Readings for the Next Lectures

Readings for the next lectures:

- Bocquet-Appel, Jean-Pierre (2011), "When the World's Population Took Off", *Science*

On Friday, we will talk about the referee report details.

How does this relate to the first several thousand years?

- So what does growth accounting tell us about the pre-industrial world?
- Generally, it tells us what to look at: technological change, capital per worker, land per worker
- It tells us that modern growth is largely about technological change
- It also shows that population growth tends to hold back income growth
- In our look at the pre-industrial world, we'll try to identify why we didn't achieve sustained growth
- This will (hopefully) tell us what had to change to enter the modern world

How does this relate to the first several thousand years?

One quote from Abramovitz to keep in mind:

> *"This result is surprising in the lopsided importance which it appears to give to productivity increase, and it should be, in a sense, sobering, if not discouraging, to students of economic growth..."*

How does this relate to the first several thousand years?

One quote from Abramovitz to keep in mind (continued):

> *"Since we know little about the causes of productivity increase, the indicated importance of this element may be taken to be some sort of measure of our ignorance about the causes of economic growth..."*

Technological Change and the Pre-Industrial World

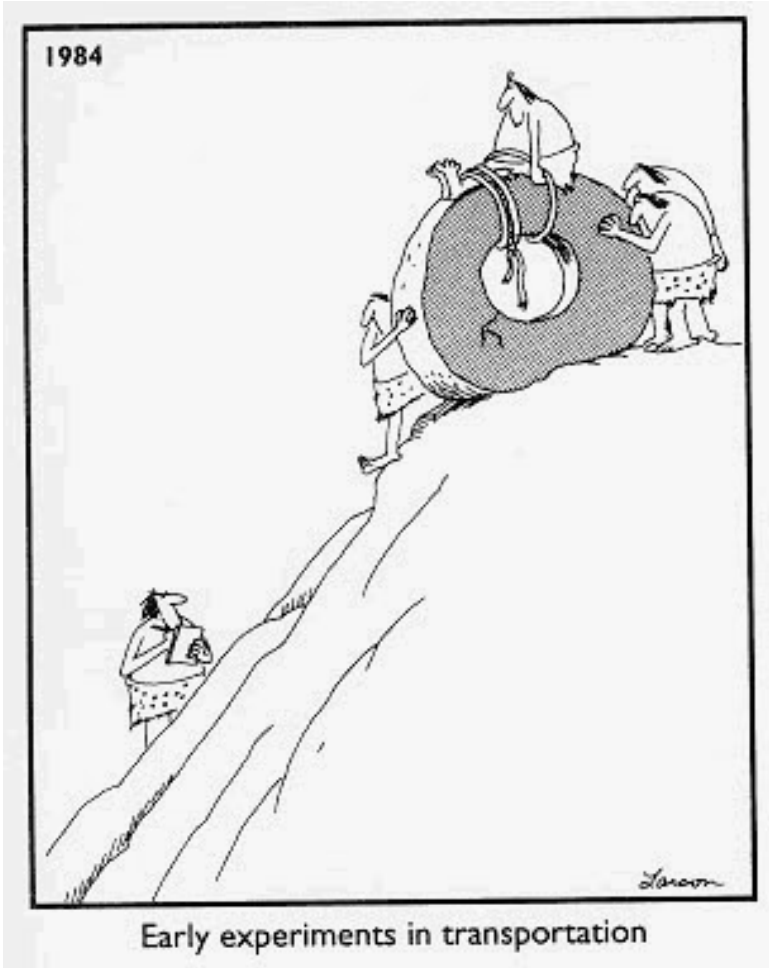
- A quick answer to stagnant standards of living in the pre-industrial world is that we simply didn't have technological change
- The quick response to this quick answer is, "That's ridiculous."
- There were incredible changes in technology before the industrial revolution.
- Think of what the world was capable of in 3000 B.C. versus what it was capable of in 1600 A.D.

The Pre-Industrial World's Greatest Hits

Prometheus Carrying Fire, Jan Cossiers, 17th century

The Pre-Industrial World's Greatest Hits

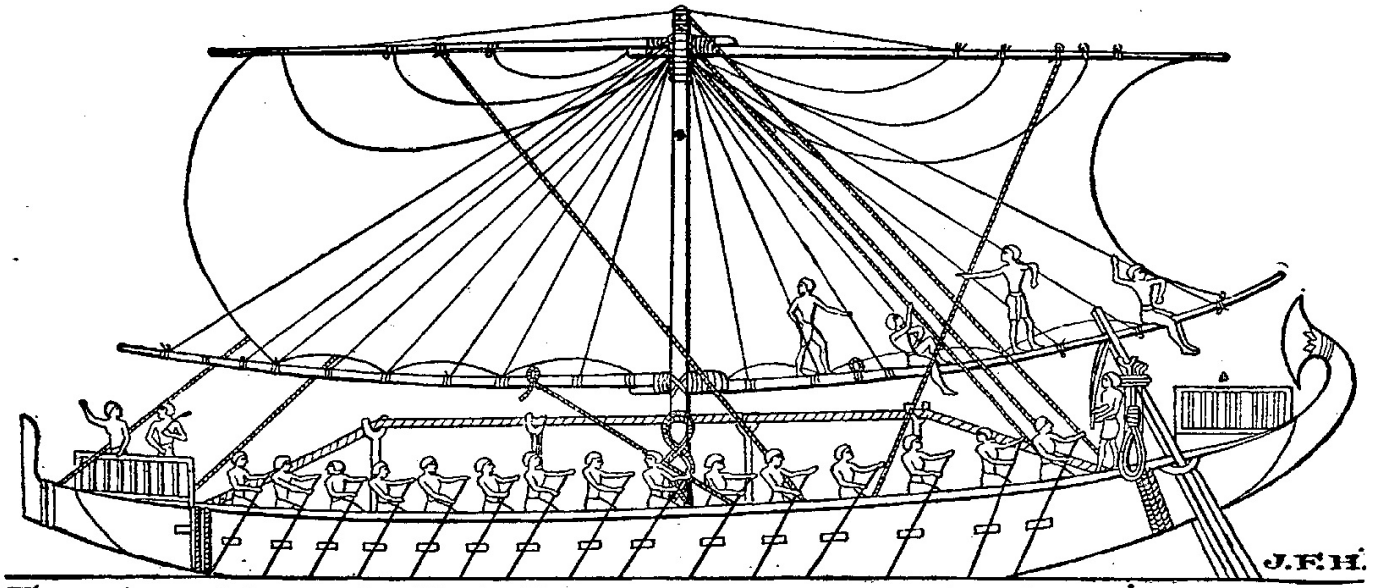
The Pre-Industrial World's Greatest Hits



