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ECON 219 Supplementary notes for Chapter 8

"Economic Growth"

These notes are to supplement the book in the following respect:

1. Description of an early model of growth by Malthus.
2. More complete description of growth facts.

If you notice any errors, omissions or typos, or if you have any others comments about these notes, please relay them to me so that I can improve upon them for future generations.

1 Malthus

Malthus was and Anglican reverent of the 18^{th} century in England. He was quite interested in social matters and tried to find some explanations for social phenomena he was observing. He was conducting scientific research, in the sense that he made some observations (gathered stylized facts), built a theory, tested the theory and drew policy implications. In this section, we want to repeat his exercice by using our terminology.

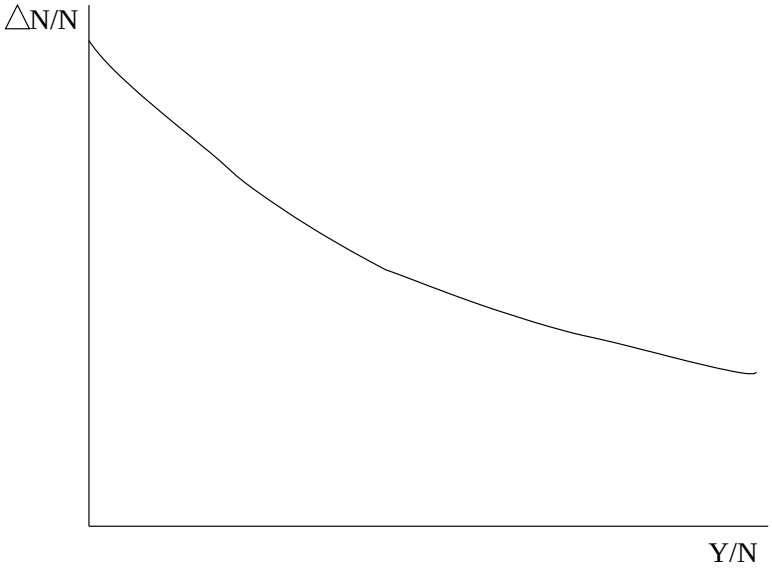
Essentially, Malthus made the following observations:

1. There is **recurrent misery**, that is the overwhelming majority of the people lived very poorly, and no measure against poverty could alleviate this. There is ample historical evidence of this, but one that is probably the most striking to modern people is the following table[1] describing the number of calories per person per day available in various place to various people.

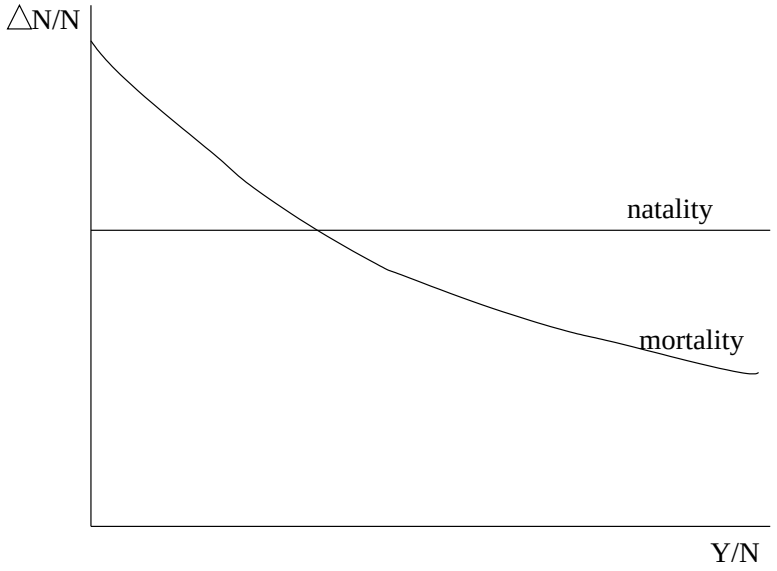
[1]This table is taken from Robert Fogel, Catching Up With the Economy, *American Economic Review*, March 1999, page 3.

