

Lectures on Economic Growth

Topic: Population & Demographics

an upper intermediate course offered at the 7th semester at the

Economics Department, University of Piraeus



Previously in this course:

In the first lecture, we discussed chapters 1–3 of Weil. The second lecture was about chapters 3 and 6..

- The pattern of economic growth is remarkable:
 - For centuries, people lived near subsistence with very little progress.
 - Since the industrial revolution, economic growth has not stopped in the Western world, leaving the average person much better off.
- Accumulation of capital is one source of growth. You can study it in the Solow model. Both physical and human capital can be accumulated.
 - Accumulation leads to (conditional) convergence, which may be analyzed with a growth regression.
 - The larger the share of the accumulable factor, the bigger the differences it may explain.
- Health is another form of human capital. It is solved together with productivity.

Today

Chapters 4 and 5 of Weil, which are all about population.

There is a complicated relationship between population growth and economic growth.

- Normally, we study GDP/capita as an indicator of productivity. That is, we correct for population levels.
- But changes in productivity will impact the level of population:
 - More food leads to better odds of survival.
 - Interestingly, the increased welfare has recently caused a fertility slowdown.
- Reversely, changes in population will impact productivity:
 - Increased numbers of people decreases marginal productivity of labor.
 - A positive rate of population growth dilutes capital per worker.

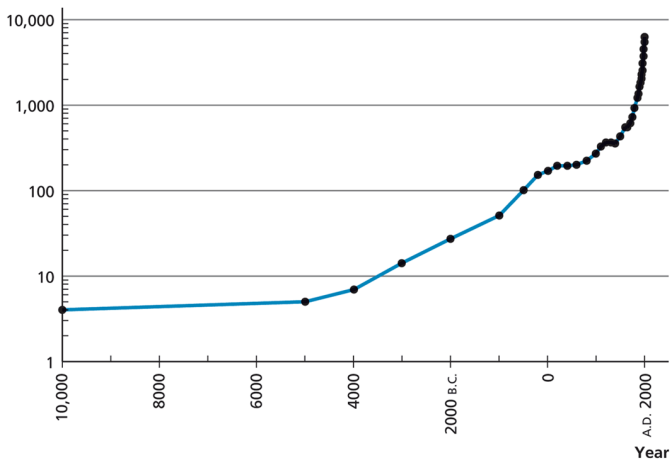
We will discuss all these themes in turn.

World population

FIGURE 4.2

World Population, 10,000 B.C. to A.D. 2000

Population (in millions, ratio scale)



World population

For a very long time, these were the facts about population and growth:

- Population grows very slowly (say 0.04%/year).
- Production per person is roughly constant.

Potentially, humans can multiply much faster. But the means to support additional persons were limited.

Thomas Robert Malthus

1798, Malthus publishes *An Essay on the Principle of Population*.

- population and food supply both grow
- population grows faster
- food scarcity is a positive check on population size
- restraint is a preventive check
- ‘The Dismal Science’



Source:

<http://www.wikipedia.org>

Malthus

I think I may fairly make two postulata.

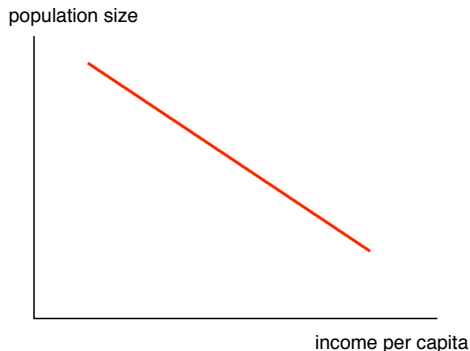
- First, That food is necessary to the existence of man.
- Secondly, That the passion between the sexes is necessary and will remain nearly in its present state.

These two laws, ever since we have had any knowledge of mankind, appear to have been fixed laws of our nature, and, as we have not hitherto seen any alteration in them, we have no right to conclude that they will ever cease to be what they now are [...].

Assuming then my postulata as granted, I say, that the power of population is indefinitely greater than the power in the earth to produce subsistence for man.

