Transition from Stagnation to Growth:

Food as an Essential Good and the Demographic Transition

The Role of the Demand for Food and Agricultural Productivity

- In our baseline model, both sectors produce the same good.
- This implies that agricultural and industrial output sells for the same price.
- A sudden decline in agricultural productivity would accelerate the transition to industry.
- But in reality, agriculture is needed for the production of (at least) food, which is essential.
- If agricultural productivity is low, it may not be possible to move workers to the industrial sector, because a certain amount of food needs to be produced first.
- Thus, low agricultural productivity may counteract a successful transition to growth.

The Role of the Demand for Food and Agricultural Productivity

- Consider the model with different productivity levels in agriculture and industry:

allow A_t different.

$$Y_t^a = (A_t^a X)^{\alpha} (N_t^a)^{1-\alpha},$$
$$Y_t^i = A_t^i N_t^i.$$

- If both sectors produce the same good, workers are allocated to equate the marginal product of labor between the two sectors:

$$A_t^i = (1-\alpha)\left(\frac{A_t^a X}{N_t^a}\right)^{\alpha}$$

$$N_t^a = (1-\alpha)^{\frac{1}{\alpha}} A_t^{i\,-\frac{1}{\alpha}} A_t^a X$$

The Role of the Demand for Food and Agricultural Productivity

- The number of workers in industry therefore is:

$$N_t^i = N_t - N_t^a = \quad N_t - \left(\frac{1-\alpha}{A_t^i}\right)^{\frac{1}{\alpha}} A_t^{\alpha} x$$

slow down the structural change $\Rightarrow$

- The relationship between A_t^a and N_t^i is negative: the more productive agriculture is, the lower industrail employment.
- Implications:
  - An acceleration in agricultural productivity growth can slow down transition to industry.
  - vice versa.

The Role of the Demand for Food and Agricultural Productivity

- Now assume that before anything else is consumed, every person has to consume f units of food. Food can be produced only using agriculture.
- If the food constraint is not binding (i.e., agriculture also produces goods other than food), the situation is unchanged from before.
- However, if the food constraint is binding, number of agricultural workers is no longer determined by equalization of marginal products.
- Instead, number of agricultural workers has to be adjusted to guarantee required production of food.

The Role of the Demand for Food and Agricultural Productivity

- The food production constraint:

$$f N_t \leq (A_t^a x)^{\alpha} (N_t^a)^{1-\alpha}$$

- The required number of agricultural workers to satisfy the food constraint:

$$N_t^a = \left(\frac{f N_t}{(A_t^a x)^{\alpha}} \right)^{\frac{1}{1-\alpha}}$$

- The number of workers available for industrial production:

$$N_t^i = N_t - \left(\frac{f N_t}{(A_t^a x)^{\alpha}} \right)^{\frac{1}{1-\alpha}}$$

$$\uparrow A_t^{\alpha} \rightarrow \uparrow N_t^i$$

The Role of the Demand for Food and Agricultural Productivity

- In the model with the food constraint, the relationship between A_t^a and N_t^i is positive: the more productive the agricultural sector is, the more workers will be in the industrial sector.
- Implications:
  - a rise in agricultural productivity would accelerate the transition to industry
  - vice versa
  - potentially unbounded population growth is problematic if population growth is greater than productivity growth! The food constrain will ultimately bind.
-

why agricultural ↑ in England: productivity in agriculture ↑

The Role of the Demand for Food and Agricultural Productivity

The particular success of industrialization in Britain may, in part, be related to gains in agricultural productivity:

- Large improvements in agricultural productivity around 1800 (enclosures etc.) allowed increase in food production with fewer agricultural workers.
- This freed up labor for the industrial sectors.
- France, for example, did not experience the same rise in agricultural productivity, and started to industrialize much later.
- Since developing countries have a comparative *disadvantage* in agriculture (i.e. agricultural productivity is particularly low compared to industrial productivity), this may be one of the reason for the lack of industrialization in sub-Saharan Africa, for instance.

Demand for Food and Population Growth

Why unchecked population growth would lead to a Malthusian disaster:

- If there is no change in the (Malthusian) income-fertility relationship, after the takeoff starts population growth is faster than productivity growth (eventually).
  - Population growth and productivity growth are just offsetting in Malthusian steady state.
  - Thus, if income per capita rises, population growth is faster than productivity growth.
- Since the demand for food is proportional to population size, after the start of the takeoff the demand for food rises faster than productivity.
- Thus, more and more workers are needed for producing a sufficient amount of food.
- With no change in the income-fertility relationship, the takeoff has to lead to a Malthusian disaster: The economy runs out of food.