Gary Larson, The Far Side

The Pre-Industrial World's Greatest Hits

The Pre-Industrial World's Greatest Hits

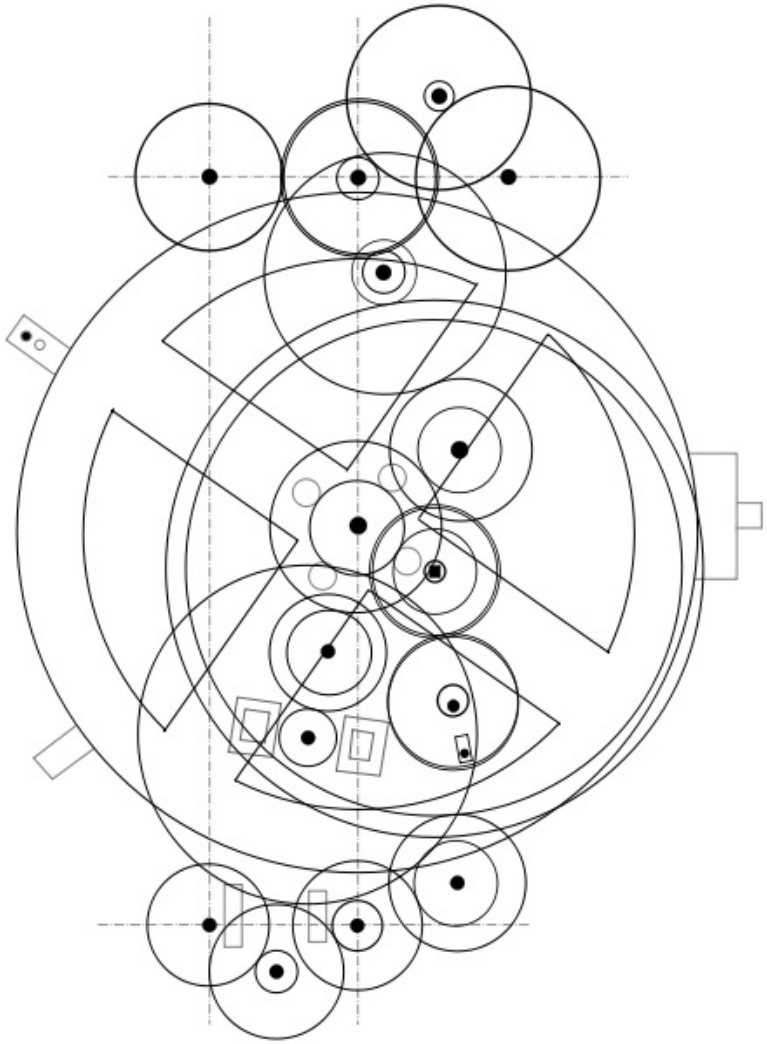


Egyptian ship on the Red Sea, about 1250 B.C. [From Torr's "Ancient Ships."]
Mr. Langton Cole calls attention to the rope *truss* in this illustration, stiffening the beam of the ship. No other such use of the truss is known until the days of Modern engineering.

The Pre-Industrial World's Greatest Hits

Antikythera mechanism fragment

The Pre-Industrial World's Greatest Hits



Antikythera mechanism schematic

The Pre-Industrial World's Greatest Hits

Technological Change and the Pre-Industrial World

- The pre-industrial world is full of big, big innovations
- The structure and capacity of the economy was transformed multiple times in dramatic ways
- Yet these changes didn't have lasting effects on the standard of living
- We'll explore three specific moments in history to try to understand this:
  - The neolithic revolution
  - The black death
  - European shipping empires

Explaining Pre-Industrial Stagnation

- Before we get to the actual test cases, we're going to build a conceptual framework to make some predictions
- What we need is a model that ties together standard of living and technology
- Standard of living is going to depend on not only how much we produce, but how many people we divide it between (note Kenya on the previous tables)
- So our model also needs to take into account population change
- What does population change look like?

Population in the Modern World

First, a few definitions:

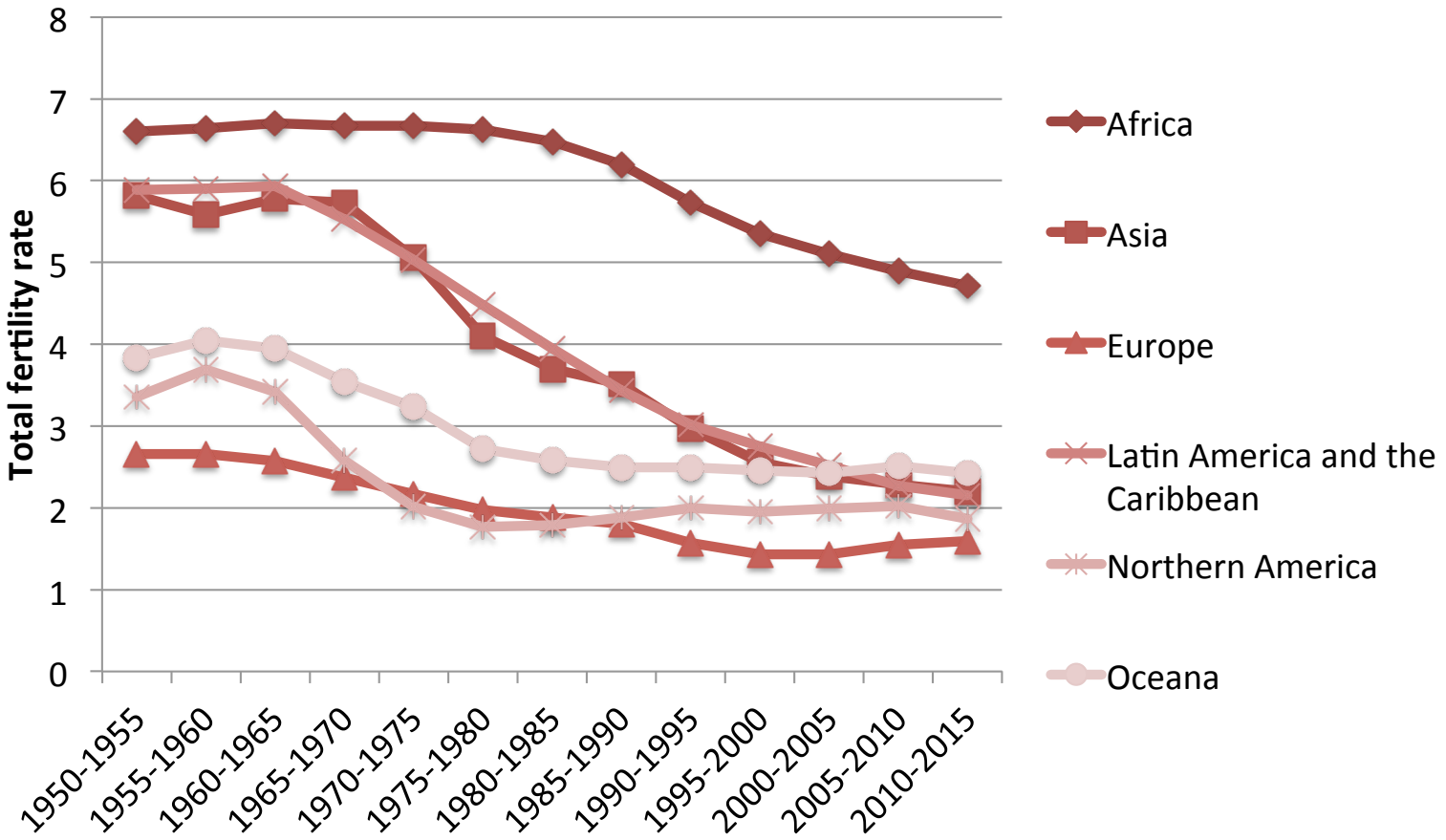
- **Crude birth rate**: annual number of births per thousand population
- **Total fertility rate**: average number of children born to a woman over her lifetime if (1) she experienced current age-specific fertility rates and (2) she survived from birth to the end of her reproductive career
- **Replacement fertility**: total fertility rate at which population levels are sustained (2.1 births per woman in developed countries, 2.5 to 3.3 birth per woman in developing countries, 2.33 globally)