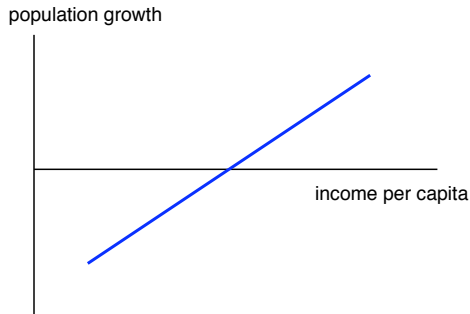
source: An Essay on the Principle of Population, <http://www.gutenberg.org/dirs/etext03/prppl10.txt>

Malthus - decreasing returns



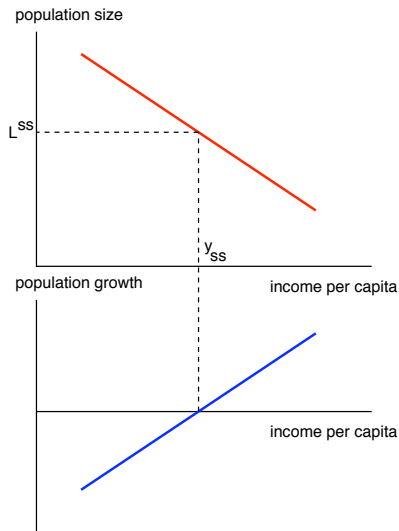
Implicitly, Malthus assumes that there are decreasing returns to labor. Adding extra people makes everyone less productive.

Malthus - population pressure



Malthus also assumes that there is a positive relation between the standard of living and the population growth rate.

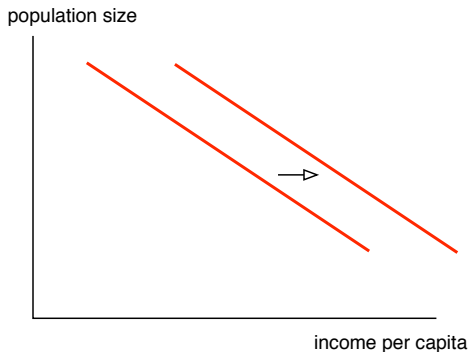
Malthus model



Combine the two graphs to find a stable equilibrium for L .

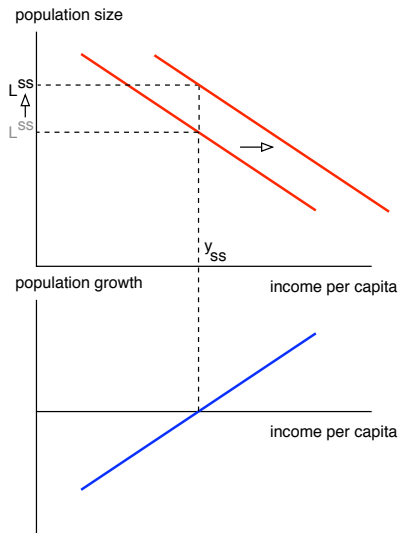
If the two curves do not move, the equilibrium is fixed.

Before the industrial revolution, there were improvements in production technology. But growth was extensive: it allowed the world to support more people, but did not improve the standard of living.



Show this in the figure by moving the red line to the right.

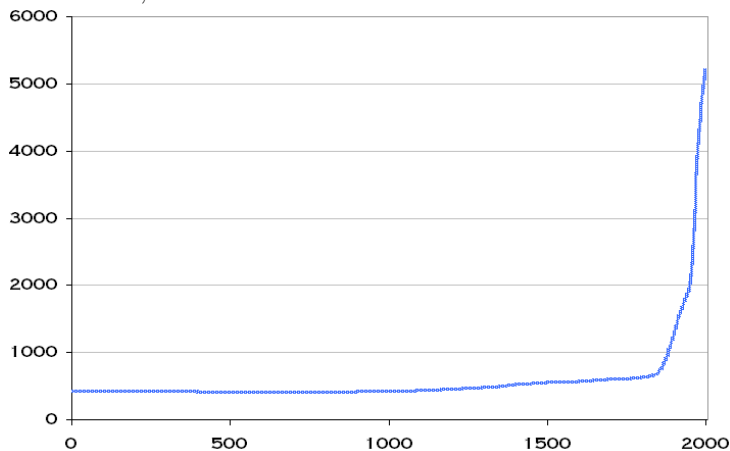
Extensive growth



The productivity improvement leads to a higher level of L^{ss} .