An Example of Takeoff Leading to a Famine

- The two technologies:

$$Y_t^a = (A_t X)^\alpha (N_t^a)^{1-\alpha},$$
$$Y_t^i = A_t N_t^i.$$

- Laws of motion:

$$A_{t+1} = (1+g)A_t,$$
$$N_{t+1} = n_t N_t = \frac{y_t}{2p} N_t.$$

- Food consumption constraint:

$$fN_t \leq (A_t X)^\alpha (N_t^a)^{1-\alpha}.$$

- If constraint cannot be met, immediate reduction in population size until constraint is met.

Putting the Model on the Computer

- Start from spreadsheet for Malthus-to-Solow model without food requirement.
- Maximum population that can be sustained given current productivity:

$$fN_t^{\max} = (A_t X)^{\alpha} (N_t^{\max})^{1-\alpha},$$

$$N_t^{\max} = f^{-\frac{1}{\alpha}} A_t X.$$

← every one is in agriculture + every one is fed f

largest population can feed + sustain given today's tech.

- Surviving population N_t^s is given by:

$$N_t^s = \min\{N_t, N_t^{\max}\}.$$

- Interpretation: If maximum population $N_t^{\max}$ is smaller than the actual population N_t at the beginning of the period, there will be a famine, and $N_t - N_t^{\max}$ people will die of starvation.

Putting the Model on the Computer

total agriculture output

$$Y_t^a = (A_t X)^\alpha (N_t^a)^{1-\alpha}$$

$$fN_t = (A_t X)^\alpha (N_t^{a\min})^{1-\alpha}$$

$$(N_t^{a\min})^{1-\alpha} = \frac{fN_t}{(A_t X)^\alpha}$$

- Number of agricultural workers required to produce sufficient amount of food:

$$N_t^{a\,\min} = \frac{(fN_t^s)^{\frac{1}{1-\alpha}}}{(A_t X)^{\frac{\alpha}{1-\alpha}}}.$$

$$A_t = (1-\alpha)(A_t X)^\alpha N_t^{a\,-\alpha}$$

$$N_t^a = \left(\frac{(1-\alpha)(A_t X)^\alpha}{A_t}\right)^{\frac{1}{\alpha}}$$

- Labor that would be used in agriculture if returns of agriculture and industry were equalized:

$$\tilde{N}_t^a = \frac{(1-\alpha)^{\frac{1}{\alpha}} X}{A_t^{\frac{1-\alpha}{\alpha}}},$$

- Labor actually used in agriculture:

$$N_t^a = \min\left\{N_t^s, \max\{N_t^{a\,\min}, \tilde{N}_t^a\}\right\}.$$

- Labor used in industry:

$$N_t^i = N_t^s - N_t^a.$$

Putting the Model on the Computer

- Income per capita:

$$y_t = \frac{(A_t X)^\alpha (N_t^a)^{1-\alpha} + A_t N_t^i}{N_t^s}.$$

- Population growth:

$$n_t = \frac{y_t}{2p}.$$

- Population at the beginning of the next period:

$$N_{t+1} = n_t N_t^s.$$

Putting the Model on the Computer

- Initial conditions needed for X, A_0, and N_0.
- Assume that economy starts out in Malthusian steady state:

$$(1+g)2p = \left(\frac{A_0 X}{N_0}\right)^{\alpha},$$

so that:

$$N_0 = \left(\frac{1}{(1+g)2p}\right)^{\frac{1}{\alpha}} A_0 X.$$

Findings from the Model with the Food Constraint

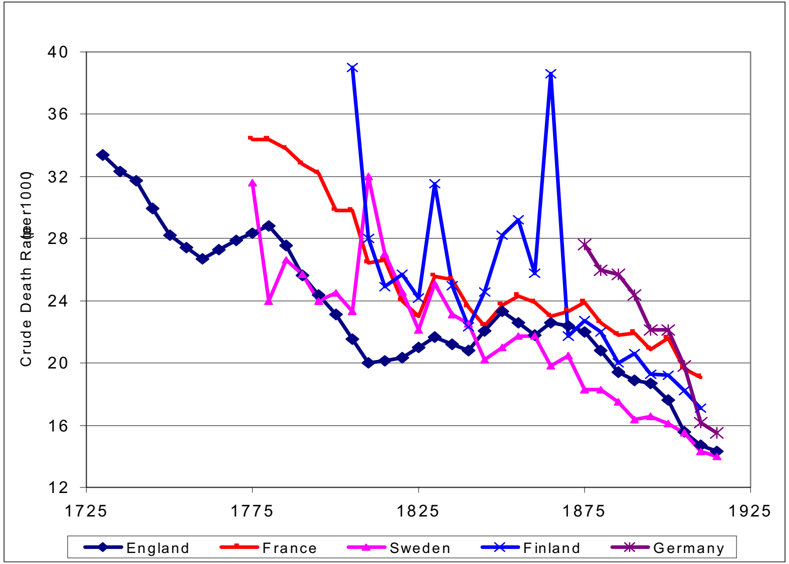
- With a binding food constraint, the takeoff to growth will ultimately be reversed.
- Reversal is faster if need for food is large.
- In the long term, takeoff from stagnation cannot be sustained unless population growth ultimately stops increasing.
- Need to understand the demographic transition.

