

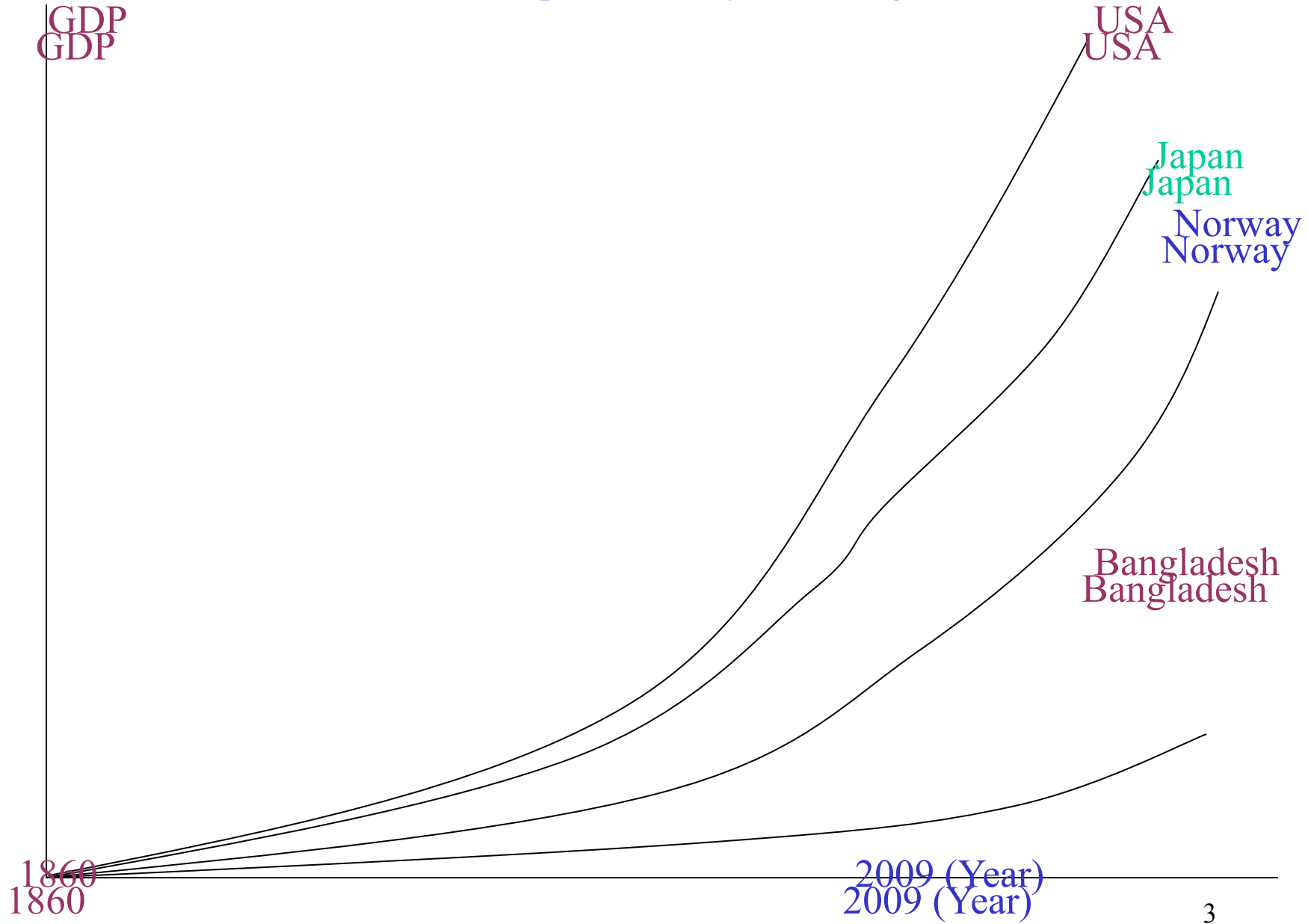
CHAPTER IV

GROWTH AND ACCUMULATION

Economic Condition: Developed and less developed countries

- ◆ The Western has far more higher incomes than their great grandfathers
- ◆ People in developed countries are far wealthier than people in the less developed countries
- ◆ Graph -1 shows GDP for four countries over more than 150 years

