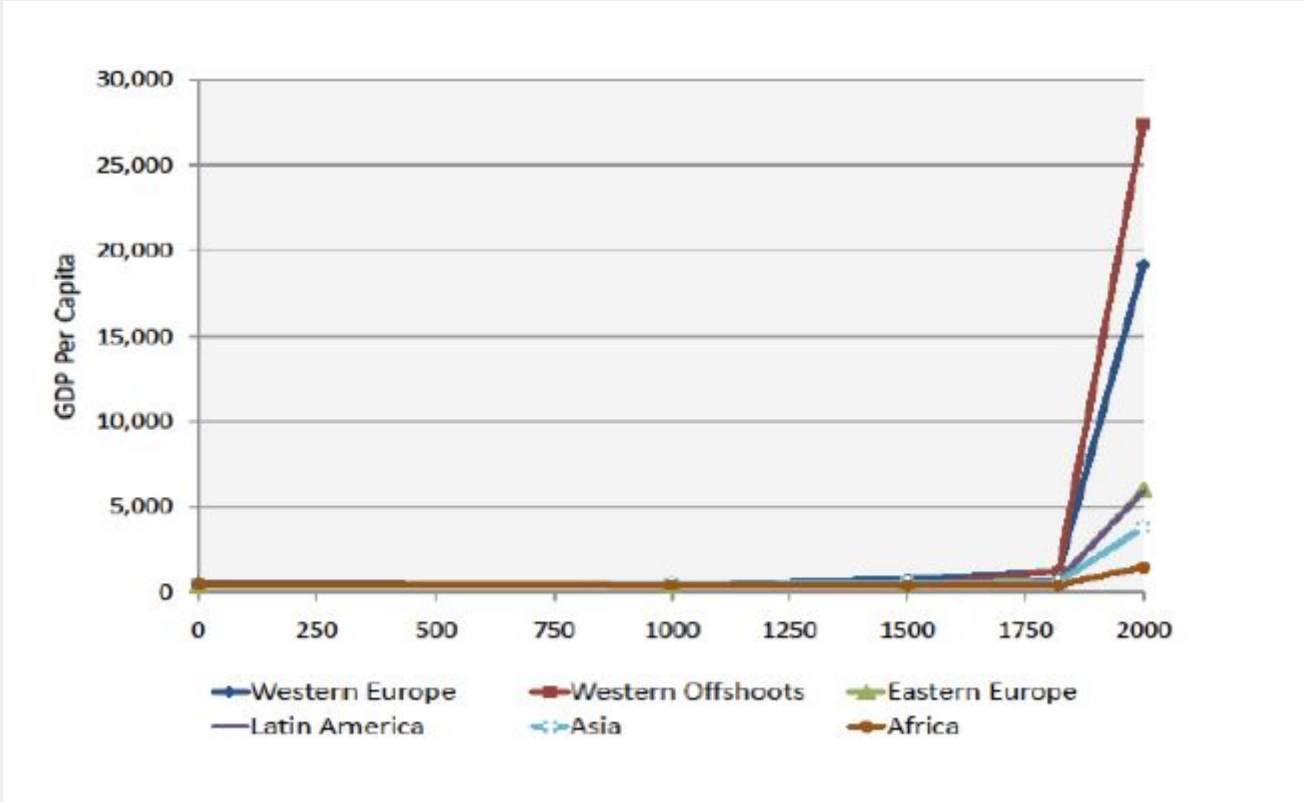
The very very long run

Econ 252

Prof. Casey

Malthusian Model


30,000
25,000
20,000
15,000
10,000
5,000
0
GDP Per Capita
0
250
500
750
1000
1250
1500
1750
2000
Western Europe
Western Offshoots
Eastern Europe
Latin America
Asia
Africa

