Macroeconomics
Topic 2: "Explain the role of capital investment, education, and technology in determining economic growth."

Reference: Gregory Mankiw's *Principles of Macroeconomics*, 2nd edition, Chapter 12.

Introduction to Economic Growth

Real gross domestic product measures the value of the final goods and services produced in a country using a given base year's prices. Because real GDP changes when the amount of final goods and services produced change (and not when the price level varies) it tells us whether there are more (or fewer) goods and services to divide among the citizenry. When real GDP falls, governmental "macroeconomic policies" often tend to change and politicians come under increased voter-scrutiny. Real GDP is one of the most closely watched indicators of economic performance.

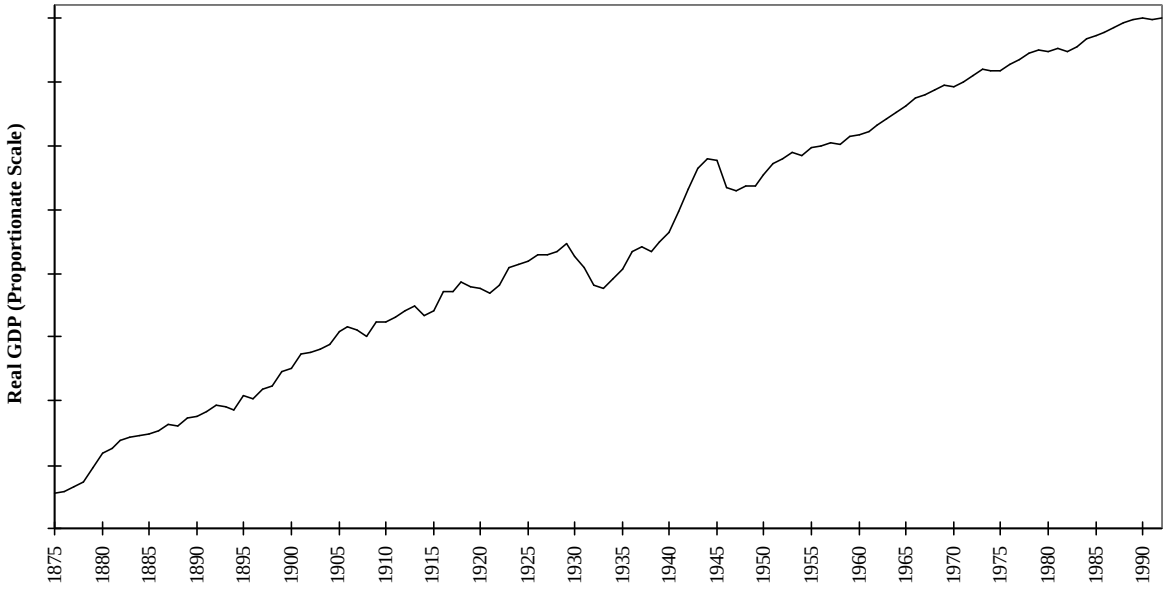

Figure 1: Real GDP in the United States 1875-1993

Figure 1 presents real GDP for the United States between 1875 and 1993 using a proportionate scale. When a variable is graphed on a proportionate scale, a constant percentage[1] increase in that variable shows up as a straight line. One of the most obvious features of Figure 1 is that real GDP has been growing almost linearly over a significant period of time. Even cataclysmic events such as the Great Depression (1929-1932) and World War II (1941-1945) seem to be merely wobbles in the steady growth of real GDP. The average growth rate from 1869 until 1993 was roughly 3.3% per year. The total

[1] A constant percentage increase in real GDP of 3% means that each year's real GDP is 1.03 times as large as the previous year.

amount of goods and services produced in the country to has increased fifty-four fold during this one hundred and twenty-five year period. The average annual growth rate in the population during this same period was 1.5%. Consequently real GDP per-person (per capita real GDP) increased by about 1.8% per year over this century and a quarter. This means that we produce eight times as many goods and services per person in the 1990's than we did in the 1870's.