Figure 3-1: GDP Growth of USA, Japan, Norway and Bangladesh



The Graph above has four characteristics:

- ❖ **It shows that in in USA income increased more than sixteen fold over this period**
- ❖ **Japan was poor country before 2nd World War. Now it has a standard of living roughly equal to USA**
- ❖ **Norwegian income has increased during the last 30 years**
- ❖ **Bangladesh was poor 150 years ago, grew very slowly and remains the same even today**

Question is:

- ❖ **What are causes behind these differences?**
- ❖ **What will determine the standard of living in future?**

The answer of these questions are given by:

- (i) Growth accounting and**
- (ii) Theory of Growth**

Growth Accounting

- ❖ **Growth accounting explains the role of different factors of production (capital, labour, technology, etc.) in growth**

Growth Theory

- ❖ **Growth theory explains how economic progress could be fostered**

1. GROWTH ACCOUNTING

Growth accounting explains the role of different Factors of production in growth

It explains Output (GDP) increases if production factors:

- (i) Capital (K) and Labour Force (N) increase**
- (ii) And productivity could be enhanced through:**
 - (a) Improved technology**
 - (b) More and skilled work force**

The condition of growth can be expressed in following functional relationship between input and output:

$$Y = Af(K, N) \quad (1)$$

It means: Output depends on the volume of Capital, Labour and Technological Efficiency (A)

► Equation (1) is the functional equation of GDP

► Equation (1) is also called production function

In Equation (1):

- ◆ **K = Capital (K) and**
- ◆ **N = Labour Force**
- ◆ **A = Level of Technology (It determines the efficiency of Labour and Capital)**

Equation (1) shows that output (Y) is a function of:

- (i) Inputs (K and N) and**
- (ii) Level of technology (A)**

Inputs

- ◆ **More input means more output**
- ◆ **Increase in labour force (one input) increases output (marginal product of labour/MPN)**
- ◆ **Increase in capital increases output (marginal product of capital/MPK)**

Level of technology

- ◆ The letter “A” in the production function (1) indicates level of ‘productivity’
- ◆ Higher level of A means more output
- ◆ It means more output is produced for certain inputs
- ◆ Let us assume that two countries X and Y have same amount of Capital and Labour
- ◆ Let us assume that the country X is more productive than Y country
- ◆ So, the country X will produce more output than the country Y

2. COMPUTING GROWTH OF OUTPUT

- ◆ Production function (1) can be used to explain causes behind the growth of output
- ◆ It means, it can be used to deduce a new equation which explains the factors of growth
- ◆ The new equation is called growth accounting equation

Our Production Function is: $Y = Af(K, N)$

- ◆ From this equation the following Growth Accounting can be deduced:

$$\Delta Y/Y = [(1 - \theta) \times \Delta N/N] + (\theta \times \Delta K/K) + \Delta A/A \quad (2)$$

Equation (2) says that growth of GDP depends on:

- ◆ Growth of Labour and Share of Labour to GDP
- ◆ Growth of Capital and Share of Capital to GDP

Following are steps to deduce Growth Accounting Equation (2) from Production Equation (1)

$$\Delta Y = MPN \times \Delta N + MPK \times \Delta K + F(K, N) \times \Delta A$$

[MPK: Marginal Production of Capital]

[MPL: Marginal Production of Labour]

$$\Delta Y = \frac{(MPN \times N)\Delta N}{N} + \frac{(MPK \times K)\Delta K}{K} + F(K, N) \times \Delta A$$

$$\Delta Y = (MPN \times N) \frac{\Delta N}{N} + (MPK \times K) \frac{\Delta K}{K} + F(K, N) \times \Delta A$$