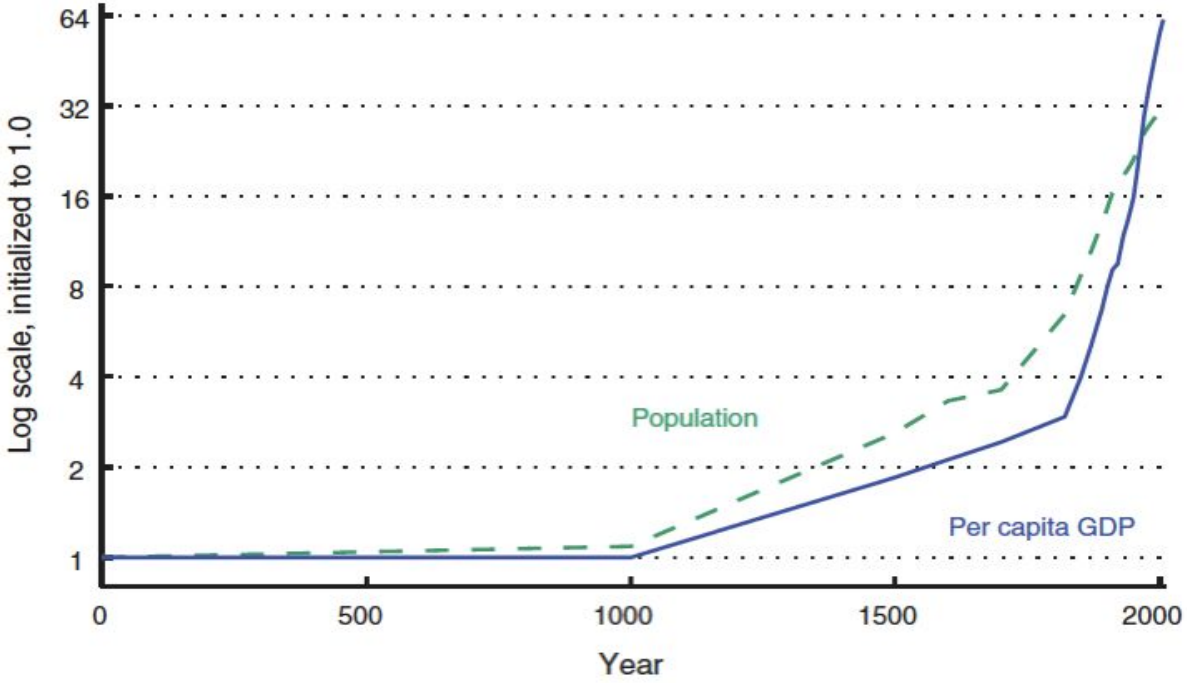


FIGURE 2. POPULATION AND PER CAPITA GDP OVER THE VERY LONG RUN

Notes: Population and GDP per capita for "the West," defined as the sum of the United States and 12 western European countries. Both series are normalized to take the value 1.0 in the initial year, 1 AD.

Malthusian Era

- So, what is different about the malthusian era?
  - England pre-1760 vs. today.
  - No investment in capital (human or physical).
    - Could be a true constraint or a decision.
    - Heavy reliance on land and natural resources.
  - Slower and more erratic technological progress.
    - No exponential growth in technology or income.
- We will examine a simple model of Malthusian population dynamics.
  - Looks a lot like Solow model.

Malthusian model: production

- Consider the following production function:

$$Y_t = \bar{A} \cdot F(\bar{X}, L_t)$$

  - $\bar{X}$: Land (fixed over time).
  - $\bar{A}$: Factor-neutral technology.
    - Doesn't regularly grow.
    - Could multiply L, but unnecessarily complicated.

- Constant returns to scale:

$$y_t = \bar{A} f(x_t), \;\; x_t = \bar{X}/L_t.$$

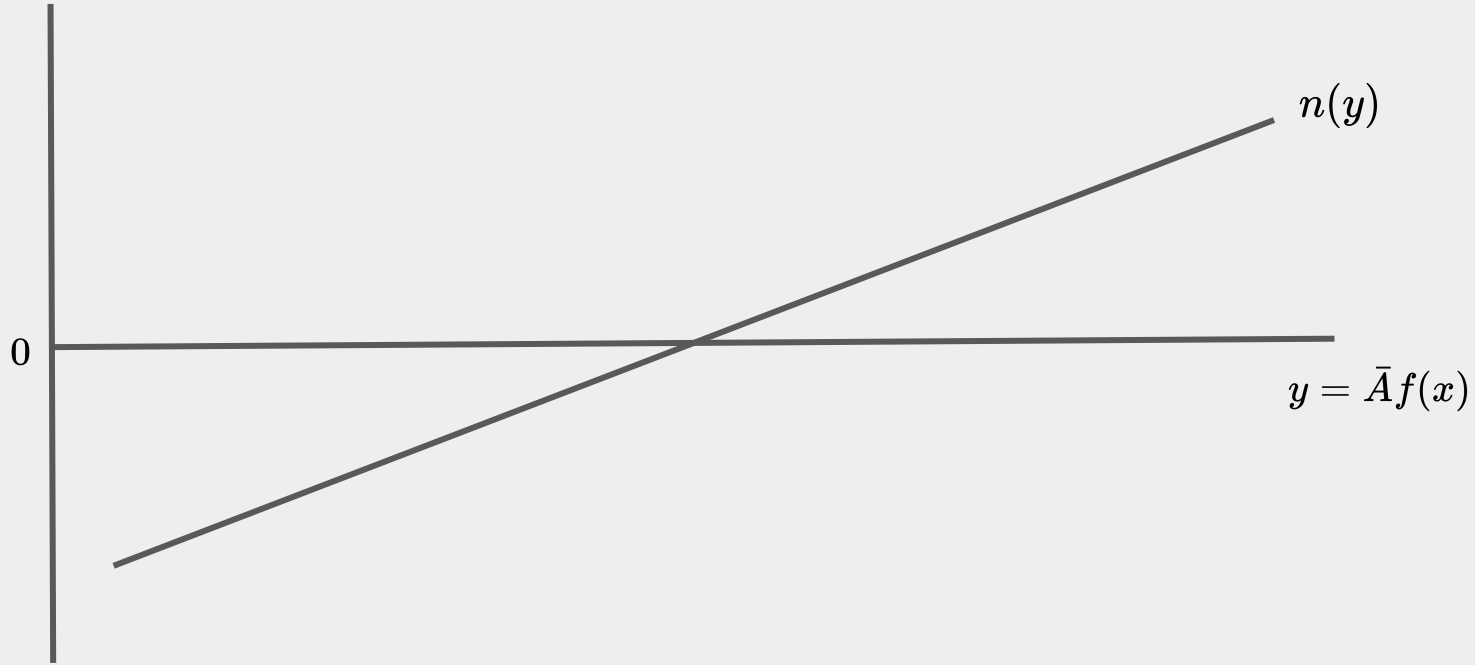
Endogenous Population Growth

- Over this period, higher income → more population growth.
  - Afford to raise more children.
  - Better nutrition → less death.