Year	France	England and Wales	United States
1700		720	2313
1705	439		
1750		812	
1785	600		
1800		858	
1840			1810
1850		1014	
1870	1671		
1880			2709
1944			2282
1975	2136		
1980		1793	
1994			2620

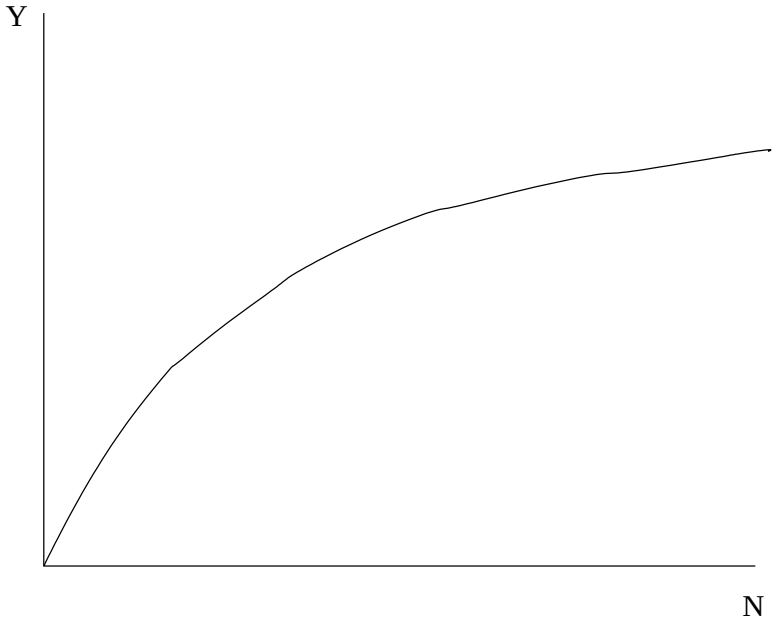
2. The **mortality rate** depends negatively on the standard of living, that is richer people have a lower probability of death. Thus if we were to graph the mortality rate (the proportion of people dying at any point of time) against the standard of living as measured by output per capita, we would get something like this:



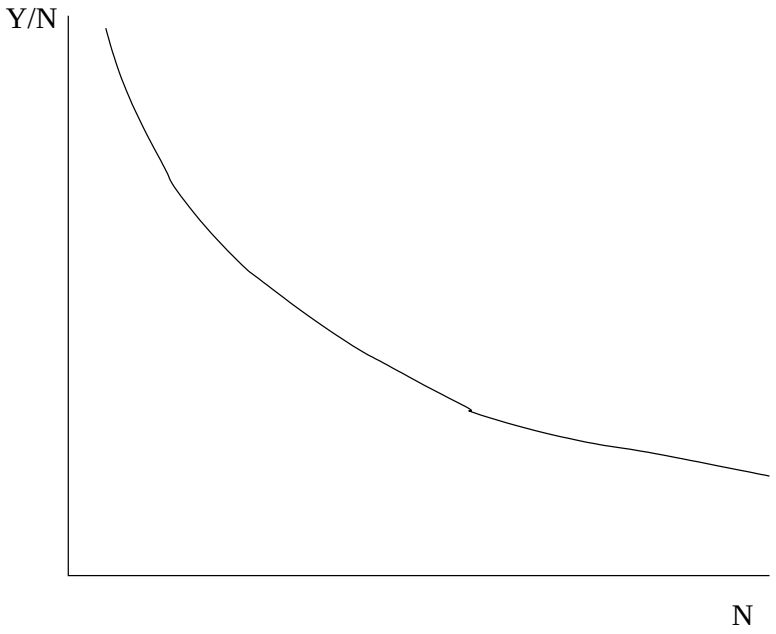
3. The birth rate (**natality rate**) is independent of the standard of living. Together with the mortality rate, this can be represented in the following way:



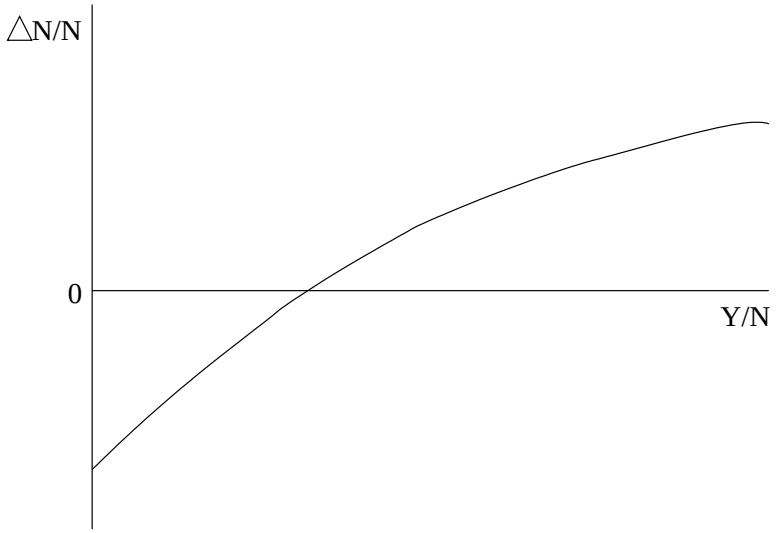
4. The **marginal return** of labor is decreasing. We have already represented this with a concave production function:



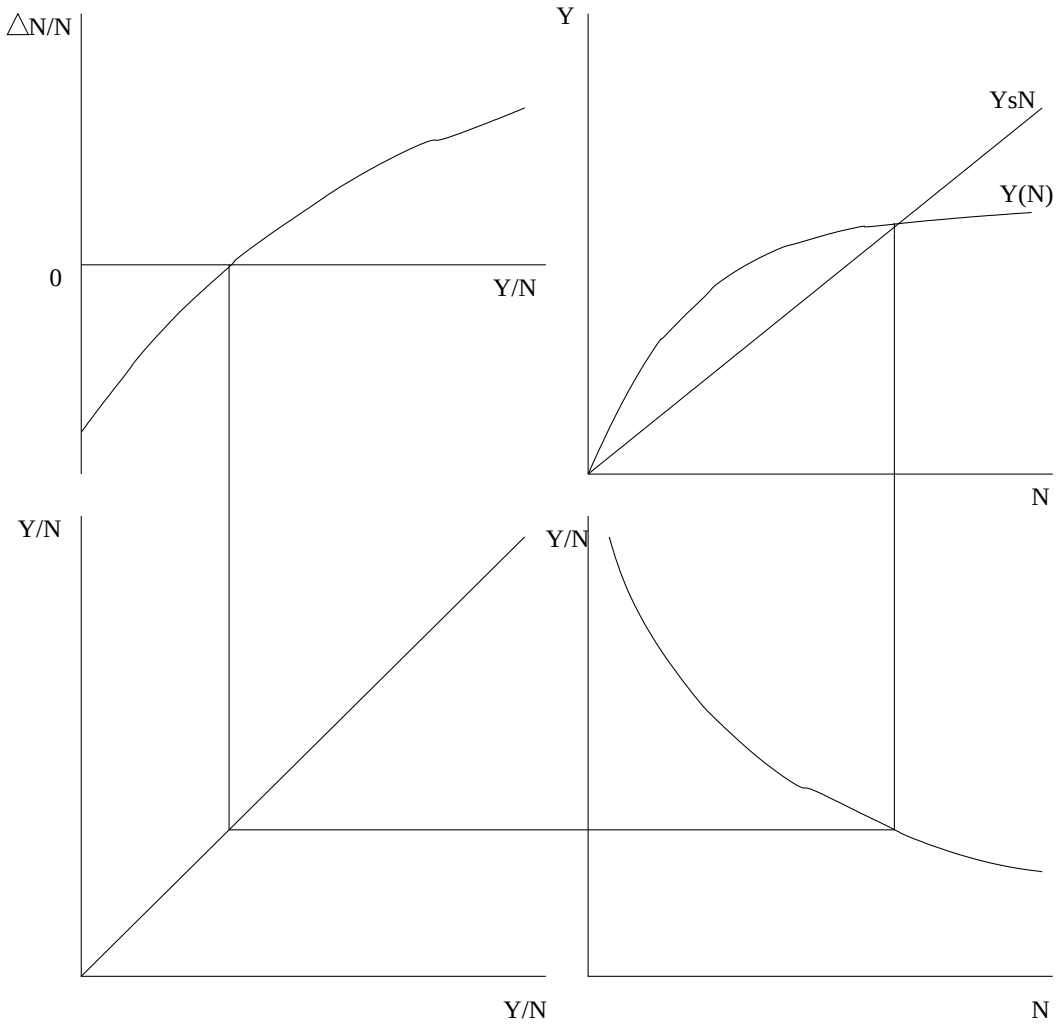
From this we can infer the shape of output per capita as a function of population (note that we assume everyone works):