It is important to recognize that small differences in the growth rate of real GDP can make enormous differences over time. Table 1 (next page) presents a comparison of real GDP per-capita growing at 1% versus real GDP growing at 2%. Period zero starts from $26,933.32 (per capita real GDP at the end of the third quarter of 1995) and in each subsequent year real per capita GDP is increased by the respective growth rate. In five years time, a 2% growth rate causes real GDP per capita to be nearly 5% higher than a 1% growth rate. In 25 years time, a 2% average annual growth leads to nearly a 25% higher level of real GDP per capita compared to a 1% growth rate. As this example illustrates, even modest changes in the rate of economic growth can have large impacts on future well being. Because of its potentially profound effect on well being, economists have long been interested in the determinants of long-run growth, and the possibility of increasing it.

Figure 2 presents the real GDP for the period since 1970. This closer examination of the data reveals that in addition to our long-term steady growth of 3.3% per year there is substantial variation in real GDP from year to year. In fact, real GDP from time to time grows slowly or even drops for several years. These "recessions" (periods of negative real GDP growth) are normally followed by periods where real GDP growth is much more rapid than usual ("recoveries"). This irregular pattern of recession and recovery is called ***the business cycle***. While recoveries seem to regularly follow recessions, the length of recessions and recoveries varies enormously. Notice that we had a large recession from the second quarter of 1973 until the fourth quarter of 1975, followed by a very short recession in 1978. After the major recession of 1982-83, the recovery lasted seven years.

Most economists make a distinction between the factors affecting real GDP over relatively short term business cycles and those that affect the long-term growth rate in real GDP. In this review we focus on the latter.

Year	Real GDP Per Person if the growth rate is 2% annually	Real GDP Per Person if the growth rate is 1% annually	% difference in real GDP per person if the annual growth rate was 2% rather than 1%
0	26,933.32	26,933.32	
1	27,471.99	27,202.65	0.99%
2	28,021.43	27,474.68	1.97%
3	28,581.85	27,749.43	2.96%
4	29,153.49	28,026.92	3.94%
5	29,736.56	28,307.19	4.93%
6	30,331.29	28,590.26	5.91%
7	30,937.92	28,876.16	6.89%
8	31,556.68	29,164.93	7.88%
9	32,187.81	29,456.58	8.86%
10	32,831.57	29,751.14	9.84%
11	33,488.20	30,048.65	10.83%
12	34,157.96	30,349.14	11.81%
13	34,841.12	30,652.63	12.79%
14	35,537.94	30,959.16	13.77%
15	36,248.70	31,268.75	14.75%
16	36,973.68	31,581.44	15.73%
17	37,713.15	31,897.25	16.71%
18	38,467.41	32,216.22	17.69%
19	39,236.76	32,538.38	18.66%
20	40,021.50	32,863.77	19.64%
21	40,821.93	33,192.41	20.62%
22	41,638.37	33,524.33	21.59%
23	42,471.13	33,859.57	22.56%
24	43,320.56	34,198.17	23.54%
25	44,186.97	34,540.15	24.51%