Population in the Modern World

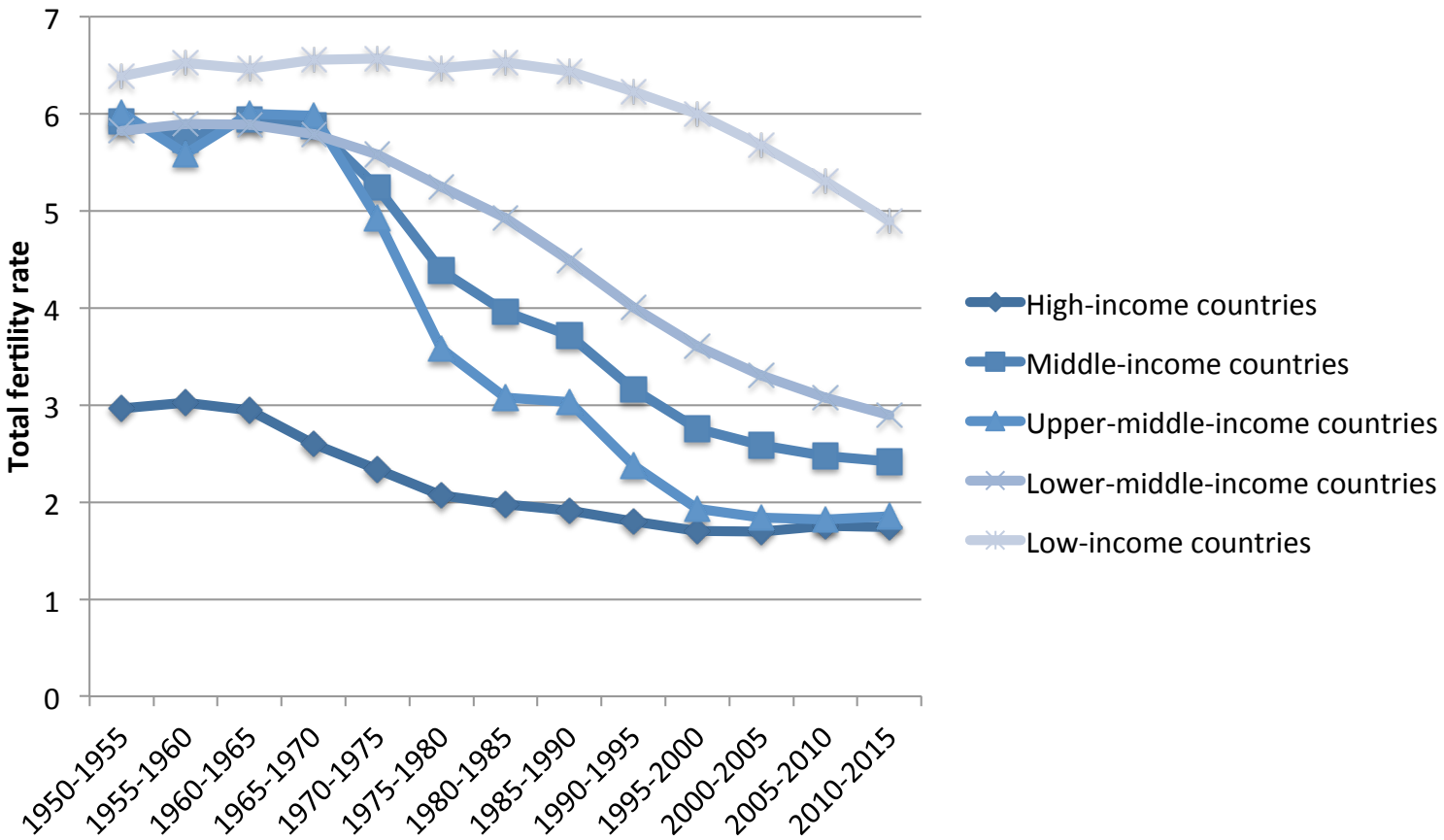
First, a few definitions (continued):

- **Gross reproduction rate**: average number of daughters born to a woman over her lifetime assuming if (1) she experienced current age-specific fertility rates and (2) she survived from birth to the end of her reproductive caree
- **Net reproduction rate**: average number of daughters born to a woman over her lifetimes assuming she experienced current age-specific fertility rates but accounting for mortality (a rate of 1 would mean no population growth)

Population in the Modern World



Population in the Modern World



Population in the Modern World

Population growth in the United States, 1850-2010

Year	Population (in thousands)	Surviving children per woman
1850	23,261	--
1870	39,905	--
1890	63,056	--
1910	92,407	2.672
1930	123,188	1.968
1950	151,684	2.870
1970	205,089	2.336
1990	250,181	1.994
2010	309,776	--

Population in the Preindustrial World

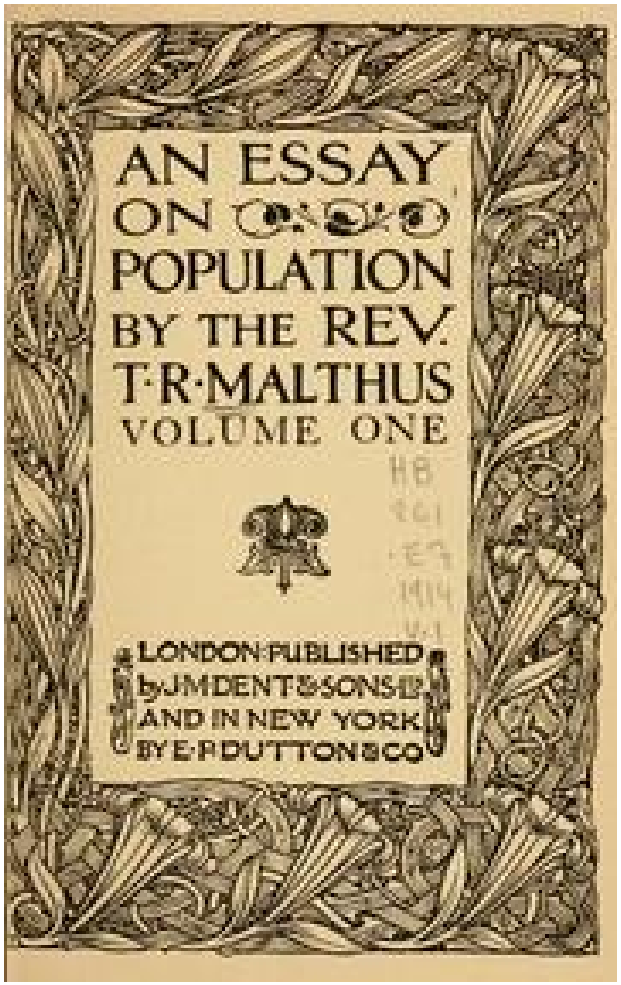
Location	Population in 1300	Population in 1800	Surviving children per woman
Norway	0.4	0.88	2.095
Southern Italy	4.75	7.9	2.061
France	17	27.2	2.056
England	5.8	8.7	2.049
Northern Italy	7.75	10.2	2.033
Iceland	0.084	0.047	1.93

Note: population is given in millions.