$$\frac{\Delta N_t}{N_t} = \underbrace{\frac{B_t}{N_t}}_{\text{Birth rate}} - \frac{D_t}{N_t} \leftarrow \text{death rate}$$

The Demographic Transition

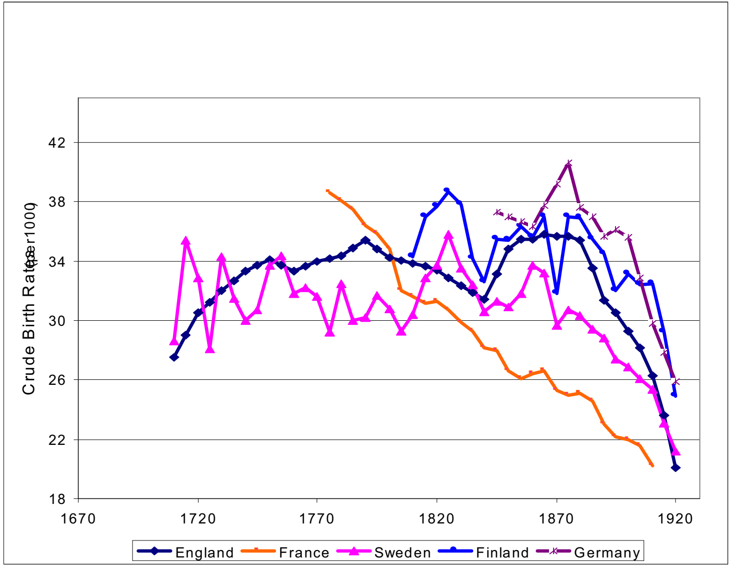
- The demographic transition:
  - a pattern of falling mortality and birth rates that has been observed in every country country that has escaped from Malthusian stagnation.
  - Usually, mortality rate fall before birth rate decline, resulting in a temporary increase in population growth
- In England, major phase of demographic transition towards the end of the nineteenth century, about 100 years after the start of industrialization.

The Crude Death Rate in European Countries



trend : drop .

The Crude Birth Rate in European Countries



The Total Fertility Rate: Definition

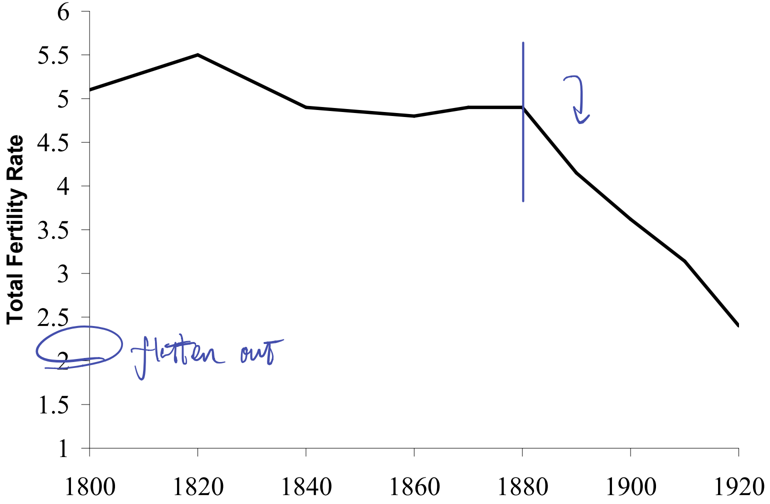
The Total Fertility Rate (TFR) is average number of children that would be born to a woman over her lifetime if:

- she was to experience the exact current age-specific fertility rates (ASFRs) through her lifetime, and
- she was to survive from birth to the end of her reproductive life.