With all these elements, we can already build a theory. First let us build a graph that describes the population growth rate as a function of the standard of living, by subtracting the mortality rate from the natality rate:



We are now ready to put all elements of Malthus' theory together. We do this in a fashion similar to what we did with the intertemporal model with investment in order to obtain all the linkages between the variables and try to find an equilibrium:



Let us go through each panel of this four-panel graph. In the NW (North-West) corner, we have the population growth relation, $\frac{\Delta N}{N}$ to $\frac{Y}{N}$. In the SW corner, we draw a 45° line that brings the standard of living $\frac{Y}{N}$ to the vertical axis. In the SE corner, we have the relationship between the standard of living $\frac{Y}{N}$ and population N. Finally, in the NE corner, we have the production function $Y(N)$ along with a new line, $Y_s N$, which represents the total amount of production necessary for subsistence, that is Y_s is what everyone needs to survive. This last line is drawn

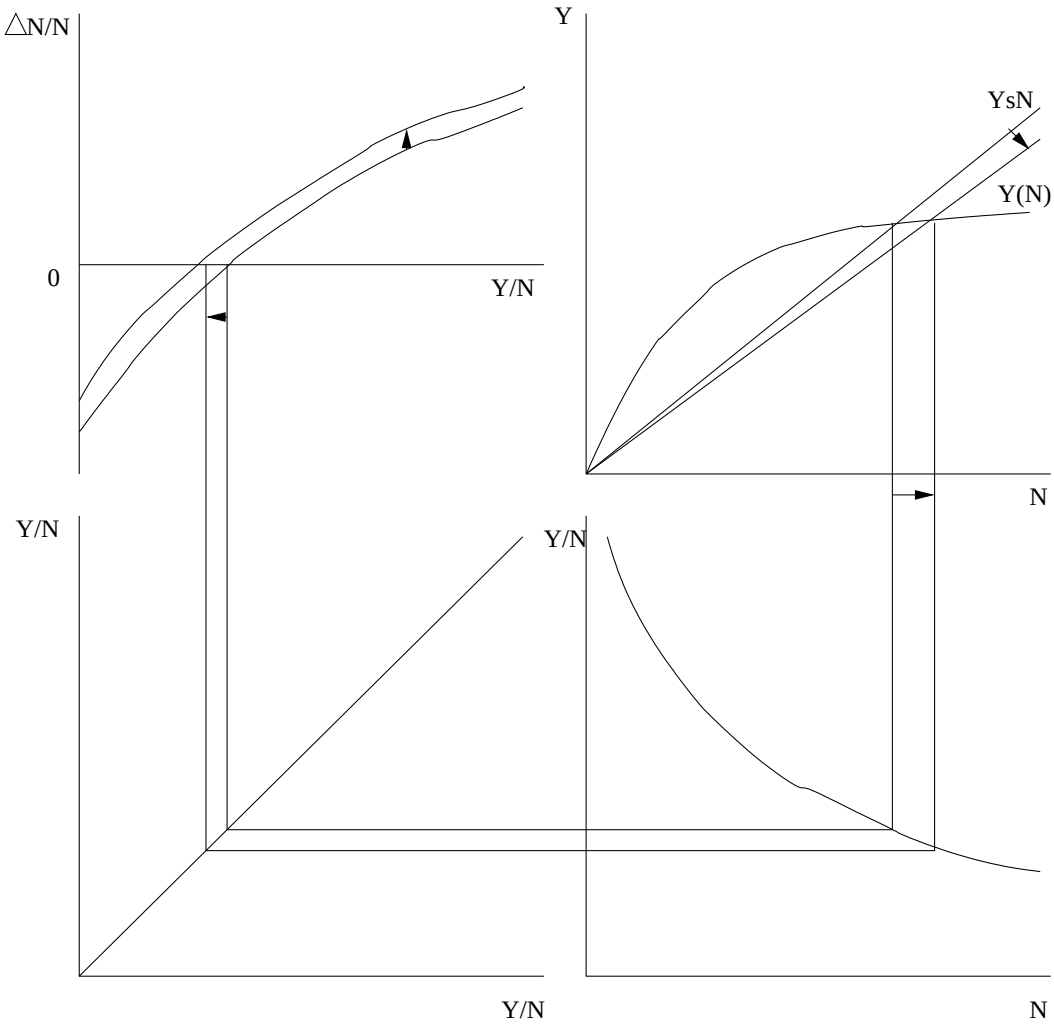
such that population is constant when $Y(N) = Y_s N$: with this level of output (or calories), as many people die as there are born.