The Malthusian Trap

The Reverend Thomas Robert Malthus

The Malthusian Trap



Essay on the Principle of Population, 1798

The Malthusian Trap

A basic but powerful framework was proposed in the late 1700s by Thomas Robert Malthus, built upon two basic principles:

- *"First, That food is necessary to the existence of man."*
- *"Second, That the passion between the sexes is necessary and will remain nearly in its present state."*

The Malthusian Trap

These two basic principles lead to societies being trapped at a particular standard of living. According to Malthus:

> *Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio...This implies a strong and constantly operating check on population from the difficulty of subsistence.*

Explaining Stationary Populations

- One of the key differences between the preindustrial world and the modern world was that population size was pretty much static
- Malthus helps provide a very simple economic argument for why this was the case that we'll try to formalize
- The argument depends on three assumptions about how preindustrial economies worked:
  - Each society had a birth rate increasing with living standards
  - Each society had a death rate decreasing with living standards
  - Living standards decline as population increases

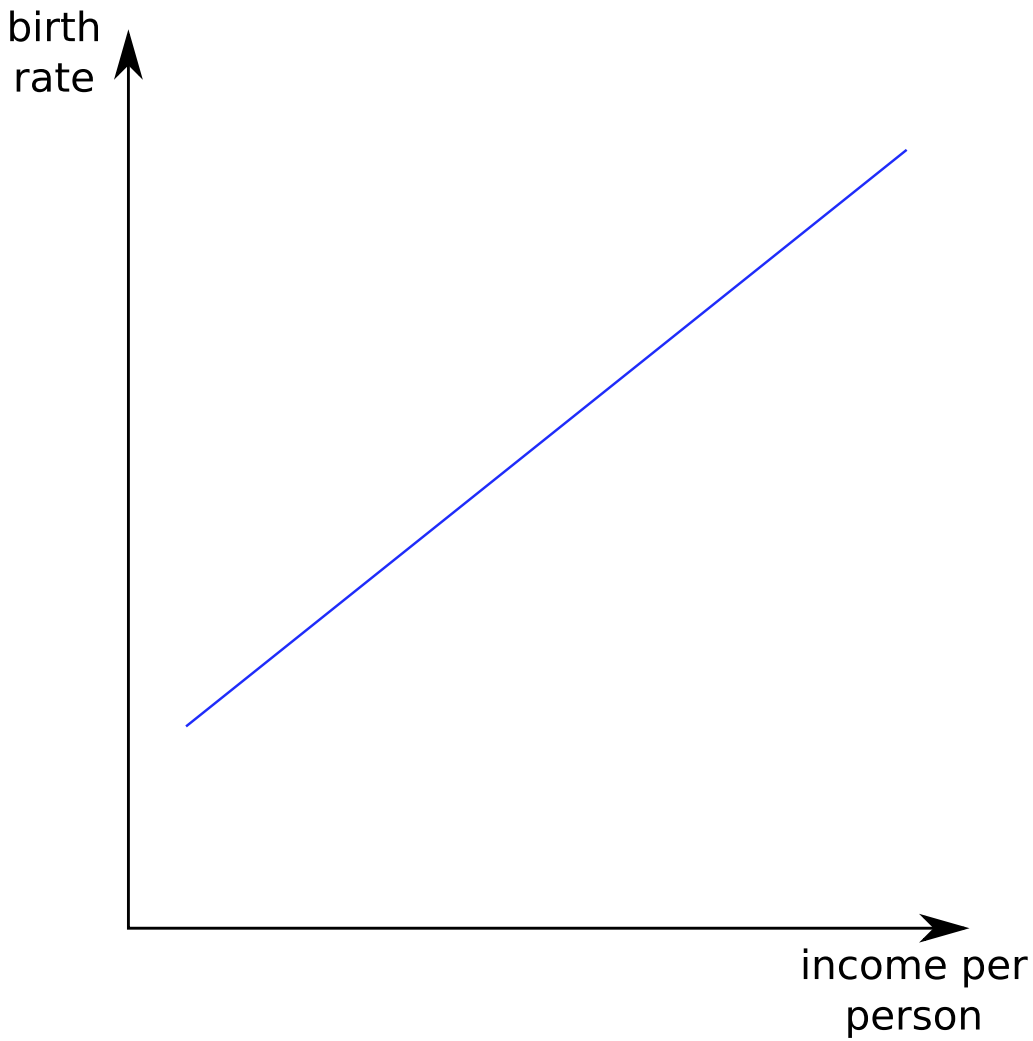
The Birth Rate Schedule

- The birth rate is just the number of births per year per thousand people
- For example, there were 4,059,000 births in the United States in 2000 and the US population was 281,421,906:

$$b_{2000} = \frac{4059000}{\frac{281421906}{1000}} = 14.4$$

- We assume that in the preindustrial world, birth rates rose with material living standards
- Why? A wealthier family could better afford an additional child, a healthier woman was more likely to have a successful pregnancy, ...

