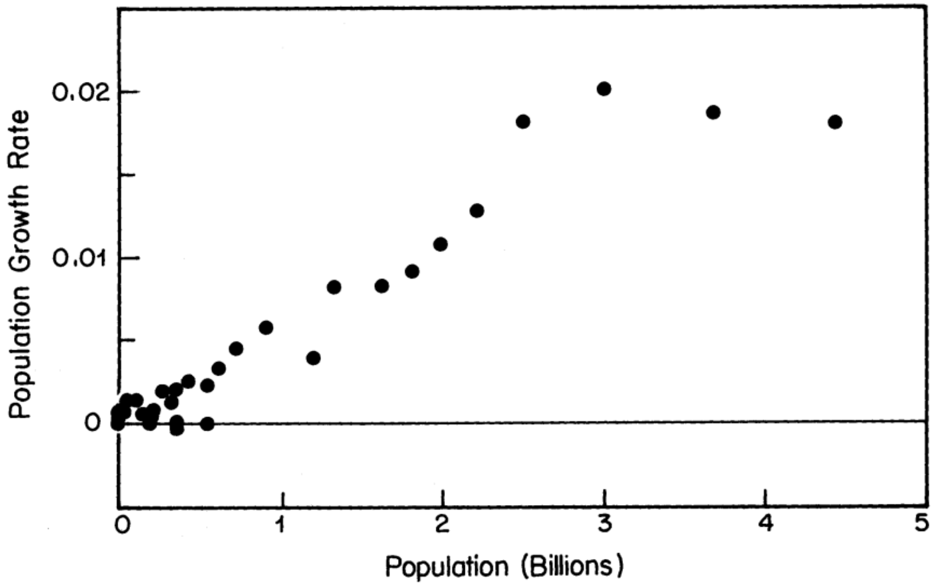


FIGURE I
Population Growth Versus Population

Endogenous Technology

Technological growth is presumed to be proportional to population size. The demographic function is assumed to be increasing then decreasing