(Dividing both side by Y)

$$\frac{\Delta Y}{Y} = \frac{(MPN \times N)}{Y} \frac{\Delta N}{N} + \frac{(MPK \times K)}{Y} \frac{\Delta K}{K} + \frac{F(K, N) \times \Delta A}{Y}$$

$$\frac{\Delta Y}{Y} = (1 - \theta) \frac{\Delta N}{N} + \theta \frac{\Delta K}{K} + \frac{F(K, N) \times \Delta A}{AF(K, N)}$$

$$\frac{\Delta Y}{Y} = (1 - \theta) \frac{\Delta N}{N} + \theta \frac{\Delta K}{K} + \frac{\Delta A}{A}$$

In Equation (2):

- ◆ $(1 - \theta)$ is the share of labour to the GDP
- ◆ θ is the share of Capital to the GDP

In words the equation can be written as

- ◆ **Growth of Output = [(share of labour to GDP) × (labour growth)] + [(share of capital to GDP) × (capital growth)] + technical progress**
- ◆ Equation 2 summarises the contribution of growth of input and productivity to growth of output

It also says

- ◆ If we get more output from same factors of production, it means there is a growth in factor productivity

Example

- ◆ The capital share of income is 25% and that of labour is 75%, which correspond to the value of US economy. Labour force growth is 1.2%, growth of the capital stock is 3% and total factor productivity is 1.5% annually. What is the growth of the output?

Solution

We know that:

$$\Delta Y/Y = [(1 - \theta) \times \Delta N/N] + (\theta \times \Delta K/K) + \Delta A/A$$

Where:

$$\theta = 0.25, 1 - \theta = 0.75, \Delta N/N = 1.2\%, \Delta K/K = 3\% \text{ and } \Delta A/A = 1.5\%$$

Hence

$$\Delta Y/Y = (.75 \times 1.2\%) + (.25 \times 3\%) + 1.5\% = 3.15\%.$$

3. ACCOUNTING GROWTH OF PER CAPITA OUTPUT

- ❖ It means to find out on what factors does per capita growth of the GDP depend
- ❖ **Equation (2) helps explain growth of the GDP**
- ❖ However, it does not say anything about the change in the per capita output
- ❖ Per Capita Output expresses the living standard
- ❖ **As for instance, Norway is a rich country and India is a poor country**
- ❖ Though, India has larger GDP than Norway

We are interested in the:

- ❖ **Growth of the Per capita GDP**
- ❖ **Per capita GDP refers to individual well-being**
- ❖ **Per capita GDP is the ratio of GDP to population**

Equation (2) says:

$$\diamond \Delta Y/Y = [(1 - \theta) \times \Delta N/N] + (\theta \times \Delta K/K) + \Delta A/A$$

Hence:

$$\diamond \Delta Y/Y = [\Delta N/N - \theta \times \Delta N/N] + (\theta \times \Delta K/K) + \Delta A/A$$

$$\diamond \Delta Y/Y = \Delta N/N - \theta \times \Delta N/N + (\theta \times \Delta K/K) + \Delta A/A$$

$$\diamond \Delta Y/Y - \Delta N/N = \theta \times \Delta K/K - \theta \times \Delta N/N + \Delta A/A$$

$$\diamond \Delta Y/Y - \Delta N/N = \theta \times [\Delta K/K - \Delta N/N] + \Delta A/A$$

$$\diamond \Delta y/y = \theta \times \Delta k/k + \Delta A/A$$

$$\diamond y = \theta \times \Delta k/k + \Delta A/A$$

$$\diamond y = \theta f(k) + \Delta A/A \quad (3)$$

Where:

$\diamond \Delta Y/Y - \Delta N/N = \Delta y/y =$ per capita out put growth, and
[Growth rate of per capita GDP equals the growth rate of GDP minus growth rate of population]

$\diamond \Delta K/K - \Delta N/N = \Delta k/k = k =$ per capita capital growth
[Growth rate of capital equals growth rate of per capita capital minus growth rate of the population]