The Birth Rate Schedule



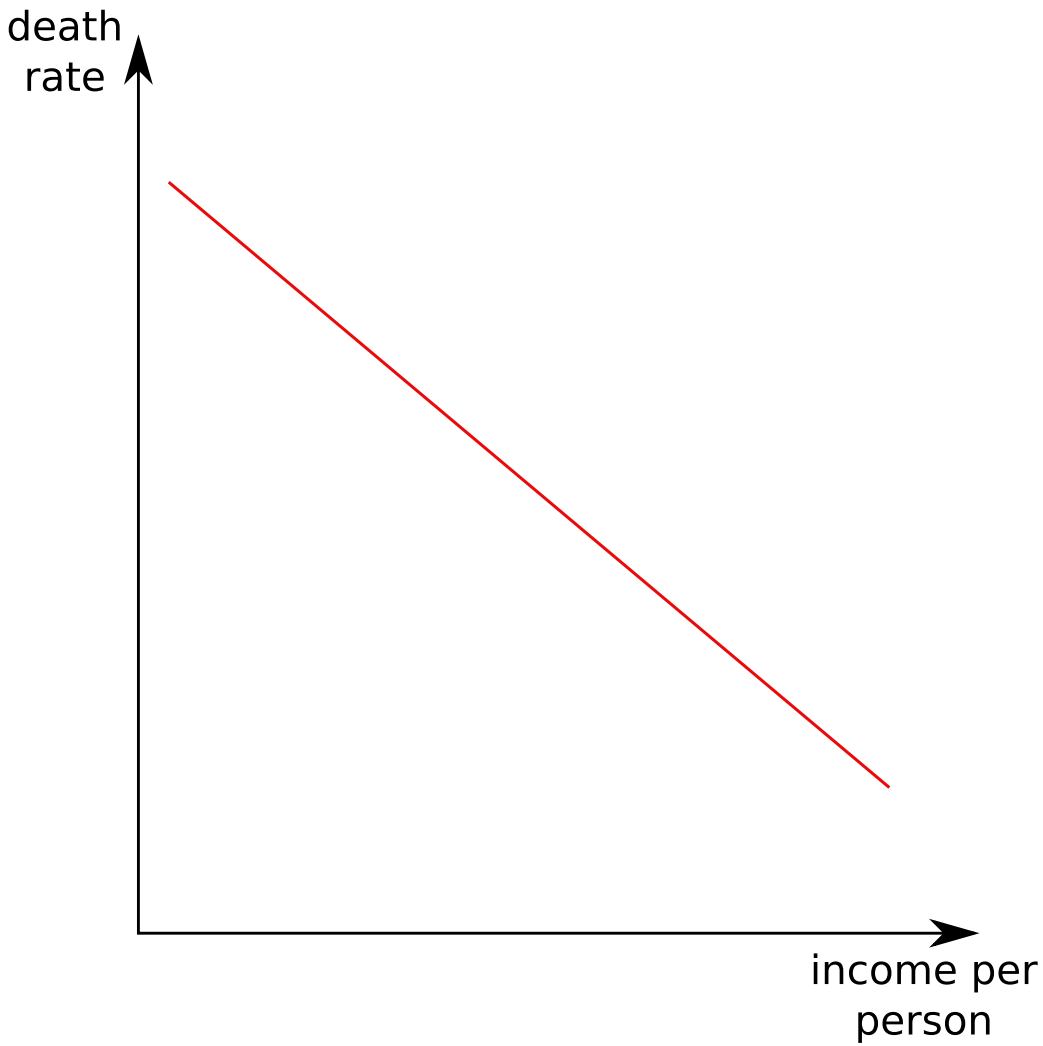
The Death Rate Schedule

- The death rate is just the number of deaths per year per thousand people
- For example, there were 2,403,000 deaths in the United States in 2000 and the US population was 281,421,906:

$$d_{2000} = \frac{2403000}{\frac{281421906}{1000}} = 8.5$$

- We assume that in the preindustrial world, death rates fell with material living standards
- Why? Higher levels of consumption (better food, clothing, shelter, etc.) helps you live longer

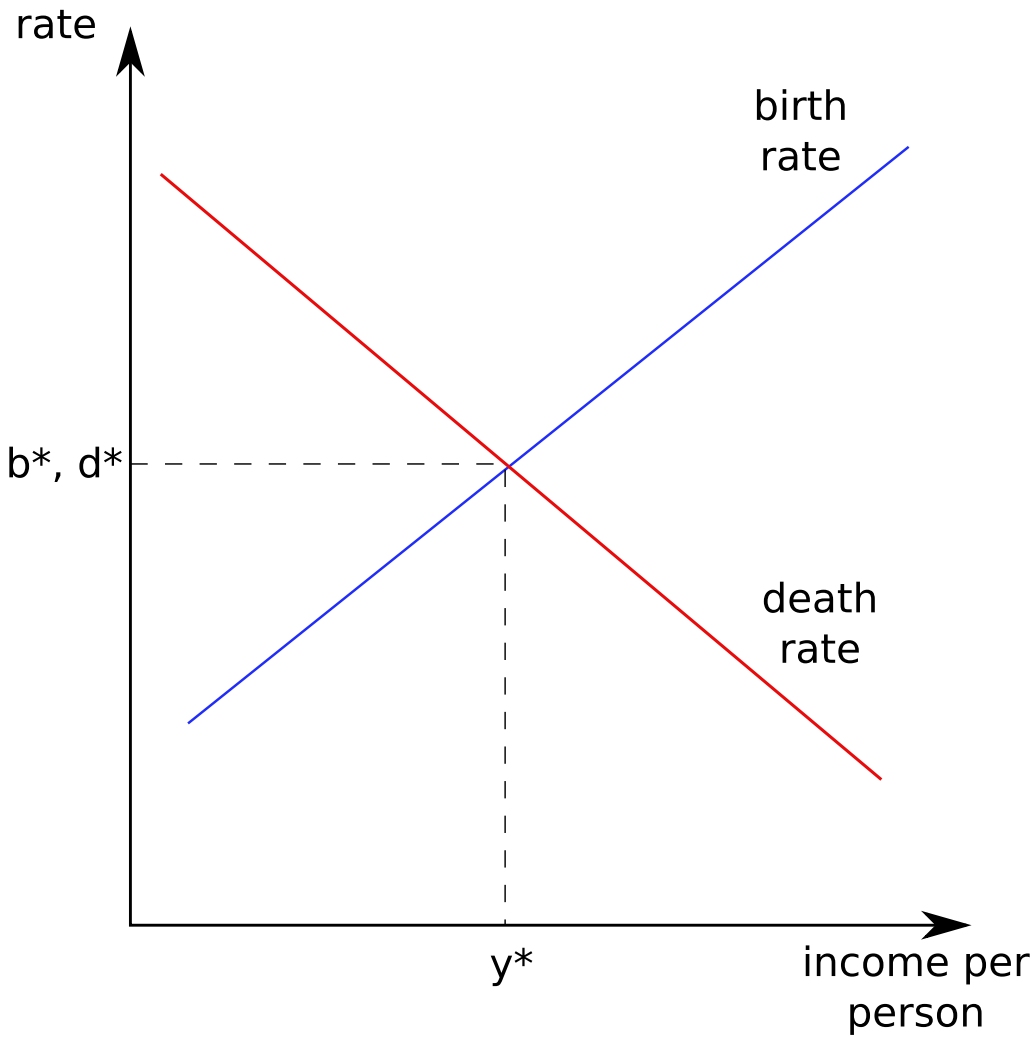
The Death Rate Schedule



Stationary Population

- Notice that for our US figures, the birth rate was 14.4 births per 1,000 people per year and the death rate was 8.5 deaths per 1,000 people per year
- This means that each year, more people are being born than are dying so population must be growing
- Recall that the preindustrial world had almost no population growth
- So in the preindustrial world, the birth rate roughly equaled the death rate (the income per person at which this occurs is called the *subsistence income*)