It does not lead to a higher level of y_{ss} .

But growth was extensive: it allowed the world to support more people, but did not improve the standard of living. — We have seen evidence of this before, remember?



For the longest time, income per capita was more or less constant.

Malthus: conclusions

This is indeed a dismal model:

- Advances in technology will only serve to create more people, not to make them better off.
- (Corollary): famine relief is pointless.
- The only way forward is to curb fertility (moving the blue line).
- See the model at work with the introduction of potatoes in Ireland.

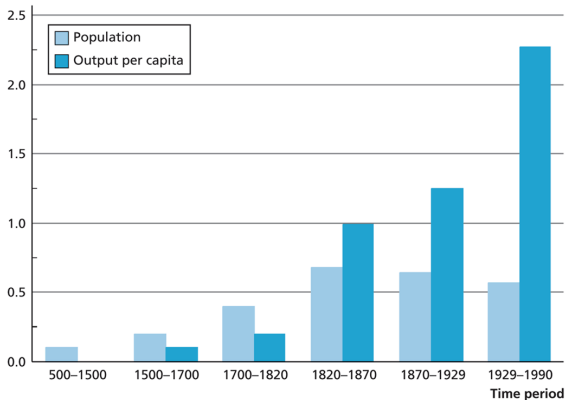
At the same time, notice that the model does not appear to be at work in the Western world, today.

Both lines (blue and red) have ceased to apply, and have been replaced by other mechanisms. These make up the rest of the lecture (and the course).

Output and population

FIGURE 4.6**Breakdown of the Malthusian Model in Western Europe**

Growth rate (% per year)



Source: Galor and Weil (2000).

Solow

Malthus' production involves a fixed factor and labor. This gives labor decreasing returns.

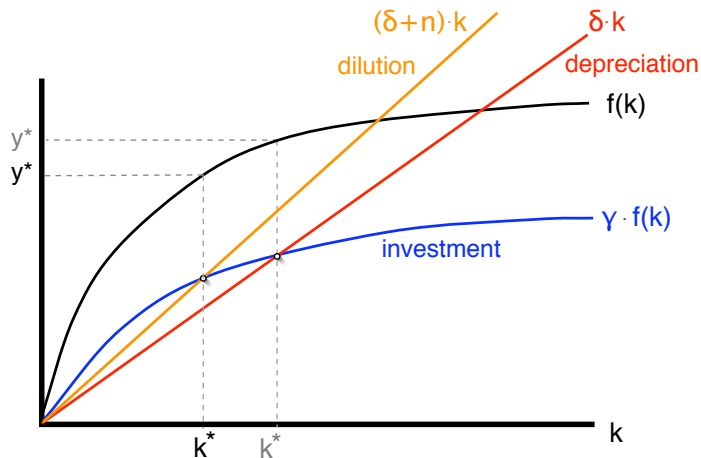
Solow's production involves labor and (reproducible) capital. This means that labor's complementary factors will spring up automatically.

Note: But only insofar they can keep up with population growth. Population growth at rate n dilutes the capital stock just like depreciation:

$$\Delta k = \gamma f(k) - \delta k - nk$$

In the Solow diagram, this moves up the straight line.

Solow and population



Note: higher n

is associated with a lower level of y^* .

Solow, intensive and extensive growth

Now we must be careful about what is in the diagram:

- All variables in the diagram are per capita.

Until now, that did not mean anything because population was assumed constant. There was no aggregate growth in the model.

- In the steady state, when population grows at rate n ,
 - production per capita y is constant
 - but GDP grows at rate n .