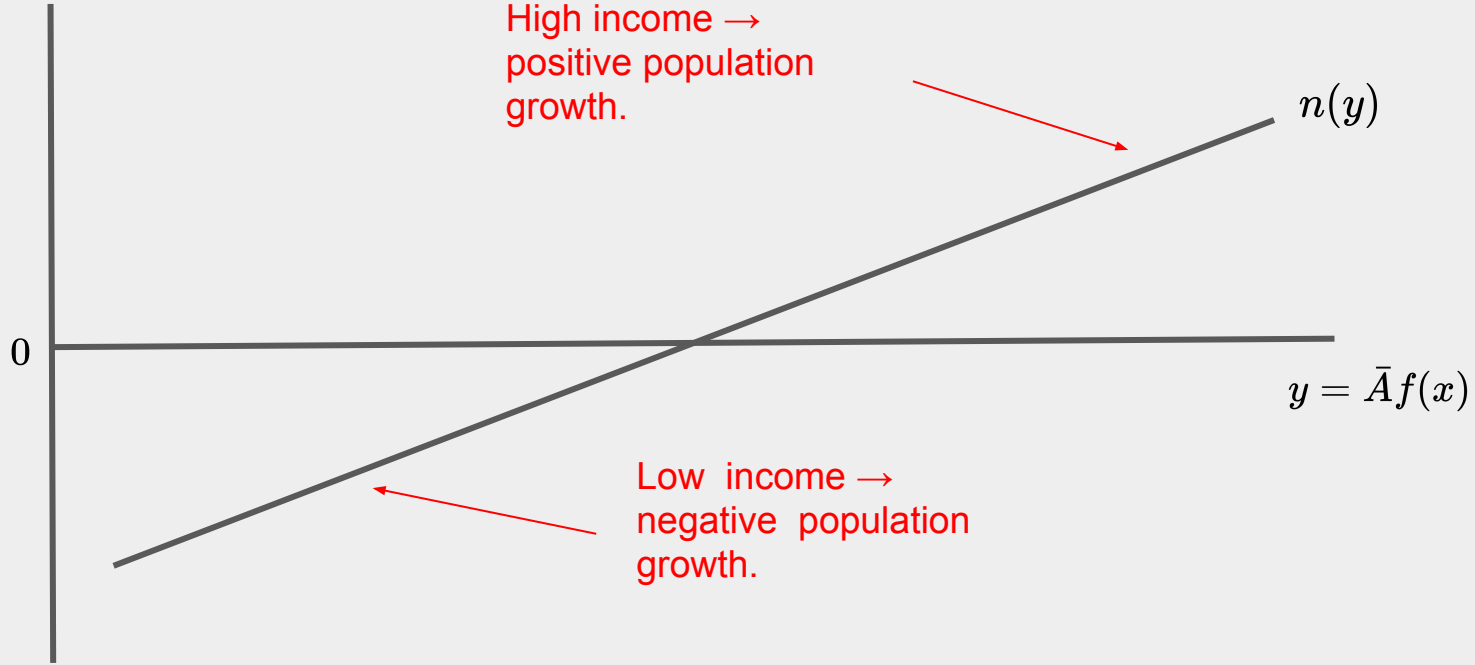
- So, population growth is a function of income per capita: $n(y_t) = \bar{n} \cdot (y_t - \tilde{c})$
  - Linear relationship between income and pop growth.
  - $\bar{n}$: exogenous parameter determining sensitivity of pop growth.
  - $\tilde{c}$: income needed to support constant population.
    - 'Subsistence consumption.'

- Recall: Can have negative population growth.

Endogenous population growth



Endogenous population growth



Law of motion for x

- The fundamental equation of the Malthusian model:

$$\underbrace{\Delta x_{t+1}}_{\text{change in } x} = \underbrace{s \cdot y_t}_{\text{investment}} - \underbrace{(n+\delta)x_t}_{\substack{\text{depreciation} \\ \& \text{ dilution}}}$$

$$\begin{aligned}
&= -n \cdot x_t && \text{(no investment or depreciation)} \\
&= -n(y_t) \cdot x_t && \text{(endogenous population)} \\
&= -n\left(\bar{A} \cdot f(x_t)\right) \cdot x_t. && \text{(intensive form)}
\end{aligned}$$