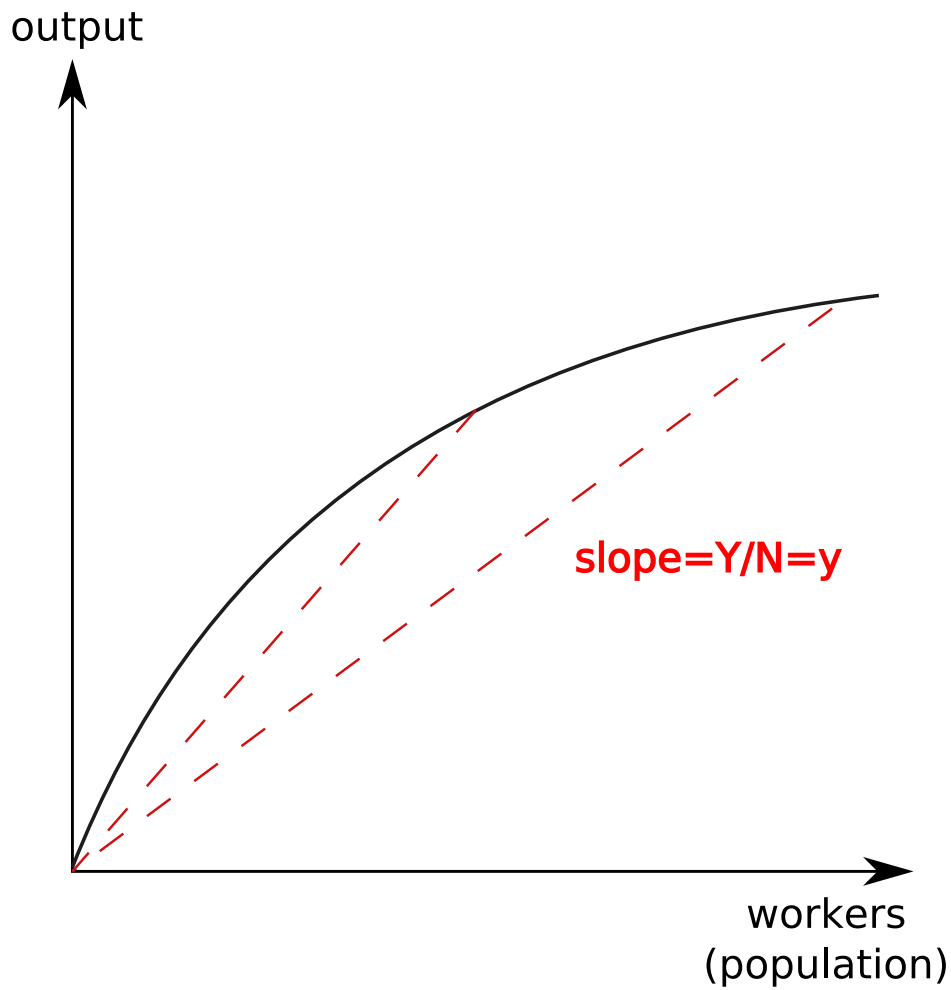
Stationary Population



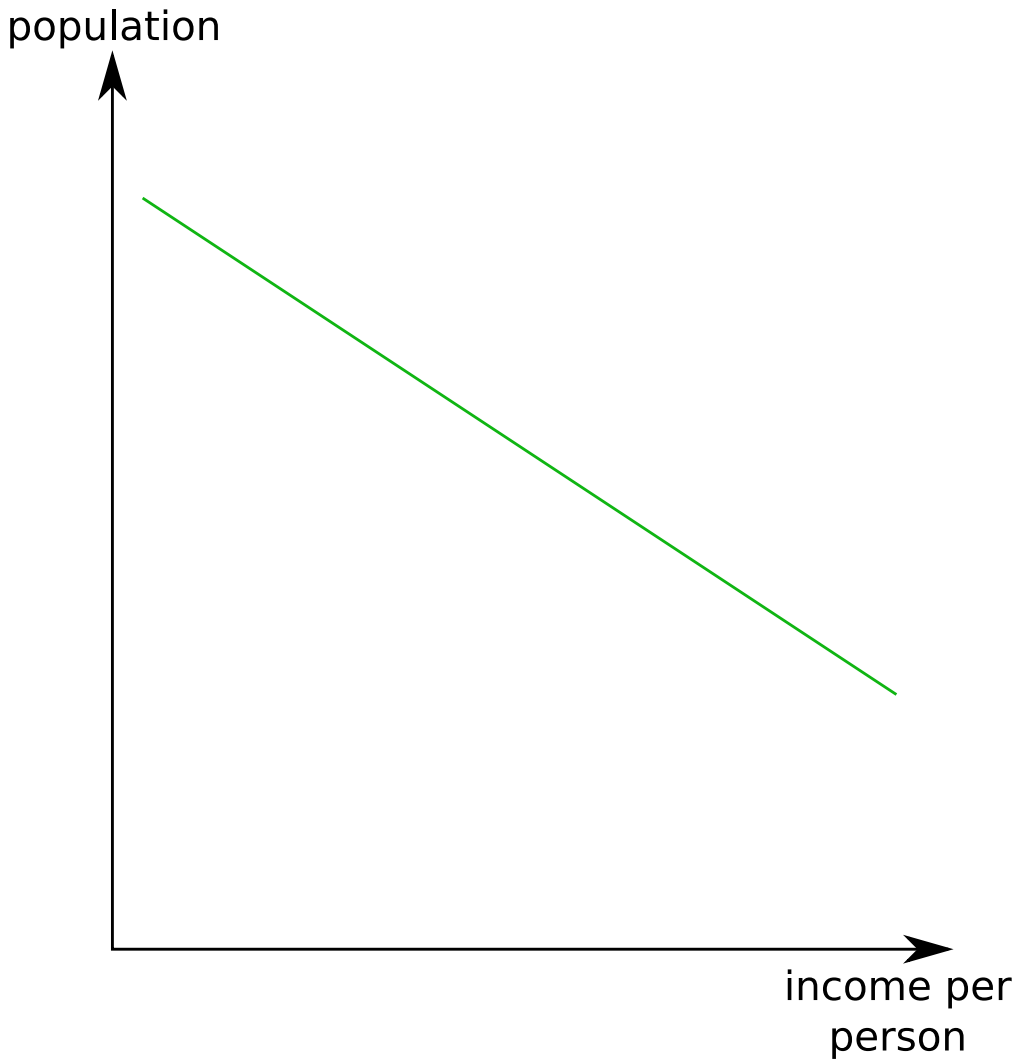
Stationary Population

- But why a stationary population?
- Because of the technology curve relating population to income per person
- With some resources fixed (for example land), the marginal product of an extra person is positive but smaller than the marginal product of the previous person
- This means that while total output increases as population increases, it increases at a slower rate than population