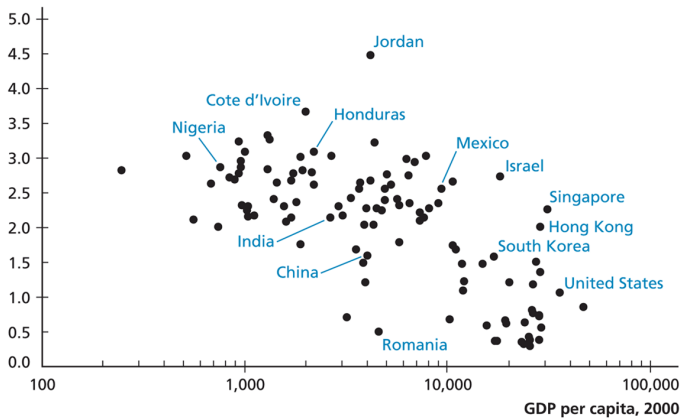
There is extensive growth, but all intensive growth is transitional.

(this gets more complicated still with technological progress.)

Economic growth and n in the data

FIGURE 4.1
Relationship Between Income per Capita and Population Growth

Population growth rate, 1960–2000 (% per year)



Population growth differences

How much can the Solow model explain? Weil shows that differences up to a factor 3 in GDP/capita can be explained by differences in n . But that leaves us with the question: what causes n ? (Not unlike the question: what causes γ ?)

It turns out that we can think about n as the result of a demographic transition with

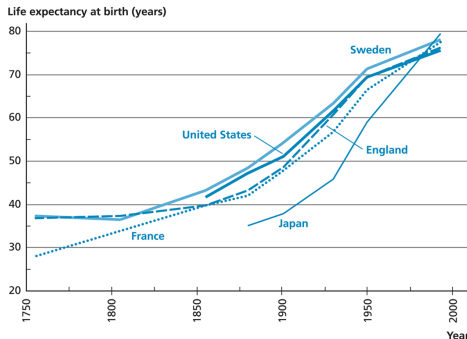
- changes in the mortality rate
- changes in the fertility rate.

The mortality transition

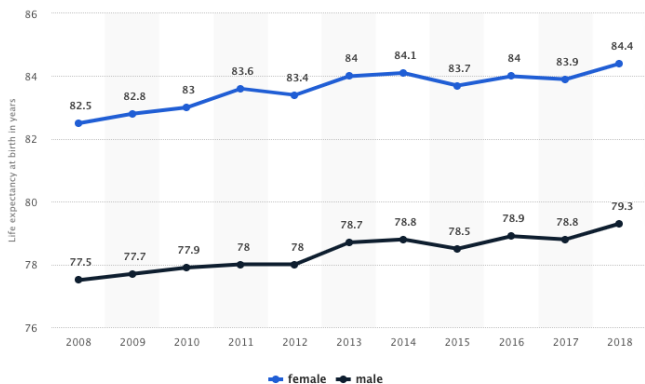
Life expectancy has gone up due to

- 1 increases in the quantity and quality of food and increases in the standard of living (shelter, clothes)
- 2 public health measures
- 3 improved medical treatments

FIGURE 4.8
Life Expectancy in Developed Countries

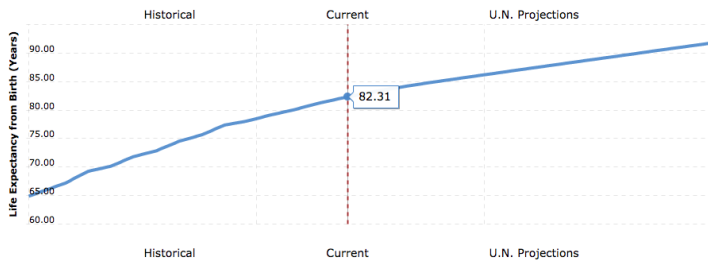


Greece: Life expectancy at birth



Source: World Bank, 2020

Greece: Life expectancy at birth, projections for 2100



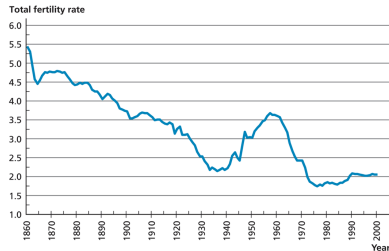
Source: United Nations, 2020

The fertility transition

An interesting pattern is visible in fertility, measured in the average number of children per woman (conditional on survival)

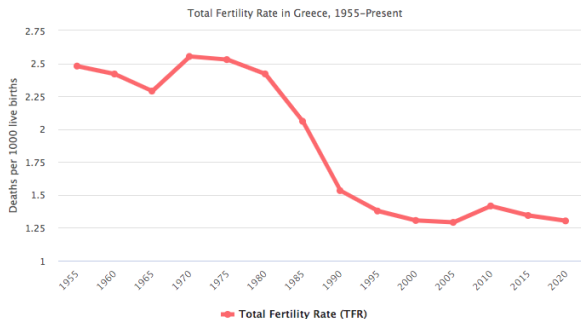
- 1 fertility falls considerably since the industrial revolution (despite growing GDP/cap!)
- 2 there is a local maximum after WWII
- 3 the Americans are dangerously close to 2.