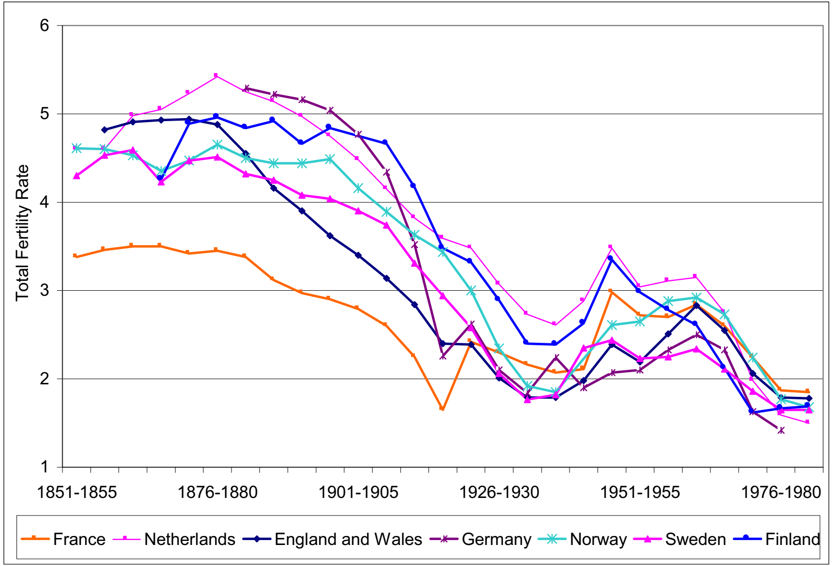
The TFR is a *synthetic* rate!

The Total Fertility Rate in England

look at all age group.



The Total Fertility Rate in European Countries



Explaining the Demographic Transition

- Need to understand why mortality rates fell.
- Need to understand why fertility rates fell.
- Need to understand the timing: mortality declining first, fertility with some delay.

Explaining Mortality Decline

$y\uparrow \to$ mortality $\downarrow$

- Some explanations for mortality decline:
  - Improvement in living standards, and agricultural productivity led to better nutrition.
  - Advance in knowledge about medical and hygiene and improved medical practices
  - Rise in some improved sanity conditions (e.g. supply of clean water, improved sewage system, less crowding in residential dwellings, less co-residense with animals
  - Later on, vaccination programs eradicated major infectious diseases

Overall, decline in mortality not surprising given improved living standard and increasing medical knowledge.

Explaining Fertility Decline

Some explanations for fertility decline:

- Lower mortality may have lowered the "precautionary" demand for children; fewer births required to guarantee some surviving children.
- People used to have children to be provided for in old age; with the rise of government-run pension systems, less need for children. ("Public Pension Channel")
- Children used to work from young ages; with the disappearance (and banning of) child labor, having children is less attractive.
- Children are raised mostly by women; as women started to acquire more education and work out of the home in larger numbers, having large families became more difficult and costly. ("LFP Channel")
- Rising return to education induced parents to invest a lot in children's skills and education; this made children costly and lowered the optimal number of children.

Evaluating the Explanations for Fertility Decline

- All of the explanations plausibly can have an affect on fertility rates.
- However, for us the key question is what drove the main phase of fertility decline during the demographic transition, i.e., between 1880 and 1920.
- For this phase, some explanations are more promising than others.

The Female Labor-Force Participation Channel

- Key idea: as female time becomes more valuable, children become more expensive, because raising children (historically) mostly involved the mothers' time.
- A rise in female labor-force participation therefore would raise the cost of children and might lower fertility.
- However, we should focus on the labor-force participation of married women, who are the ones having (most of) the children.

← married women ↓
women drop out
after married.

The Female Labor-Force Participation Channel

- From the timing perspective, explanation not promising for main phase of fertility decline:
  - fertility fell fastest between 1880 and 1920
  - During this time, vast majority of married women (in U.S., U.K. and Western Europe) were home makers
  - Large rise in married female labor-force participation during WWII.

Female labor more likely to be relevant for fertility decisions today compared to the turn of the 20th century

The Public Pensions Channel

kids: low return
welfare: limited pension.

- If people have children mostly as an insurance for old age, pubic provisions of pensions should lower the demand for children.
- Not clear if this motive is sufficiently strong to explain fertility:
  - historically, people did not live long enough to need a lot of support in old age.
  - Financially speaking, children are a bad investment. If one just wanted money when old, better to put money into the bank then to buy food and toy for children
- In addition, for main phase of fertility decline, the timing does not work:
  - Social security introduced in U.S. in 1930s during the great depression.
  - national insurance introduced in the U.K. in 1908 and expended in 1946

too late.
already drop.