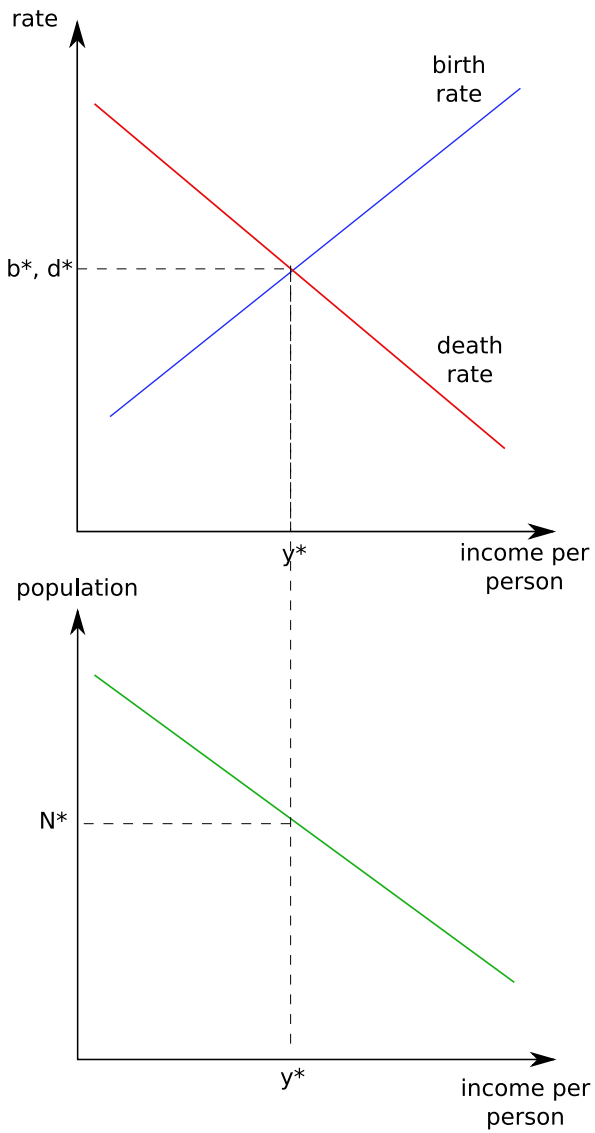
Diminishing Marginal Product of Workers



The Technology Curve



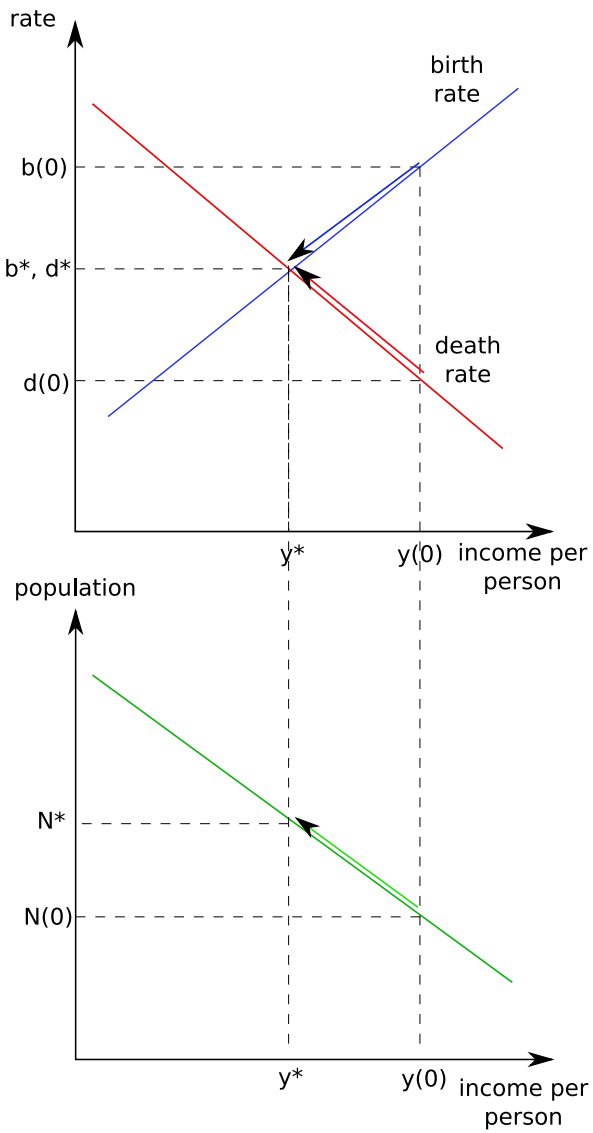
The Malthusian Equilibrium



Moving to the Malthusian Equilibrium

- Suppose we were at an income per person greater than the equilibrium level
- Then births would exceed deaths leading to population growth
- As the population grows, we move up and to the left along the technology curve
- This leads to lower income per person increasing the death rate and decreasing the birth rate
- Things stop moving once the birth rate equals the death rate

Moving to the Malthusian Equilibrium



Moving to the Malthusian Equilibrium

- Notice that equilibrium income per person had nothing to do with the level of technology
- Equilibrium income per person is determined entirely by the birth rate and death rate
- The technology curve mattered for two reasons:
  - The downward slope told us how income per person would change if the population was growing or shrinking
  - The position determined the equilibrium population level

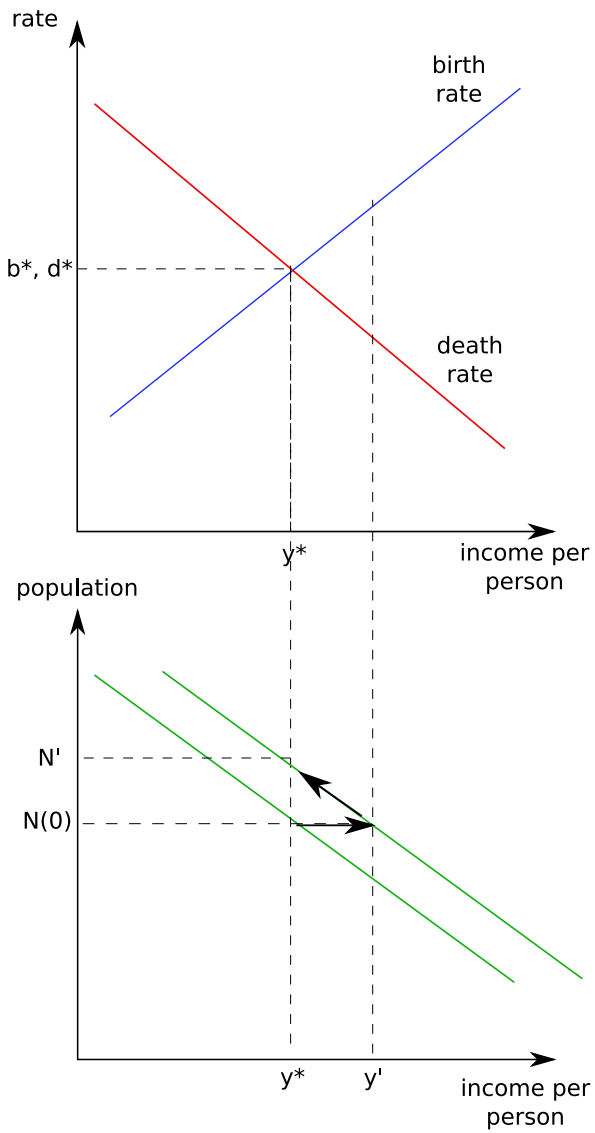
The Effects of a Change in Technology

Suppose that there is an improvement in technology (we invent the wheel). What happens?