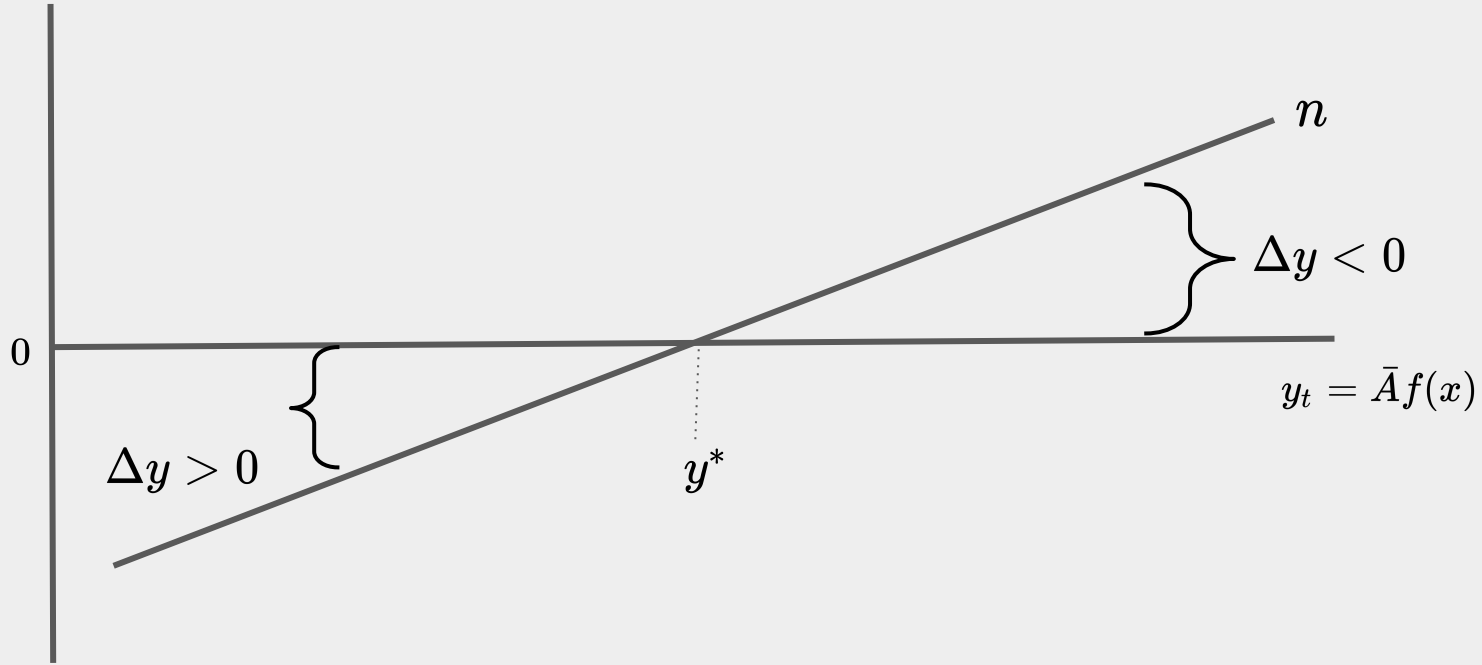
Impact of population on income

- So, $\Delta x_{t+1} \gtreqless 0 \iff n \lesseqgtr 0.$
  - x increases if and only if n is negative.

- Also, $\Delta y_{t+1} \gtreqless 0 \iff \Delta x_{t+1} \gtreqless 0.$
  - Income per capita increases if and only if capital per worker increases.

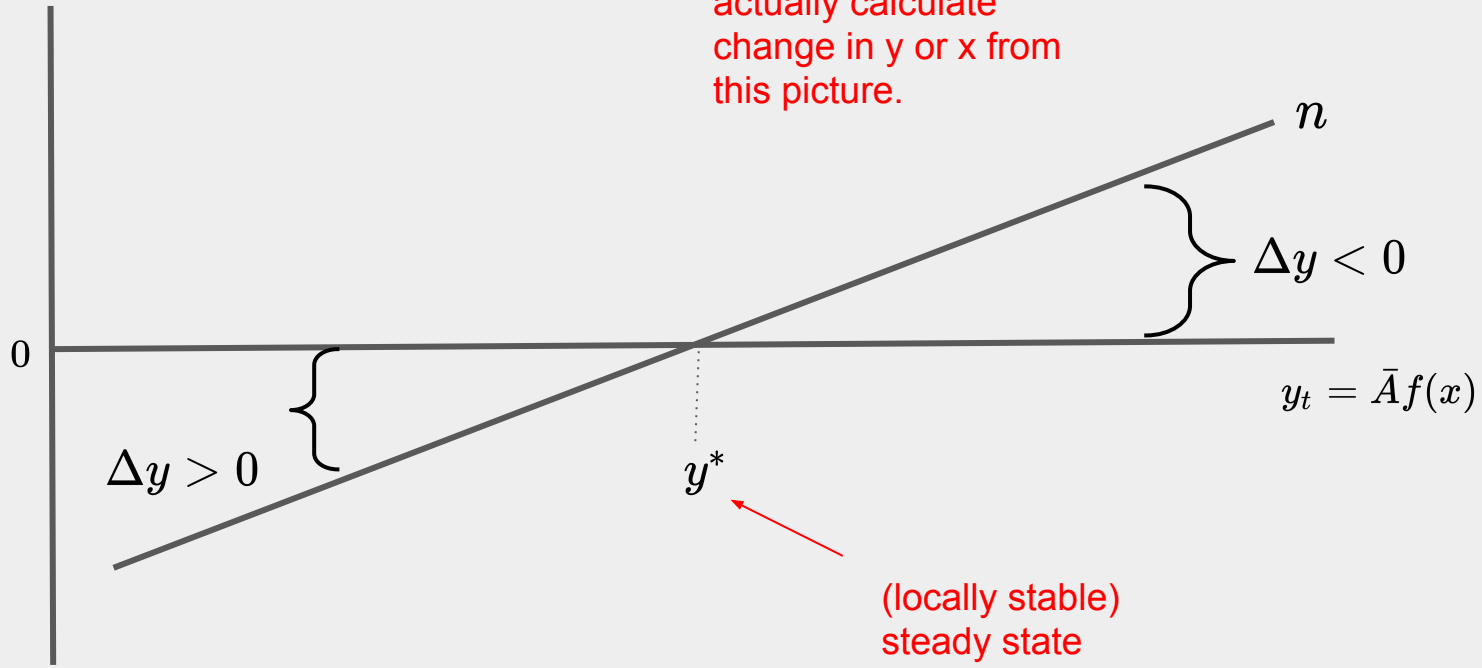
- Putting these together, $\Delta y_{t+1} \gtreqless 0 \iff n \lesseqgtr 0.$
  - Smaller population → more land per person and vice versa.
  - All income derived from land.