Table 1: The Effect of Differences in Long Term Growth Rates

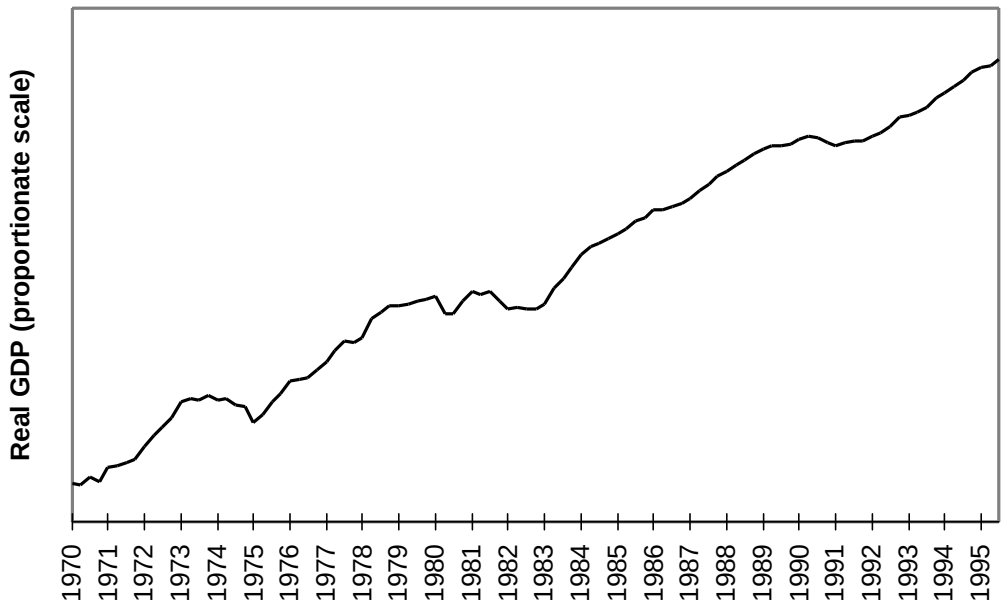

Figure 2: US Real GDP 1970-1995

Determining Real GDP: The Aggregate Production Function

The relationship between the economy-wide amount of final goods and services produced and the inputs (so-called factors of production) used in the process is called the aggregate production function. As a general rule, anything that tends to increase our utilization of inputs will increase our real GDP. Thus aggregate output can increase due to an increase in the quantity (and quality) of inputs or due to an increase in our ability to obtain output from inputs. In the subsections that follow, we consider this in more detail.

Labor

One of the most obvious ingredients to production is labor. The more time people spend working in the market sector, the more final goods and services are likely to be produced. Recall that the supply of labor consists of the total number of hours that people are willing to work in the economy, while the demand for labor represents the amount of labor that firms want to hire. Anything that tends to increase the equilibrium amount of employment (e.g., higher population growth) will tend to increase real GDP.

Physical Capital

Economists use the word capital to denote any durable input. Examples of capital include computers, buildings, roads and factories. In each case, these inputs last for many years and tend to increase the amount of final goods and services that a firm can produce in a given year. Because physical capital lasts for a long period, the amount of capital available in the economy in a given year is typically much greater than the amount that has been added in the year. Economists refer to new capital produced as investment.

The amount of capital available to firms today helps determine how much they can currently produce and consequently affects real GDP. The amount of investment determines how much capital there will be next year and consequently helps determine the growth rate in real GDP.

Human Capital

Economists have long noted that the education (and training) of the population is an important factor in the aggregate production function. The better educated and trained the population, the more final goods and services they are able to produce. Since education and training may be accumulated over time it is often useful to think of them as a type of capital that is embodied in human beings. For this reason, economists often treat the education level of the population as a proxy for the economy's human capital. When people go to school or get on-the-job training, they are acquiring new human capital which subsequently increases real output. Non-human capital of the type discussed earlier is sometimes called physical capital to distinguish it from human capital.

Natural Resources

Natural resources are raw materials and minerals, such as oil, that are found in nature and are useful in production. Clearly, the more natural resources available to an economy, the more final goods and services it can produce. Having said that, economists are often quick to note that while natural resources may easily increase real GDP, it is not necessary for a country to be abundant in natural resources to produce goods. Many countries, such as Japan, manage to make a very large amount of final goods and services per person despite having relatively few natural resources. As long as natural resources can be purchased from other countries, it is not essential for a country to be endowed with large domestic reserves.

Sources of Long-term Growth in Real GDP

Input Growth and the "Catch-Up Effect"

Economists have spent a lot of effort to determine what causes real GDP per person to increase over long periods. For some countries, growth comes from increased usage of factors of production. With input-growth, real GDP rises because the country utilizes more labor, increases the training of its population, and increases its usage of physical capital. In principle, a key feature of this kind of growth is that it involves no new technology. Rather than developing new, more efficient methods of production, this type of growth comes from using increased amounts of human and physical capital, labor and natural resources.