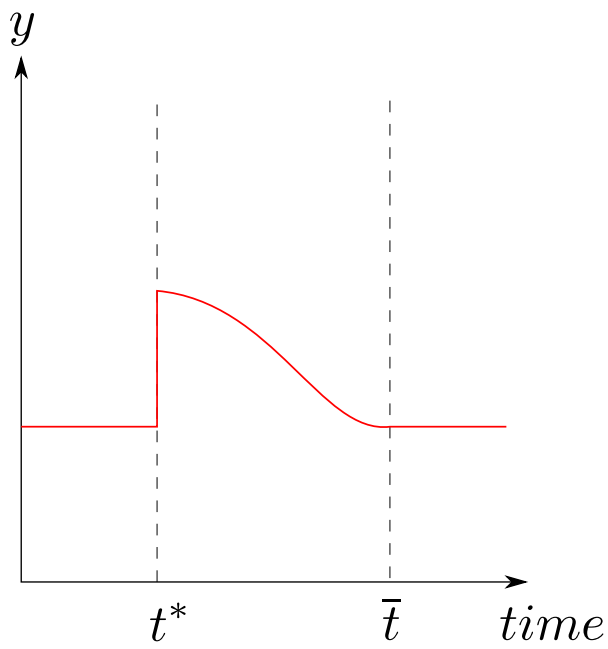
- The advance in technology will shift the technology curve to the right
- In the short run (before population adjusts), this means greater income per person
- Births will rise, deaths will fall and the population will grow
- The economy returns to the old income per person only at a new higher population

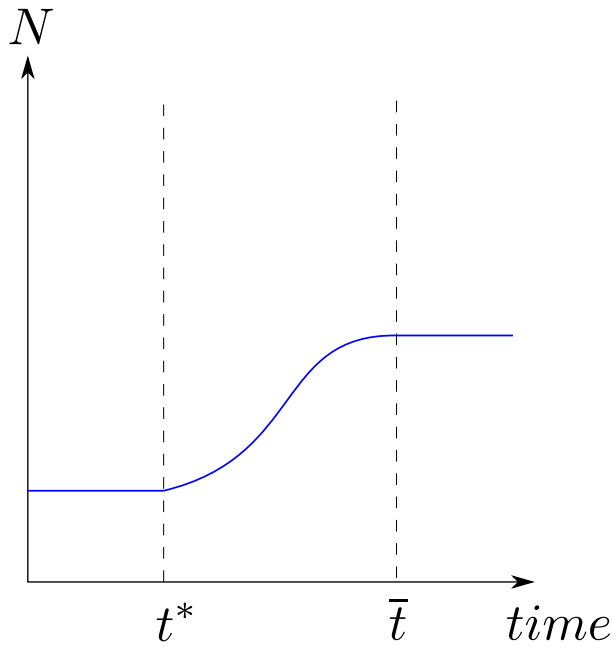
So an improvement in technology can allow for greater population density but doesn't improve average income per person

The Effects of a Change in Technology



The Effects of a Change in Technology



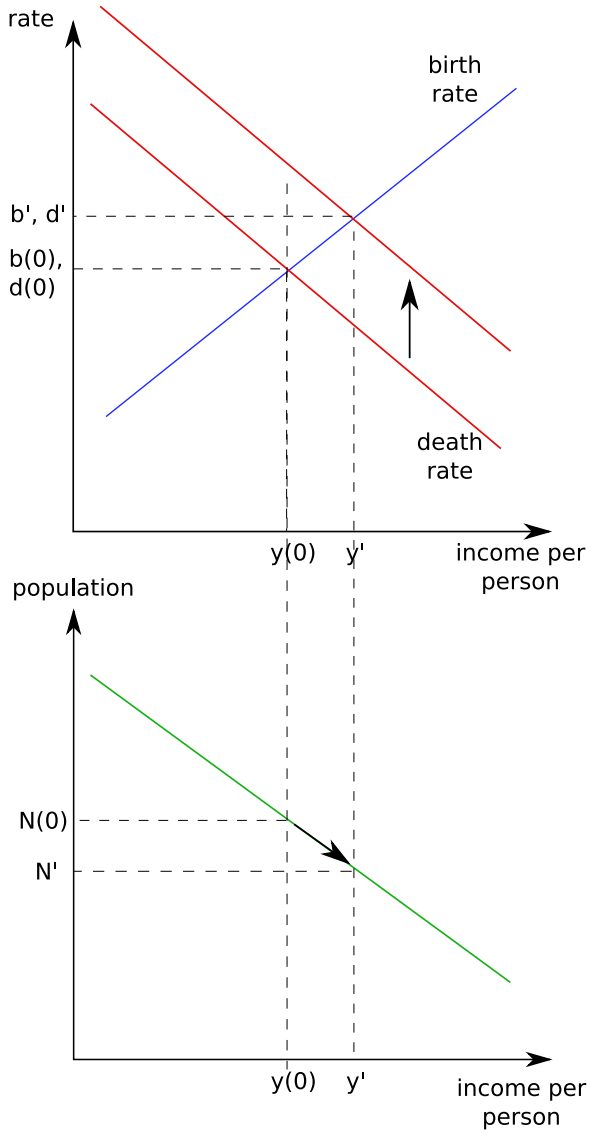


The Effects of a Change in the Birth or Death Schedules

A shift in the birth or death schedules can change equilibrium income per person. Suppose that the plague comes along, what happens?

- The rise in disease will shift the death rate curve up (more deaths at any given income level)
- At the current income per person, deaths will now outnumber births and the population will decrease
- As the population decreases, income per person will rise until deaths once again equal births
- The economy settles at a new higher income per person and a new lower population

A Shift in the Death Rate Curve



The Effects of Change in the Birth or Death Schedules

Now let's think about a shift in the birth schedule. Suppose that Viagra finds its way to a preindustrial economy:

- There will be an increase in births at any given income level, shifting the birth rate curve up
- At the current income per person, births now outnumber deaths and population will grow
- As the population grows, income per person will start to fall until births once again equal deaths
- The economy will end up in a new equilibrium with a lower income per person and a higher population than the old equilibrium

Change in the Malthusian World

- The birth and death rate curves determine the subsistence income
- The technology curve determines the population size based on this subsistence income
- A change in technology can lead to a different population size in the long run but not a different subsistence income
- A change in the birth rate or death rate curve is the only way to change the long run subsistence income

Subsistence income in the Malthusian World

Features of a society that would lead to a higher subsistence income:

- Low fertility rates:
  - Late age at first marriage
  - Small families being a social norm
  - Greater diffusion of contraceptive practices
- High death rates:
  - Bad disease environment
  - Poor health practices
  - High levels of violence

Better technology just means greater population density in the long run