LECTURE NOTES ON
MACROECONOMIC PRINCIPLES

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Ch 25 Production and Growth

Introduction

Real GDP per person in the United States, Japan, or Germany is about ten times larger than real GDP per person in India, Indonesia, or Nigeria. Why?

In the US over the past century, real GDP per person has grown at an average annual rate of 2 percent. This number may seem small, but it implies that the average real income doubles every 35 years, and that average income in the US today, at the beginning of the 21st century, is more than seven times as large as it was a century ago, at the beginning of the 20th century. Why?

In some East Asian countries, such as Singapore, South Korea, and Taiwan, real GDP per person has grown at an average rate of 7 percent in recent decades. This implies that average real income doubles every ten years. Yet there are other countries, especially in Africa, where GDP per person has not grown at all. Why?

It is no exaggeration to say that these issues, explored in this chapter, are some of the most important in all of economics.

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        iv. Technological Knowledge
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Economic Growth Around the World

Table 1 shows data on real GDP per person in 13 countries around the world:

1. Real GDP per person varies widely from country to country:
    a. Income per person in the US is now about 8 times that in China and 16 times that in India.
    b. Average income in India today is less than average income in England in 1870.
2. In the US, real GDP per person has grown at an average annual rate of 1.80% since 1870.

3. Japan's real GDP per person has growth at an average annual rate of 2.71% since 1890:
    a. In 1890, average income in Japan was similar to average income in Mexico and Argentina.
    b. Today, average income in Japan is similar to average income in Germany and the United Kingdom.

Productivity: Its Role and Determinants

Why Productivity is So Important

Economists studying production and growth often like to start by thinking about Robinson Crusoe, a sailor stranded on a desert island.

Everything Crusoe consumes, he must produce himself.

What determines Crusoe's standard of living? His **productivity**, the quantity of goods and services produced by each unit of labor input.

For the US economy, the Bureau of Labor Statistics collects data not just on how many workers are employed, but also on how many hours each of those workers actually spends on the job. Therefore, the BLS can compute productivity as output per hour of work.

For our purposes, however, we can put things even more simply: productivity measures output per worker.

This seems obvious – it holds true almost by definition – when thinking about Crusoe, but it also holds true when thinking about GDP – income or expenditure – per person in a real-world economy.

How Productivity is Determined

What determines how many fish Crusoe eats?

His productivity: how many fish he catches.

But what determines his productivity?

1. How many fishing poles does he have?
2. How much training in fishing does he have?
3. How plentiful is the supply of fish near his island?
4. How effective is he in inventing new techniques for catching more fish?

Again, these basic principles extend to real-world economies.

Physical Capital per Worker

Crusoe catches more fish if he has more fishing poles.

Workers are more productive when they have more tools.

Physical capital (or capital) is the stock of equipment and structures that are used to produce goods and services.

A larger stock of physical capital per worker makes an economy more productive.

Recall that capital and labor are inputs or **factors of production**.

But capital is a *produced* factor of production: an output of past production that has now become an input to new production.

Human Capital per Worker

Crusoe catches more fish if he has had better training.

Human capital is the stock of knowledge and skills that workers acquire through education, training, and experience.

A larger stock of human capital per worker makes an economy more productive.

Although human capital is less tangible than physical capital, we can still think of human capital as being itself "produced" in schools, training programs, etc.

Natural Resources per Worker

Crusoe catches more fish if fish are more plentiful in the nearby waters.

Natural resources are the inputs to production that are provided by nature: land, water, mineral deposits, etc.

Natural resources can be:

1. Renewable: forests.
2. Nonrenewable: oil.

A larger stock of natural resources per worker also tends to make an economy more productive.

Although some countries, such as Japan, can be quite productive without having access to a lot of natural resources.

Technological Knowledge

Crusoe catches more fish if he is good at inventing new fishing techniques.

Technological knowledge refers to society's understanding of the best ways to produce goods and services.

Technological knowledge can be:

1. Common knowledge: Henry Ford introduced assembly lines in auto manufacturing, but other companies in other industries followed suit.

2. Proprietary: a pharmaceutical company develops a new drug and patents it, and then has exclusive rights to produce that drug for a period of time.

A larger stock of technological knowledge makes an economy more productive.

Technological knowledge and human capital are closely related, but ultimately distinct:

- Technological knowledge refers to society's understanding of how the world works.
- Human capital refers to each individual worker's ability to use that technological knowledge.
- "Technological knowledge is reflected in textbooks, human capital is reflected in the amount of time each worker has spent reading those textbooks."

Summary

What determines Crusoe's standard of living?	**What determines the US standard of living?**
His productivity (output per worker).	Our productivity (output per worker).
What determines Crusoe's productivity?	**What determines US productivity?**
Number of fishing poles.	Amount of physical capital per worker.
Amount of training in fishing.	Amount of human capital per worker.
Supply of fish.	Amount of natural resources per worker.
Invention of new fishing techniques.	Amount of technological knowledge.

The Aggregate Production Function

These determinants of productivity are often depicted mathematically using an **aggregate production function**.

Let

$$Y = \text{quantity of output}$$

$$L = \text{quantity of labor (number of workers)}$$

$$K = \text{stock of physical capital}$$

$$H = \text{stock of human capital}$$

$$N = \text{stock of natural resources}$$

$$A = \text{stock of technological knowledge}$$

Economists often assume that output is related to inputs via an aggregate production function of the form

$$Y = A\text{F}(L,K,H,N)$$

This equation assumes that holding other inputs constant, an increase in the stock of technological knowledge leads to a direct increase in output.