FIGURE 4.10
Total Fertility Rate in the United States, 1860–2000



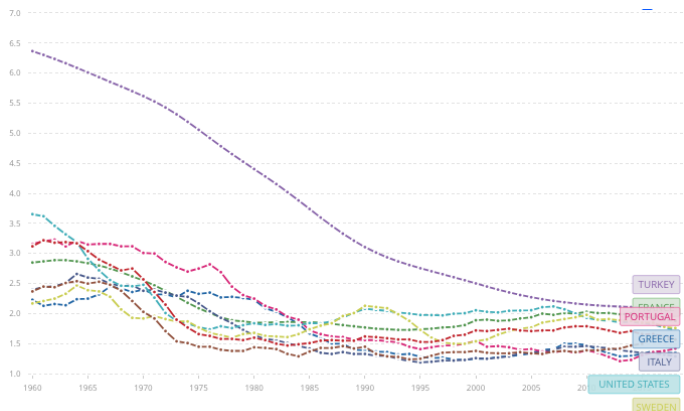
Source: Coale and Zelnik (1963), Wade (1989).

Greece: fertility (# of children per woman)



Source: World Bank, 2020

Greece: fertility comparisons across countries (# of children per woman)



Source: World Bank, 2020

Explaining the fertility transition

Malthus assumed that fertility goes up as income increases. What is going on?

- Greater control of fertility due to contraception
 - true, but explains only part of the decline
- Changing costs and benefits of children
 - Assume that parents choose the number of children based on some kind of maximization, if costs and benefits change the optimum number of children may change as well.
- Costs
 - Wage and participation increases increase costs
 - Longer education increases costs
- Benefits
 - Child mortality reduction reduces insurance benefits
 - Changing prices may change optimal $N \times w$.
 - Institutions reduce pension benefits.

Mortality and fertility

How many sons do you need to have at least a 95% probability of one or more sons over 18?

Child mortality	Necessary sons	Expected grownup sons
50%	5	2.50
35%	3	1.95
20%	2	1.60
5%	1	0.95

Uncertainty causes overshooting on average.

Mortality and fertility (cond.)

Having a child costs 1, each year of education costs 1 and leads to a wage increase of 1, you value $u(N \cdot w)$ with $u(x) = \sqrt{x}$. Your budget is 10.

Child mortality	50%	25%	10%
<hr/>			
N = 1			
education	9	9	9
wage	9	9	9
expected u	1.50	2.25	2.70
<hr/>			
N = 2			
education	4	4	4
wage	4	4	4
expected u	1.70	2.34	2.65
<hr/>			
N = 3			
education	2.3	2.3	2.3
wage	2.3	2.3	2.3
expected u	1.71	2.24	2.49

Direct costs and benefits

- Children cost time and money; both the outright price of raising a child and the price of time have gone up.
 - More educated women
 - Opportunity costs of time have gone up
- The economic benefit of children as old-age insurance has declined in the face of the welfare state.
 - Effect of fertility-decision on PAYGO pensions is now an externality.
 - Some people argue that internalization is needed.
 - French sponsor third child with 750 euros per month.
 - H.W.Sinn wants child-dependent pensions in Germany.

Demographic transition and ageing

What happens when both fertility and mortality drop? Consider a simple population model:

- People die at rate λ independent of age.
- The fertility rate is also constant at λ , independent of age.

The population is then constant at $1/\lambda$, and the number of people of age t is $\exp(-\lambda t)$.

What is the fraction of the population younger than some age x ?