A difficulty with input-growth as a source of continuing growth in real GDP is that it tends to not last forever. Eventually, an economy will encounter diminishing marginal returns to capital, which means that each additional unit of capital adds a smaller amount to output than did previous units of capital. To see why, consider input growth associated with the personal computer technology available in 1980. (We want to consider the accumulation of computers with a given level of technology.) Firms and individuals in a

country without any personal computers in 1980 might decide to invest substantially in new computers to reduce the costs of doing business and increase the quality of service provided to customers. In the first few years, it is likely that growth in the physical capital stock (due to the purchase of new computers) and growth in the human capital stock (due to increased training in how to use the new computers) would increase real GDP per capita in the country substantially. However, as time passes firms would begin to have all of the new personal computers that were desirable. Additional computers would be needed only to replace old computers that had worn out. At that point, accumulating additional personal computers would not contribute much too real GDP. As a result the accumulation of computers would not be likely to provide a permanent source of growth unless there were new developments allowing you to use computers more efficiently.

Poor countries often have very limited amounts of physical capital. As a result, the initial effect of adding modern machinery, roads and technology often causes very rapid growth in real GDP. While this can allow them to catch-up to the higher real GDP per capita levels of the rich countries, the effect diminishes with time as their physical capital levels per person begin to match those in the rich countries, which have already encountered diminishing marginal returns. As a result, the observation that input-growth begins very rapidly and then diminishes is often called the catch-up effect.

Technological Growth

Much of the growth in countries that have been rich for some time tends to come from the discovery of new products and better ways to make old products. When technology improves, more final goods and services can be produced from a given amount of labor, physical capital, human capital and natural resources.

To get an idea of the importance of technological growth relative to other sources of increases in real GDP, we consider an example of what economists call growth accounting. In growth accounting, economists estimate a country's aggregate production function and use the estimated equation to calculate the fraction of growth in real GDP that is due to growth in the country's inputs to production and what is due to improvements in technology. A growth accounting for various countries is presented in Table 2. According to analysis summarized in Table 2, in the period from 1960-1990, 36% of the growth in real GDP in the United States came from improvements in technology, while 31% came from increases in labor, 24% from increases in capital and 7% from increases in human capital.

In the developed countries (France, Germany, Japan, the United Kingdom and the United States) improvement in real GDP comes mostly from technical progress. By contrast the developing countries of the Pacific Rim (Hong Kong, Singapore, South Korea and Taiwan) got essentially all of their growth from growth in inputs. Some economists think that this is a good reason to expect the growth rates in the Pacific Rim countries, which have been extraordinarily high in the recent past, to slow in the near future.

	Percentage Contributions to Growth in Real GDP (1960-1990)			
Country	Capital	Labor	Human Capital	Technical Progress
Hong Kong	63	20	17	0
Singapore	63	19	18	0
South Korea	61	20	19	0
Taiwan	70	14	16	0
France	34	-1	8	58
Western Germany	37	-7	9	61
Japan	45	6	4	45
United Kingdom	37	4	9	49
United States	24	31	7	36

Source: Kim Jong-Il and Lawrence J. Lau.(mimeo. December 1995) "The Sources of Economic Growth of East Asian Newly Industrialized Countries: Some Further Evidence."

Table 2: Accounting for Growth 1960-1990

Summary

Economic growth refers to an increase in real Gross Domestic Product (i.e., more goods and Services being produced and exchanged).

A. By <u>increasing investment</u> in the capital stock (adding real buildings & equipment), the activities of labor become more productive thus generating more output per worker and <u>raising real GDP.</u>
B. By <u>increasing the education</u> of the labor force, workers become more productive thus generating more output per worker and <u>raising real GDP.</u>
C. As <u>technology changes</u> we learn more efficient ways to produce goods and services thus generating more output per worker and <u>raising real GDP.</u>