Economists also often assume that holding the stock of technological knowledge fixed, the production function exhibits **constant returns to scale**; doubling *L, K, H,* and *N* all at once leads to a doubling of output, so that

$$2Y = A\mathrm{F}(2L,2K,2H,2N)$$

Similarly, tripling *L, K, H,* and *N* all at once leads to a tripling of output, so that

$$3Y = A\mathrm{F}(3L,3K,3H,3N)$$

Or, for any number *x*:

$$xY = A\mathrm{F}(xL,xK,xH,xN)$$

Now set x = *1/L* in this last equation to write

$$Y/L = A\mathrm{F}(1,K/L,H/L,N/L)$$

This last equation just restates in mathematical terms when we learned in words from Crusoe: that productivity (output per worker) *Y/L* is determined by:

1. Physical capital per worker *K/L.*
2. Human capital per worker *H/L.*
3. Natural resources per worker *N/L.*
4. Technological knowledge *A*.

This production function also highlights that a decrease in natural resources per worker, due to the depletion of nonrenewable resources, will tend to decrease productivity.

This last observation raises the question: will productivity-driven economic growth someday have to end, given that natural resources are ultimately limited?

Maybe, but evidence from history suggests not:

- Growth in the stock of technological knowledge makes production processes and goods themselves more resource-efficient.
- Prices of natural resources tend to be volatile, but also have tended remain stable or in some cases even fall over long period of time.
- If we use the price of a good to measure its economic scarcity, the stable or falling historical trend in natural resource prices suggest that while supplies may be falling, demands are declining just as fast or even more rapidly.

Economic Growth and Public Policy

What can governments do to increase productivity and thereby raise standards of living?

They can adopt policies that lead to larger stocks of

1. Physical capital per person.
2. Human capital per person.
3. Technological knowledge.

Saving and Investment

Since physical capital is a produced factor of production, a larger stock can be accumulated over time.

But this requires that people save and invest more and consume less today.

Chapter 26 takes a more detailed look at how financial markets coordinate saving and investment.

Diminishing Returns and the Catch-Up Effect

Diminishing returns refers to property whereby the benefit from an extra unit of input declines as the quantity of the input increases.

Economists usually assume that capital accumulation is subject to diminishing returns, as illustrated in Figure 1.

The diminishing returns assumption implies that higher savings leads in the long run to higher *levels* of productivity and incomes but not to higher *growth rates* in these variables.

It also implies that poorer countries have more to gain, relatively speaking, from capital accumulation than richer countries. There can be a **catch-up effect**, according to which countries that start off poor tend to grow more rapidly than countries that start off rich.

This catch-up effect seems to have been particularly important in fast-growing East Asian economies.

Investment from Abroad

A country's capital stock can also be augmented by investment from abroad:

1. **Foreign direct investment** occurs when foreigners make capital investments that they own and operate in the domestic economy.
2. **Foreign portfolio investment** occurs when foreigners lend money to domestic corporations that use the funds to acquire more physical capital.

When foreigners invest in a country, they expect to earn a return. But the capital they supply makes domestic workers more productive, increasing the workers' incomes as well.

The **World Bank** raises funds in advanced countries and uses those funds to make loans in developing countries.

Education

Like physical capital, human capital accumulation raises productivity.

But also like physical capital, human capital accumulation has a cost: when students are at school, they forego the wages that they could earn by working instead.

Many economists believe that human capital is even more important than physical capital because of positive *externalities*. An externality is the impact that one person's actions have on the well-being of bystanders. If an educated worker comes up with new and better ways of producing goods and services, he or she adds to the stock of technological knowledge that is available to everyone.

Perhaps for this reason, governments are heavily involved in education.

Health and Nutrition

Although human capital is most often associated with education, it applies on an even more basic level to the health of workers.

Economist Robert Fogel argues that improved nutrition and heath accounts for about 30 percent of the growth in GDP per person in Britain between 1790 and 1980. During that time, the average caloric intake in Great Britain rose by 26 percent and the height of the average man rose by 3.6 inches.

Property Rights and Political Stability

A key aspect of both physical and human capital accumulation is an *intertemporal trade-off*:

- Physical capital: consume less and save more today to have more physical capital in the future.
- Human capital: attend school and forgo wages today to have more human capital in the future.

If people are to willingly accept these intertemporal trade-offs, they need to be assured that they will be able to enjoy the future benefits of today's sacrifices.

This requires a stable political and judicial system that respects **property rights**, that is, the ability of people to exercise authority over the resources that they own.

Free Trade

Free trade can help raise productivity by:

1. Allowing a country to specialize in goods that it can produce most efficiently.
2. Allowing a country to import foreign capital.

Research and Development

Research and development leads to increases in the stock of technological knowledge, hence to higher productivity.

Like human capital accumulation, research and development activities yield positive externalities when one person's discoveries can be used by other people in other activities.

For this reason, the National Science Foundation and the National Institute of Health provide research grants to scientists.

The federal government is also a big sponsor of higher education.

Population Growth

Our equation for productivity

$$Y/L = A\text{F}(1, K/L, H/L, N/L)$$

derived above from the aggregate production function, suggests that population growth (an increase in the number of workers L), can decrease productivity by:

1. "Diluting" the stocks of physical and human capital.
2. Stretching natural resources too thin.

On the other hand, increases in population may make technological progress more rapid, since there are more people around to discover and invent.

Which of these effects "wins out" in the end?

Again, it's hard to say for sure, but evidence thus far has not supported the "Malthusian" (named after British economist Thomas Robert Malthus, 1766-1834) view that population growth will ultimately lead to widespread poverty.

Summary

Our equation

$$Y/L = A\text{F}(1, K/L, H/L, N/L)$$

suggests that productivity improvements can come through policies that work through several channels.

K/L	***H/L***	***A***
Saving and investment	Education	Research and development
Catch-up effect	Health and nutrition	
Investment from abroad		
Free trade		
Property rights and political stability		