In this graph, I have represented a potential equilibrium where population is constant. To verify whether this is an equilibrium, imagine that we had more population than this. This would imply that production would be lower than necessary for subsistence (NE), a lower standard of living (SE), and a negative growth rate (NW). Thus in the next period, population has to be lower, and so on until N reaches our candidate equilibrium.

What if population were lower than the candidate equilibrium? Then there is more production available than necessary for substistence (NE), the standard of living is higher (SE) and the population is growing (NW). The next period, population has to be higher, and so on until we reach the candidate equilibrium. The latter turns out to be an equilibrium towards which any population converges.

Thus we have a so-called stable equilibrium. Stable equilibria are very powerful objects, as they are inescapable. Note some of the properties of this equilibrium: zero population growth, and a standard of living corresponding to the bare minimum ($\frac{Y}{N} = Y_s$). In other words, this economy and its population size is governed by hunger, and it is impossible to escape from this misery. Imagine being in the position of Malthus, who can only draw the conclusion that his parishioners are doomed to misery. He argued that while they are materialistically doomed, they face spiritual paradise.

Of course, the next question one might ask is: What policy could alleviate this situation? Suppose that we build a sewer system. This brings better health and should reduce the mortality rate and consequently involve that less output per capita is necessary in order to survive (fewer calories are needed when fewer illnesses are present). Thus the population growth curve and the $Y_s N$ curve shift as in the following graph:



Again, we reach a stable equilibrium. It has again zero population growth, although at a higher level of population (thus, we have positive population growth for a limited period). The standard of living remains at the subsistence level, which is in fact lower than before. In other words, we have more people in misery, hardly a positive outcome.

Thus, policy prescription in this context become rather strange, as one would advocate the opposite of the policy described above, that is ways to increase the mortality rate, for example waging wars at regular intervals, which is obviously not what a priest would like to propose. Another option which would have the same effect on the population growth curve would be to reduce the natality rate. Again, the priest is in an akward situation, as he has to suggest contraception or

celibacy, which are against biblical prescription. In some editions of his work, he even recommends prostitution as a way to alleviate the "passion of the sexes" while driving natality lower.

But one recommendation he could do in the policy context of his period and without going counter to church principles was to find ways to encourage the postponement of marriages. Indeed, social security at this time had to be provided by parishes on the condition that indigents be married (Speenhamland Law, instituted to prevent welfare tourism). Such a condition encouraged early marriages, and more births.