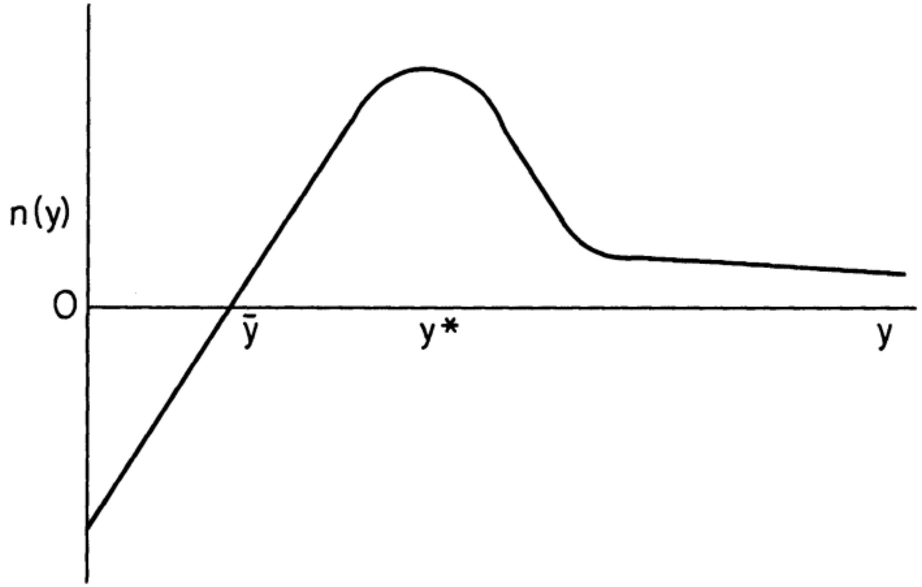


FIGURE II
Population Growth Versus Income

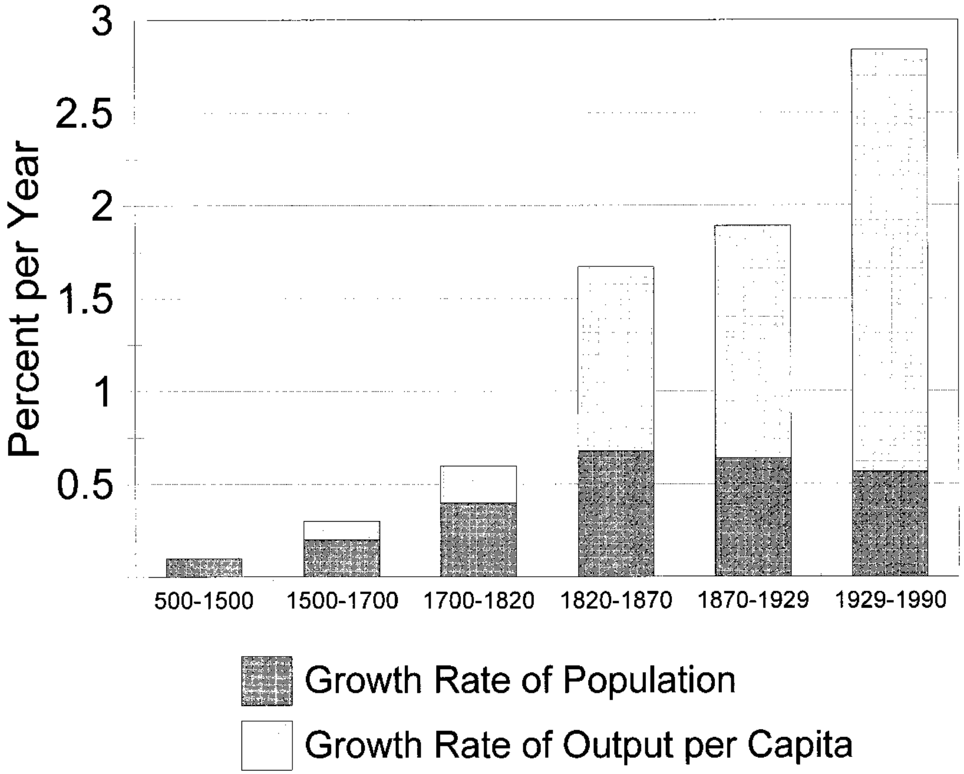
Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond

By ODED GALOR AND DAVID N. WEIL*

This paper develops a unified growth model that captures the historical evolution of population, technology, and output. It encompasses the endogenous transition between three regimes that have characterized economic development. The economy evolves from a Malthusian regime, where technological progress is slow and population growth prevents any sustained rise in income per capita, into a Post-Malthusian regime, where technological progress rises and population growth absorbs only part of output growth. Ultimately, a demographic transition reverses the positive relationship between income and population growth, and the economy enters a Modern Growth regime with reduced population growth and sustained income growth. (*JEL* J13, O11, O33, O40)

Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond (by Galor and Weil, 2000)

Motivating Facts



At some point in Western Europe the Malthusian chain between per capita output and population growth breaks

Timing of Events

Galor and Weil push for a particular order in which various regimes occurred

$$\text{Malthusian} \quad \underbrace{\longrightarrow}_{\text{tech growth}} \quad \text{Post-Malthusian} \quad \underbrace{\longrightarrow}_{\text{demo transition}} \quad \text{Modern Growth}$$

Malthusian: minimal population growth and stagnation in income

Post-Malthusian: both income growth and population growth

Modern Growth: continued income growth and leveling off of population growth rates