Population growth



Population growth

Note: unlike Solow model, we can't actually calculate change in y or x from this picture.



Subsistence consumption

- Using our specific function:

$$n(y_t) = \bar{n} \cdot (y_t - \tilde{c})$$

- In steady state:

$$n(y^*) = 0 \Rightarrow y^* = \tilde{c}.$$

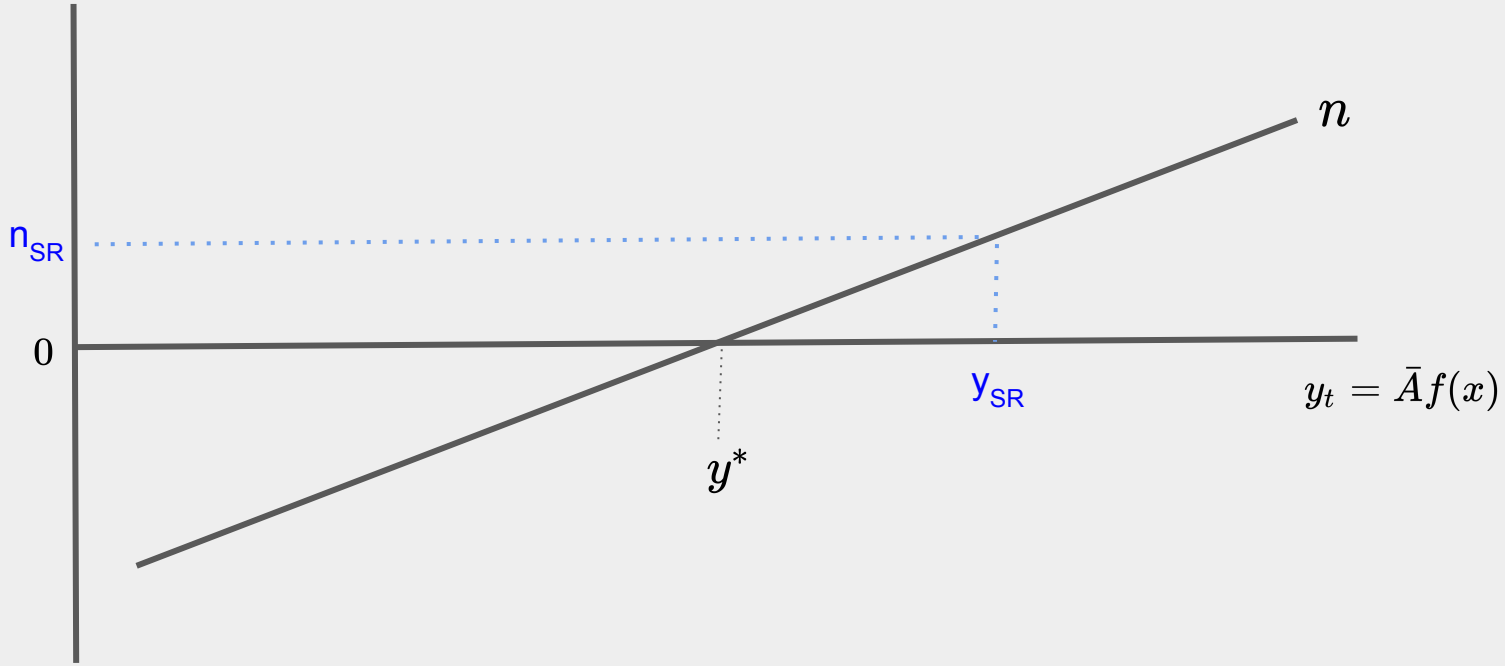
  - Endogenous population growth pushes income to level needed for constant pop
  - ‘Subsistence consumption’

Technology Improvements

- There is still technological improvement in the Malthusian era.
  - Just not constant (or exponential) growth.

- What happens when tech suddenly improves)?
  - I.e., impact of a one time increase in A …
    - On n in short run and long run?
    - On y in short run and long run?
    - Population in the long run?

Population growth



Technology Improvements

- There still technological improvement in the Malthusian era.
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- What happens when tech suddenly improves)?
  - I.e., impact of a one time increase in A …
    - On n in short run and long run?
      - Increase in SR. Then back to zero.
    - On y in short run and long run?
      - Increases in SR, then back to subsistence.
    - Population in the long run?
      - Higher. Population growth is positive until end up back in steady state.

Data

- These results are consistent with evidence.
  - Ashraf and Galor (2011).

- In malthusian era,
  - Higher productivity → higher population.
  - Higher productivity has no impact on income.