Malthus' principal recommendation was thus to find ways to reduce population growth, such that people can enjoy higher standards of living. He thus highlighted the dangers of overpopulation. But does this apply today? His theory implies that any increase in population leads to a descrease in living standards. If we look back at the periods since Malthus, we notice that population and standards of living have both tremendously increased. This was triggered, among others, by the Agricultural and Industrial Revolutions.

This highlights that Malthus' model may be a too restrictive abstraction from the reality, as population is the only driving force. History shows us that there should be at least two other driving forces, capital accumulation and technological progess. This means that we have to reexamine the stylized facts, not only to include capital and technology, but also to incorporate the new situation in which the modern economy currently lives in. This is the task of the next section.

2 Modern Stylized Facts

The stylized facts presented here are taken from Romer (1989).[2] They are listed and summarily discussed. I will present evidence for these facts in the forms of various graphs in class, and I leave some space after each fact for you to add your own comments.

There are two sets of facts. The first six are due to Kaldor (1961),[3] who already then recognized some long-term regularities in the data. Paul Romer then added five of his own.

[2] Paul M. Romer, Capital Accumulation in the Theory of Long-Run Growth, in: Robert J. Barro (ed.), *Modern Business Cycle Theory*, Cambridge MA:Harvard University Press, pages 51–127, 1989.

[3] N. Kaldor, Capital Accumulation and Economic Growth, in: F. A. Lutz and D. C. Hague (eds.), *The Theory of Capital*. New York: St. Martin's Press, pages 177–222, 1961.

1. **Output per worker shows continuing growth "with no tendency for a 'falling rate of growth of productivity".** The standard of living, when measued as output per worker, is continuously increasing.

2. **Capital per worker shows continuing growth.** The amount of machinery and structures for each worker is continuously increasing.

3. **The rate of return of capital is steady.** One way to measure this is to look at *real* interest rates. There is no theoretical reason why they should have an upward or downward trend, as this would not be sustainable in the long run. Computing real interest rates to verify this in the data is tricky, though.

4. **The capital output ratio is steady.** The amount of physical capital necessary to produce one unit of output is remarkably stable over time.

5. **Labor and capital receive constant shares of total income.** Labor income represents about 64% of total income, and this number barely varies over time. Labor income includes wage income and a share of proprietors' income.

6. **There are wide differences in the rate of growth of productivity across countries.** Over 30 years, some countries have had average growth rates of output of 6%, while it has been negative for others.

7. **In cross section, the mean growth rate shows no variation with the level of per capita income.** This means that low-income countries do not seem to be catching up with high-income countries. This fact is quite striking when including world-wide data. But when one looks only at developed countries, or regions (states) with a developed country, income convergence appears to be a strong regularity: low-income regions catch up to high income regions.

8. **Growth in the volume of trade is positively correlated with growth in output.** Every increase in output seems to be in synchronization with an even bigger increase in international trade, be it measured by exports or imports.

9. **Population growth rates are negatively correlated with the level of income.** Countries with higher population growth rates appear to be poorer. However, this fact has been challenged in more recent literature arguing that very rich countries have higher natality rates.

10. **The rate of growth of factor inputs is not large enough to explain the rate of groth of output: that is, growth accounting always finds a residual.** This fact is due to Solow who noticed that population growth or capital accumulation cannot explain the bulk of output growth. This large residual, called Solow residual, is similar to the total factor productivity z we used earlier on.

11. **Both skilled and unskilled workers tend to migrate toward high-income countries.** High-income countries have net immigration, low-income countries have net emigration.

Note that some stylized facts of Kaldor are redundant. For example, facts 1, and 4 imply fact 2: If $\frac{Y}{N}$ increases and $\frac{Y}{K}$ is constant, then $\frac{K}{N}$ obviously increases. Or, facts 4 and 5 imply fact 3: If $\frac{K}{Y}$ is constant and $\frac{rK}{Y}$ is constant, then r has to be constant. Thus, when checking for the relevance of a model, we do not need to look at facts 2 and 3. And obviously we will not be able to address facts 8 and 11 unless we have an international model (called open-economy model).