Equation (3) says per capita growth rate of GDP depends on:

- ◆ **Per capita capital growth ($\Delta k/k$) and**
- ◆ **Change in technological development ($\Delta A/A$)**
- ◆ **And share of capital to the GDP**

Example

- ◆ **The value θ is around 0.25 in USA**

It means that:

- ◆ **For 1% increase in the per capita output (GDP) 4% capital has to be employed**

We know that:

- ◆ **$y = \theta f(k) + \Delta A/A$**

Hence

- ◆ **$1\% = 0.25 \times k + 0$ [In Short term $\Delta A/A = 0$]**
- ◆ **$1\% = 0.25 \times 4\%$**

[It means 1% per capita growth of GDP needs 4% growth of per capita capital]

4. Accounting Technological Change

Let us the growth of GDP, Population Growth and Capital Growth are known, so:

$$\frac{\Delta Y}{Y} = (1 - \theta) \frac{\Delta N}{N} + \theta \frac{\Delta K}{K} + \frac{\Delta A}{A}$$

Hence:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - (1 - \theta) \frac{\Delta N}{N} - \theta \frac{\Delta K}{K}$$

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \frac{\Delta N}{N} + \theta \frac{\Delta N}{N} - \theta \frac{\Delta K}{K}$$

$$\frac{\Delta A}{A} = \left[\frac{\Delta Y}{Y} - \frac{\Delta N}{N} \right] - \theta \left[\frac{\Delta K}{K} - \frac{\Delta N}{N} \right]$$

$$\frac{\Delta A}{A} = y - \theta k \tag{4}$$

- ❖ **Technological progress cause increase of labour productivity**
- ❖ **Such progress is called labour stimulating technological progress**
- ❖ **For labour stimulating technological progress the equation (4) can be written as:**

$$y = \frac{\Delta A}{A} + \theta k$$

Hence:

$$y = (1 - \theta) \frac{\Delta A}{A} + \theta \frac{\Delta K}{K}$$

$$\frac{\Delta A}{A} = \frac{1}{1 - \theta} \left(y - \theta \frac{\Delta K}{K} \right) \quad (5)$$

5. Cobb-Douglas Production Function

$$Y = AK^\theta N^{1-\theta}$$

Here:

- ◆ θ is share of capital to the GDP [For USA $\theta = 0.80$]
- ◆ $1-\theta$ is the share of the labour to the GDP
- ◆ K is Capital and N Population

Cobb-Douglas Production Function could be transferred into per capita form and used for growth accounting:

$$y = \frac{Y}{N} = \frac{AK^\theta N^{1-\theta}}{N} = AK^\theta N^{-\theta} = A \frac{K^\theta}{N^\theta} = A \left(\frac{K}{N} \right)^\theta = Ak^\theta$$

[k is per capita growth of capital, A is the change in productivity]

In functional form this equation could be written as:

$$y = f(k)$$

For labour stimulating technological progress, the Cobb-Douglas Production Function could be written as:

$$Y = AK^\theta N^{1-\theta}$$

- ◆ **In this case the technological productivity increases at the same rate (1- θ) with labour**

Hence:

$$Y = K^\theta (AN)^{1-\theta}$$

$$Y = K^\theta A^{1-\theta} N^{1-\theta}$$

$$A^{1-\theta} = \frac{Y}{K^\theta N^{1-\theta}}$$

6. Empirical Estimate of Growth

Capital Growth

- ◆ Robert Solow studied period 1909-1949 in USA and concluded that over 80% of the growth was due to technical progress
- ◆ Important determinants of per GDP growth are (i) Technical Progress and (ii) Capital Accumulation

Population Growth

- ◆ More workers means more output, but output increases proportionately slowly
- ◆ 1% growth of labour force leads to about 0.80% growth in output
- ◆ As output grows slowly than numbers of workers, per capita output falls