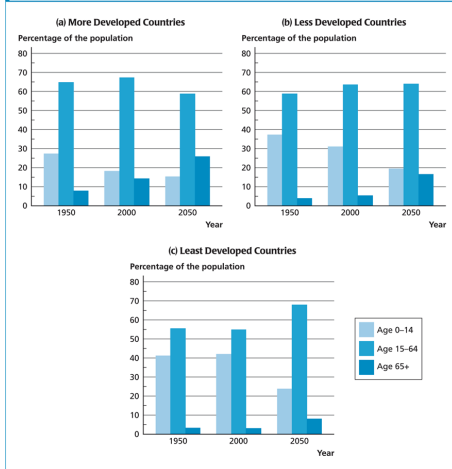
$$\lambda \cdot \int_0^x \exp(-\lambda t) dt = 1 - \exp(-\lambda x)$$

This is an increasing function of λ :

When fertility and mortality drop, a larger fraction of the population is old: there is population ageing.

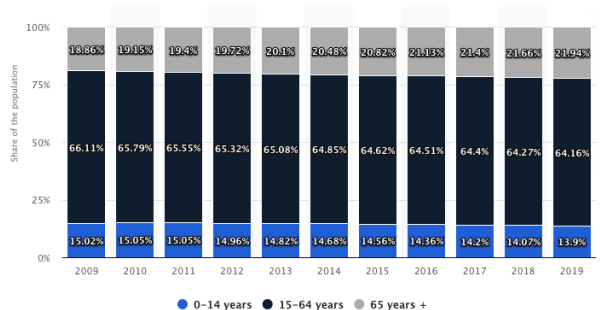
Population ageing worldwide

FIGURE 5.6
Changes in the Age Structure of the Population, 1950–2050



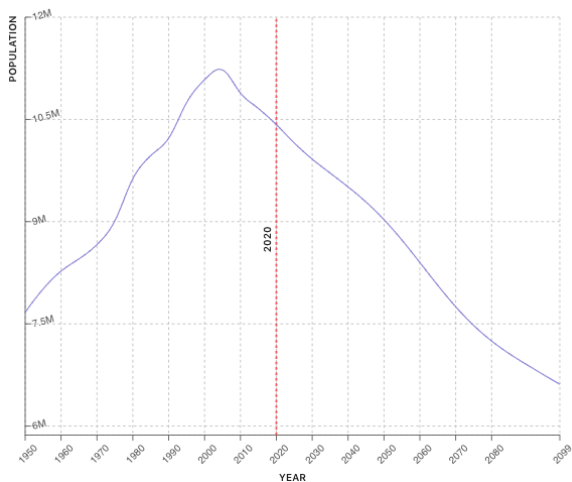
Source: United Nations (1998).

Population demographics - Greece



Source: World Population Review, 2020

Population ageing - Greece



Source: World Population Review, 2020

Population ageing and growth

There are many effects of ageing on growth:

- 1 A decrease in n will increase steady-state income (Solow).
- 2 As the working-age fraction of the population decreases, growth will fall:

$$\text{GDP/capita} = \text{GDP/worker} \times \frac{\text{number of workers}}{\text{total population}}$$

$$\begin{aligned} \text{growth GDP/capita} &= \text{growth GDP/worker} \\ &\quad + \text{growth working-age fraction} \end{aligned}$$

Population ageing and growth (cond.)

Expect the working-age fraction to drop from 51.9% to 43.8% in 30 years. This adds

$$\left(\frac{0.438}{0.519}\right)^{\frac{1}{30}} - 1 = -0.0056 = -0.56\%$$

to growth on average.

TABLE 5.3

Some Cases of Population Aging

Country	Time Period	Percentage of Population Aged 20–64 in the First Year	Percentage of the Population Aged 20–64 in the Last Year	Effect of Aging on Growth of Income per Capita (% per Year)
Japan	2000–2020	62.3	54.9	–0.6
Malaysia	1980–2010	45.9	54.1	0.6
Mexico	1985–2015	42.7	57.7	1.0
Thailand	1990–2010	55.2	62.3	0.6
Turkey	1990–2010	49.2	63.2	0.8
Bangladesh	2000–2020	47.1	59.8	1.2

Source: U.S. Bureau of Census International Database.