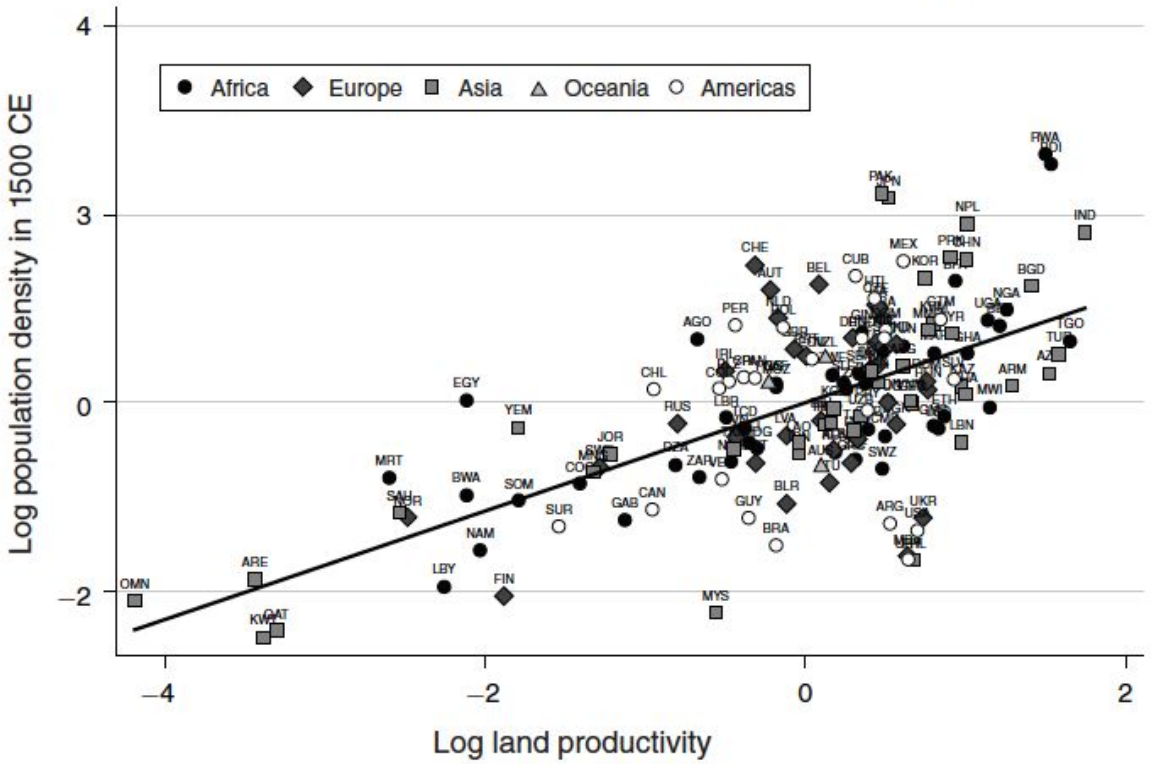


FIGURE 3. TRANSITION TIMING, LAND PRODUCTIVITY, AND POPULATION DENSITY IN 1500 CE

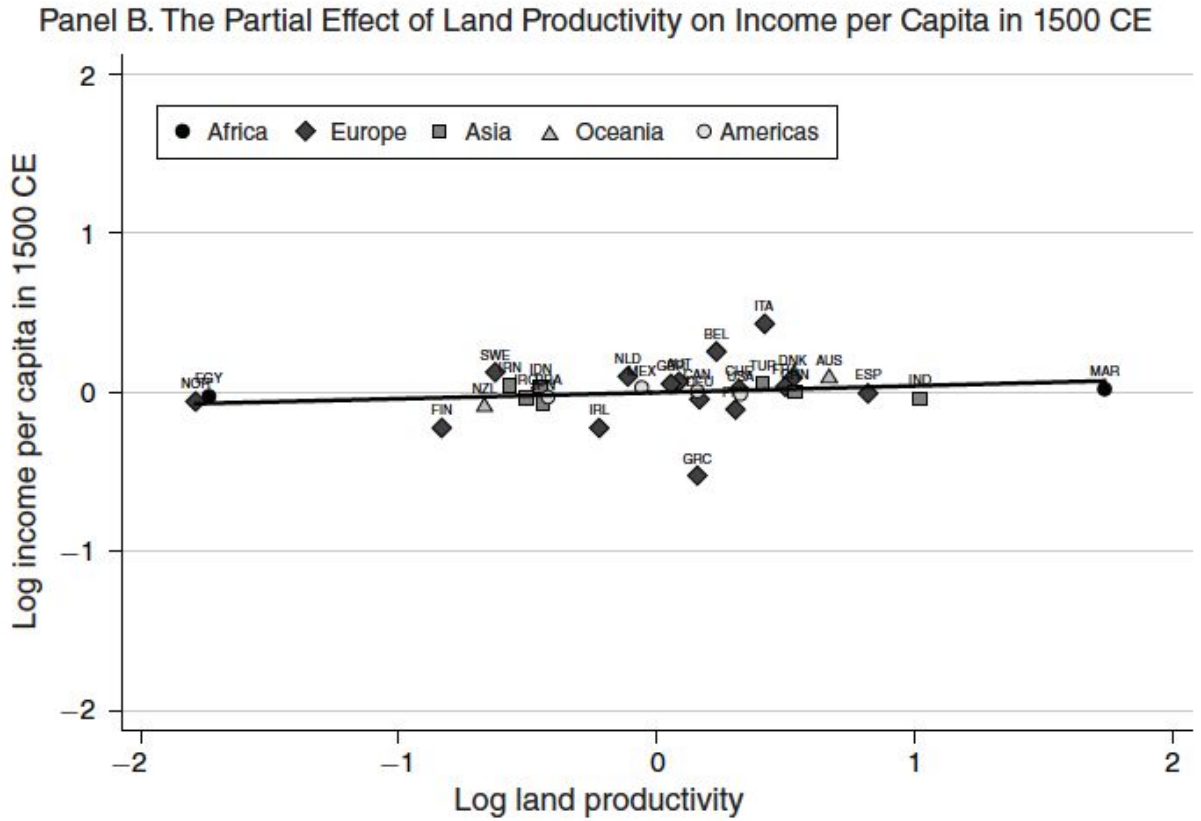
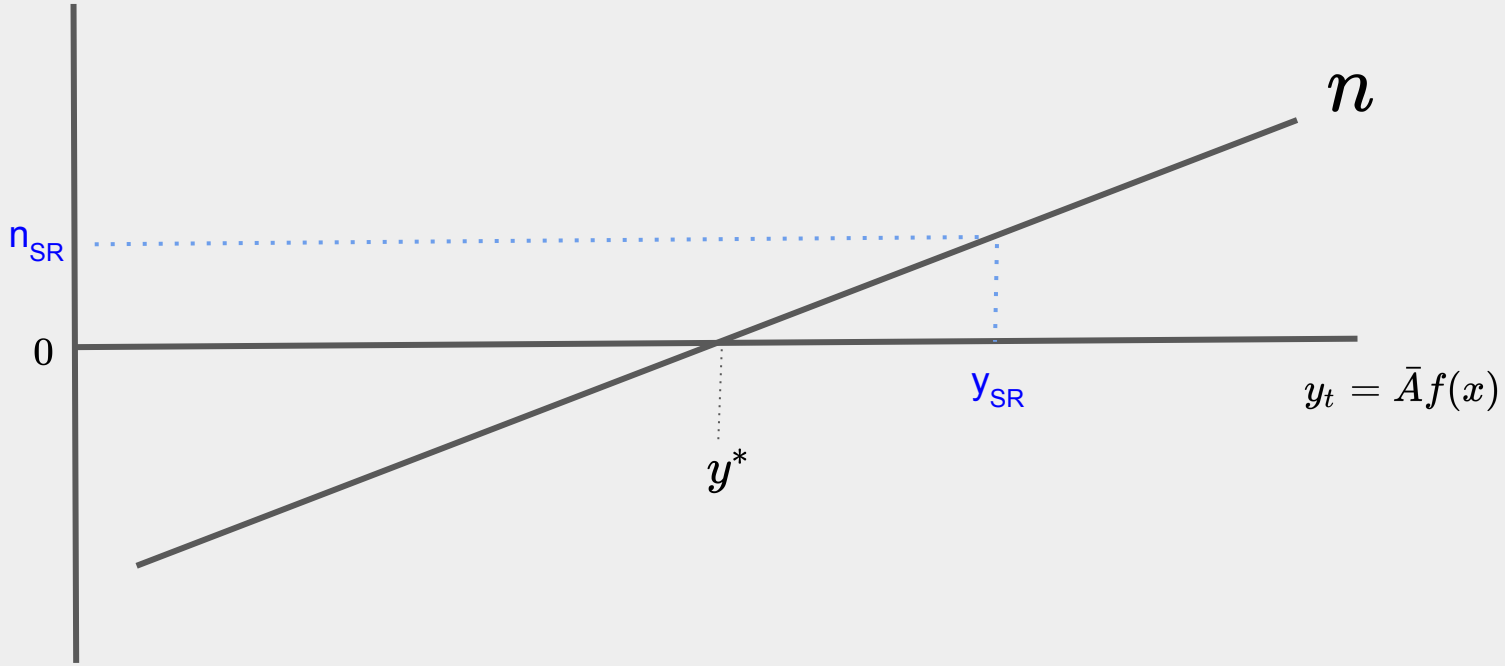


FIGURE 4. TRANSITION TIMING, LAND PRODUCTIVITY, AND INCOME PER CAPITA IN 1500 CE

Practice Problem

- Economic Impacts of the Plague: How does a sudden, one time drop in pop affect:
  - Income per capita in the short run and long run?
  - Population growth in the short run and long run?
  - Total population in the long run?
  - Total income in the long run?