7. Growth Factors Other Than Capital and Labour

Other important factors of growth are:

1. **Natural resources and**
2. **Human capital**

Natural Resource

- ❖ **Early prosperity of USA was due to abundant land**
- ❖ **From 1820 to 1870 arable land grew 1.41% annually**

Recent example

- ❖ **From 1970-2000 per capita GDP of Norway rose from 61% to 100% of the USA**
- ❖ **This was due to the usages of massive oil reserves**

General Trend

- ❖ **Generally countries with natural resources do worse**
- ❖ **Some such countries squander their wealth**

Human Capital

- ◆ In industrialized countries, qualified workers is more important than unqualified labour
- ◆ Stock of unqualified workers could be reduced by investment in human capital

Adding human capital (H), the production function could be written as:

$$y = A f(K, N, H) \quad (4)$$

- ◆ Human capital is difficult to measure precisely
- ◆ However, length of schooling may be used as an indicator for human capital development

Impact of Immigration on Human Capital

- ◆ Immigration boosts per capital output when skilled workers enter in the migrating country
- ◆ From immigration USA has benefited so far
- ◆ In USA always the qualified workers immigrated

Impact of Refugees on Human Capital

- ◆ Immigration of refugees decreases per capita output in the short run
- ◆ A factor of production increases the growth only when the supply of this factor grows

Problem # 1

In a simple scenario with only two factors of production, suppose that capital's share of income is .4 and labor's share is .6 and that annual growth rates of capital and labor are 6 and 2 percent, respectively. Assume there is no technical change.

- a. At what rate does output grow?
- b. How long will it take for output to double?
- c. Now suppose technology grows at a rate of 2 percent. Recalculate your answers to (a) and (b).

Problem # 2

Suppose output is growing at 3 percent per year and capital's and labor's shares of income are 0.3 and 0.7, respectively.

- a) If both labor and capital grow at 1 percent per year, what would the growth rate of total factor productivity have to be?
- b) What if both the labor and the capital stocks are fixed?

Problem # 3

Suppose that capital's and labor's shares of income are 0.3 and 0.7.

- a) What would be the effect on output, if capital & labour stock increase by 10% and 1% respectively?
- b) What would be the effect on output, if the capital stock & pool of labor increase 1% and 10% respectively?
- c) If the increase in labor is due entirely to population growth, will the resulting increase in output have an effect on people's welfare?
- d) What if the increase in labor is due, instead, to an influx of women into the workplace?

Problem

Consider the following production function: $Y = K^{.5}(AN)^{.5}$, where both the capital and the pool of labor are growing at a rate $n = .07$; the capital stock is depreciating at a rate, $d = .03$, and A is normalized to 1.

- a) What are capitals' and labors' shares of income?
- b) What is the form of this production function?
- c) At what rate is per capita output growing at the steady state?
- d) At what rate is total output growing?
- e) What if total factor productivity is increasing at a rate of 2% per year ($g = .02$)?

Questions

- Explain with mathematical model on which factor the growth of the economy depends. What for suggestions would you made for a country like Bangladesh from your analysis.
- The capital share of income is 25% and that of labour is 75%, which correspond to the value of Bangladesh economy. Labour force growth is 1.2%, growth of the capital stock is 8% and total factor productivity is 1.5% annually.
- What is meant by the growth of the output? Explain with mathematical model on which factor the growth of per capital GDP depends. What for suggestions would you made for a country like Bangladesh on the basis of your analysis.

Questions

- ❖ **How do you express growth of per capita GDP using Cobb Douglas production function? Discuss the growth of per capita GDP following Cobb Douglas production function. Explain the role of Natural resources and (ii) Human capital on the growth of the economy.**
- ❖ **Explain using model on which factors growth of the economy depends?**
- ❖ **Explain using model on which factors per capita growth of the economy depends?**
- ❖ **Explain the role of natural resources and human capital for the development of an economy with model.**

End of the Chapter

Tank You Very Much

For Patient Listening