Demographic Transition

Galor and Weil add some nuance to the demographics and education situation

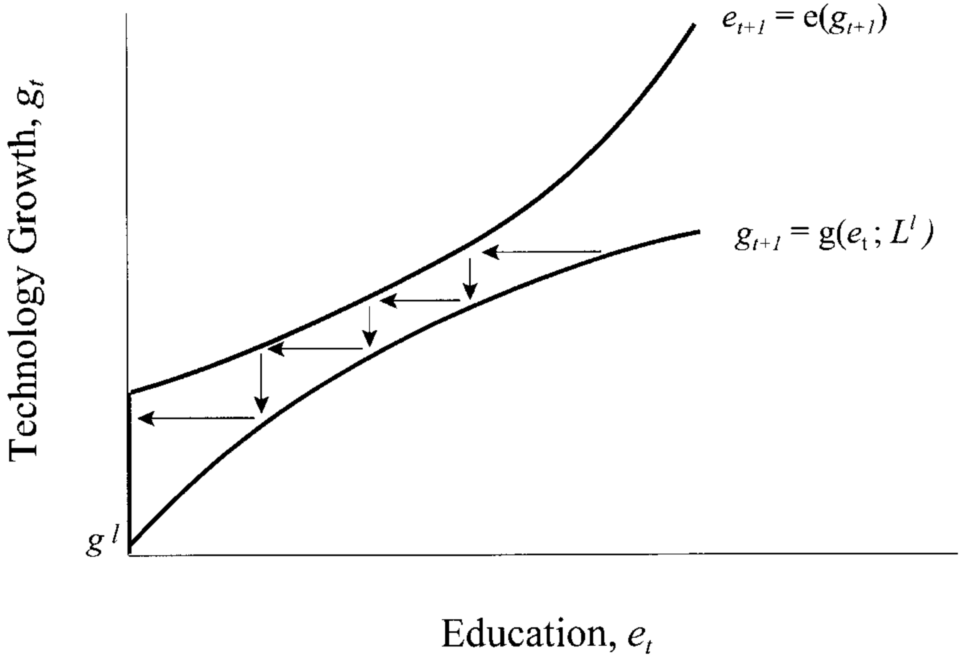
Why did the demographic change occur and why did it do so right after technological takeoff?

- Switch from focus on *quantity* of children to *quality* of children
- Parents will devote more time to educating a smaller number of children

Rapid technological growth requires more education to "keep up", and this education ultimately spurs future economic growth

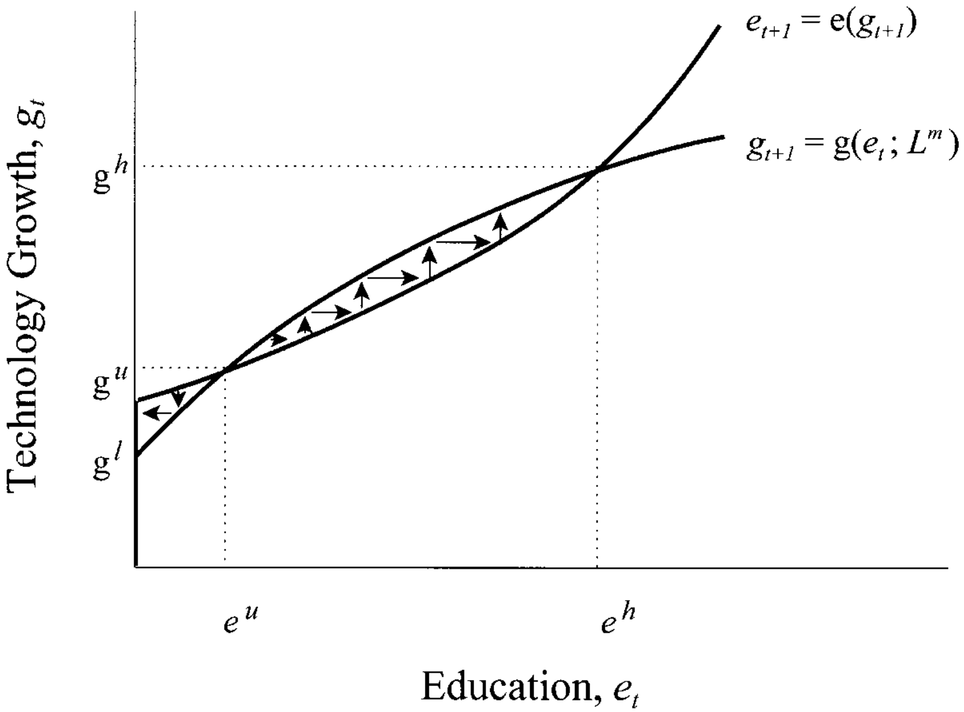
Population Scale Effects I

With a Kremer-like effect of population on technological growth, a sufficiently large society will induce education "race" and effect a demographic transition



Population Scale Effects II

Larger population creates one high growth, high education equilibrium, with remaining possible of low/low equilibrium



Population Scale Effects III

Sufficiently large population levels make high growth, high education equilibrium inevitable