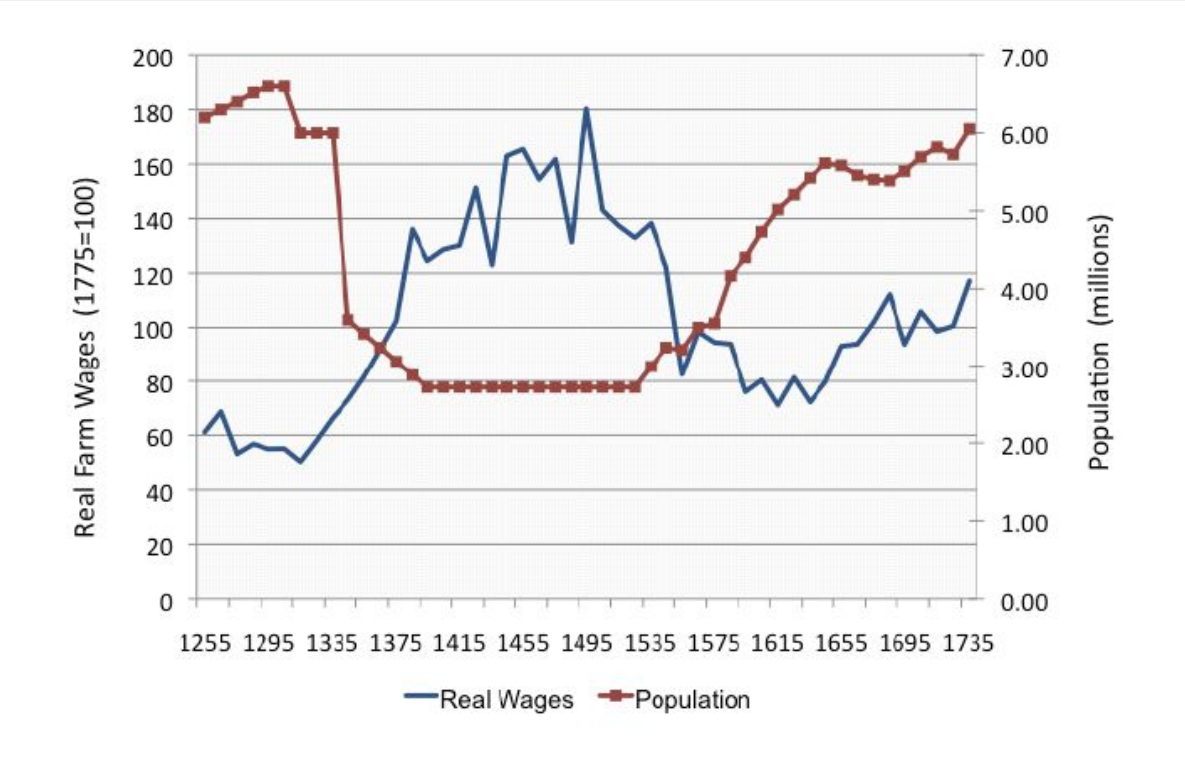
Plague



Practice Problem

- Economic Impacts of the Plague: How does a sudden, one drop in population affect:
  - Income per capita in the short run and long run?
    - SR: Lower L → higher x → higher y.
    - LR: back to steady state.
  - Population growth in the short run and long run?
    - SR: higher income → higher (and positive) pop growth.
    - LR: Back to steady state (zero pop growth).
  - Total population in the long run?
    - LR: y is back to starting point. A and X haven't changed → L must also be back to original level.
  - Total income in the long run?
    - y and L back to starting point → Y also back to starting point.

Evidence from malthusian England



Unified Growth Theory

From Malthus to Solow

- How do we get from Malthus to Solow?
  - Biggest question in macroeconomics?
  - Could spend the rest of your life studying this question.
  - Similar question: what caused the industrial revolution?

- What's the difference between Malthusian and Solow 'Regimes'?
  - Ability/desire to invest.
  - Relationship between income and pop growth.
  - Rate of technological progress.

- These are closely related.

Mathus to Solow

- Many different theories of the take-off. Essentially all involve ...
  - Some sort of technological progress → changes in incentives/ability to invest.

- Example: invention of steam engine → possible for large scale industrial production → investment in capital goods.
  - Probably part of the story.
  - Doesn’t explain why fertility changes.
  - Very specific invention.
  - Doesn’t explain where inventions come from.

- A more complete story: Unified Growth Theory.

Quantity-Quality Tradeoff

- 'Quantity-Quality' trade-off:
  - Term from biology.
  - Parents (like everyone) have limited resources.
  - Face a tradeoff: have more children (quantity) or invest in the well-being of each child (quality).
    - Education, health, etc.

- Decision depend on incentives:
  - E.g., More quality investment when returns to education are high.

Boserup Effect

- Due to Esther Boserup (1965), who worked on agricultural productivity

- So far, we have mostly seen the negative effects of population growth:
  - Dilution of physical (K) and natural (X) capital.

- But, population growth can promote economic growth:
  - More people → more idea new ideas.
  - More people → more people to use new ideas (non-rivalry).

- We already thought about this is the context of R&D.
  - Also: more education → faster tech progress.

Unified Growth Theory

- Technological progress tends to be skill-biased.
  - As we have discussed when looking at recent data.

- In Malthusian times, sporadic technological progress → little incentive for edu.
  - Increases in productivity → more people (as we have seen).
  - More people increases the likelihood of a big breakthrough.

- When there is a big breakthrough → high returns to education.
  - Parents switch from 'quantity' to 'quality' and invest in education.
  - Higher education → faster tech progress.
  - Faster progress → more return to edu.
  - New cycle generates a Solow world with investment in education.

Related theories

- Unified Growth Theory due to work of David Weil, Oded Galor and coauthors.

- Many people believe that some story like this is correct.
  - But, the exact details are still hotly debated.

- Examples:
  - Maybe its physical capital, rather than technology, that increases return to skill?
  - What role does health play?