Chapter 3: Physical capital

The nature of capital

The term ‘capital’ refers to physical stock of production means like machines, buildings, also infrastructure, used together with labor to produce output. Therefore, the more capital per worker available, the more output can be produced, which points out a striking relationship between capital accumulation and GDP. Differences of capital availability account therefore also for the worldwide income gap between economies. The theory, which tries to examine that relationship, is called *Capital-based theory*.

Five main key characteristics of capital:

1. The creation/production of capital is defined as *investment*.
2. Nature of enhanced productivity: more capital available will increase the output that a worker can produce.
3. *Rivalry* of Capital since capital items can only be used by limited amount of people at the same time.
4. *Return* of Capital: Because of its productivity enhancing (Point 2) characteristics and Rivalry nature (Point 3) capital will create a return, which is often the incentive to carry out investments in capital.
5. *Depreciation*; Capital stock will decline in its value over time, either through physical depreciation, reduced demand or obsolescence.

Relationship between capital and productivity

As noted in Point 2 above, capital has the characteristics to increase productivity and therefore output. To assess the degree of that correlation, we will use the production function which relates inputs used and output produced. The two production factors utilized are Labour (L) and Capital (K). Therefore the production function can be written as

$$Y=F(K,L).$$

The return of both inputs (Capital and Labour) together has **constant returns to scale**; if we multiply the quantities of each input by some factor, the quantity output will increase by that same factor, and where each individual separate factor has a diminishing marginal return.

The diminishing marginal product holds on the other hand that adding one more unit of e.g. labour and holding capital constant will increase the output produced less than the unit before (and so on) and less than the input “1”. That law is described by the *Cobb-Douglas production function*:

$$Y=AK^{\alpha}L^{1-\alpha}$$

Where A is a measurement for productivity, and $\propto$ takes values between 0 and 1, which

describes the composition of how much capital is used in relation to labour (and vice versa). Therefore, a country with a higher productivity A will have a higher output for a fixed amount of Capital and Labour.

Another implication of the marginal (diminishing) product of labour/capital is that a firm will set the wages (for labour) and rental rate (occurring cost when renting a capital good) in the competitive market equal to its MPL (marginal product of labour) or MPK (marginal product of Capital).

The capital's share of income is the fraction of national income, Y, that is paid out as rent on capital. It is given by the formula:

Capital's share of income = $\frac{MPK\ x\ K}{Y} = \frac{\alpha A K^{\alpha} L^{1-\alpha}}{A K^{\alpha} L^{1-\alpha}} = \alpha$

From this results that labor's share of income is equal to 1 - α

The Solow model

Robert Solow formulated the neoclassical economic growth model which incorporates Labour, Capital and technological change to explain differences in levels of income per capita and called this model the **Solow model.** The model focuses on the amount of physical capital that each worker has to work with.

The change in capital is determined by two factors:

- Investment in capital, which increases capital stock, which we will call 'γ'
- Depreciation of capital over time, which reduces the total value of capital which we name 'δ'.

Consequently, the change in capital (per worker in this case) can be written as;

(Change in Capital = investment*capital - depreciation*capital)

➔ $\Delta k = \gamma k - \delta k$

Hence, as investment is larger than depreciation, capital grows, is investment smaller than depreciation, the capital will shrink. The **steady-state** scenario of an economy occurs, when depreciation of capital available per worker is equal to the investment in capital stock per worker. Hence in the steady-state, the capital will not change over time. That is a stable equilibrium; as soon as investment is greater than depreciation, the capital will grow until it reaches the steady-state equilibrium. On the other hand, if depreciation is higher, capital stock will decrease and move back to the equilibrium. The shifting towards the equilibrium is called *convergence* towards the steady state.

A change in δ or γ, depreciation or investment, will shift either the depreciation, which is

assumed to be a straight curve, or the investment with a diminishing growth curve and will thus move the steady state equilibrium.

If we plug the steady-state level of capital per worker into the production function we get an equation of the steady-state level of output per worker:

$$Y^{ss} = A(K^{ss})^{\alpha} = A^{1/1-\alpha}(\frac{\gamma}{\delta})^{\alpha/(1-\alpha)}$$

Solow compares the differences in the level of income per worker between two countries by comparing their steady-state levels of output, which is done by dividing one output level in the steady-state equilibrium by the other. Assuming the same level of productivity, the same depreciation rate but differences in the rate of investment, if that is given, we are able to calculate a numerical result, which represents the multiple level of income of country A compared to country B. Therefore, we can interpret the Solow model as a theory of income differences, because it allows us to compare different income level.

- If two countries have the same rate of investment but different levels of income, the country with lower income will have higher growth.
- If two countries have the same level of income but different rates of investment, then the country with a higher rate of investment will have higher growth.
- A country that raises its level of investment will experience an increase in its rate of income growth.

Nevertheless, can we use it to explain growth differences between two economies? In the steady-state level theory, the possibility is not incorporated that countries grow over a long period, because with the steady-state theory each country is supposed to reach its stable steady state equilibrium. Hence, the theory can only be applied if we assume that the countries are located in **a convergence towards the steady state**.

Investment and Saving

The investment rate plays an important role in Solow's theory of income differences, because it determines the growth of capital stock. Different rates of investment lead to different steady state levels.

In order to examine what determines the investment rate we will first focus on the **saving rate**; the rate to which people save. It is determined by the opportunity costs of saving. But the reason why savings rates differ cannot purely be explained by how much people can afford to save, e.g. live above the existence minimum. Factors which influence the saving rate and every economic model are either:

- **Endogenous variables:** Determined within the model.
- **Exogenous variables:** Are taken as given when we analyse a model, they are determined outside the model.

To reduce the complexity of the theory, we assume that saving is endogenous, thus not determined by flows of investment among countries. Therefore, all capital which is saved has to be used for domestic investment, it must hold:
$s = \gamma$ with s fraction of output saved and γ fraction of output invested

If saving is dependent on income, we can corporate the assumption that an economy can have two saving rates; one for high income, one for low income. Thus, that economy is able to have **multiple steady-states** (in this case two). If a country is stuck at the lower saving rate, the economy is in danger to be trapped there, because at the low savings rate, the economy has a lower income, which in turn determines the lower savings rate. Thus, the initial level of income determines to which steady-state the economy will move.