

INVESTMENTS IN EDUCATION DEVELOPMENT

Course:

**Economics II (macroeconomics)** 

Chapter 7

# 7.1 Long Run Economic Growth, Part I.

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#### Introduction

The aim of this chapter is to analyze and explain key determinants of long-term economic growth (potential GDP growth) and the possibility of activating them as a prerequisite for improving the standard of living and creating economic conditions for strengthening the country's defense.

We will focus here on identifying the main determinants of potential output growth in the long run. We will explain the basic categories by which we can analyze the neoclassical production function and long-term economic growth model, developed by Robert M. Solow. In the second part of this lecture we will analyze the Solow model that characterizes stable (permanent) state and relationships between savings, capital accumulation and economic growth.

# 1 Production function and the neoclassical model of long-term economic growth

### Basic concepts and relationships

The productive resources of the economy are the following:

1) *the factors of production (inputs)* – labor and capital: growth in the volume (quantity) inputs directly affects the growth of production.

2) *level of technology* – raising the level of technology used leads to the growth of the product for a given (fixed) amount of inputs.

Used level (state) technology is reflected in the growth of total (integral) productivity of factor inputs, respectively so called "multifactor productivity".

Aggregate production function (general form) - describes the relationship between potential output (Y<sup>\*</sup>) and factor inputs used in its manufacture - capital (K), labor (N) and level of the technology ( $\kappa$ ).

The aggregate production function is transformed in a given period factor inputs to a maximum achievable potential output - shows "creating" the maximum capacity of the economy, which in the long run fully used, i.e. the real unemployment rate is equal to the natural rate of unemployment and capital is fully utilized.

A special form of the production function:  $Y^* = \kappa F (K, N)$ , where

 $\kappa$  = summary (integral) factor productivity, respectively multifactor productivity and

F (K, N) = standard neoclassical production function

Average productivity per worker = product or production per hour worked, or briefly the production per unit of work output:  $Q = Y^*/N$  (provided that the actual product is equal to the potential product).

Returns to scale (assuming that the level of technology does not change):

- constant returns to scale = increase the range, i.e. the amount or size of the process used in the production of capital and labor, results in an increase in production at the same rate;
- II. increasing returns to scale = output is growing faster than the growing volume of used capital and labor;
- III. decreasing returns to scale = production is growing more slowly than the growing volume of used capital and labor.

Capital intensity means the average volume of equity attributable to the use of one employee, respectively unit of work (coefficient of capital intensity: v = K/N

Intensive production function is:  $q = f \kappa (v)$ 

Intensive production function establishes the possibility of substitution between capital and labor, because each point of this function is the ratio of average labor productivity (q) and capital intensity (v).

Increase in technological progress shifts the production function upwards. The analysis shows that the average productivity can be increased:

- increasing capital intensity, i.e. moving through the intensive production function;
- increasing the level of technology used, i. e. from the "lower" intensive production function to a "higher" intensive production function or shift intensive production function upward;
- as a result of growth of the capital intensity, and consequently increasing the level of the technology used, i.e. introduction of technological progress.

b) Rate of output growth and basic equation of growth accounting

Theoretical framework of growth accounting, under which the rate of growth analyzed, was developed by Robert M. Solow. Its growth model is based on standard neoclassical assumptions:

1) In economics, there is perfect competition in both the labor market and the capital market, firms maximize profits and wages are perfectly flexible. Therefore, in the long run marginal product of labor determines the real wage and the marginal product of capital determines the rate of profit on capital.

2) There is a perfect substitution between capital goods and consumer goods.

3) There are constant returns to scale.

4) The coefficient of labor participation is invariant, i.e., that population growth is consistent with the growth rate of labor (labor input).

5) It is a closed economy here.

The starting point for determining the determinant tempo (rate) growth (potential) product (retired) as key performance characteristics of the economy is the general form of the aggregate production function and the assumption of neutral technological progress (a special form, resp. Type) that increase the level of technology used in the same way increases the marginal product of capital and the marginal product of labor.

The basic equation of growth accounting:  $y * = \psi + w. k + (1 - w). n$ 

The equation shows that the potential growth rate is equal to the sum of:

i) the rate, respectively aggregate growth rate (integral) factor productivity ( $\psi$ );

ii) the pace, respectively the growth rate of capital (k) multiplied by (weighted) share the cost of capital for the product (w);

iii) the pace, respectively growth rate of labor input (n) multiplied by (weighted) share of labor costs on the product (1 - w).

The coefficient  $\psi$  in the literature called residual member or also as a Solow residue, and because of its direct measurability is difficult and practically determined indirectly:  $\psi = y^* - w \cdot k - (1 - w) \cdot n$ 

Summary (integral) productivity or multifactor productivity grows when it gets higher (measurable) product from the same amount (volume) of production factors capital and labor. This means that grows mainly due to the utilization of research and development, improved technology, increased education and qualifications, experience and professional training, due to the use of improved methods of work organization and management, etc.

In the world literature, there is a more general concept of comprehensive (integral) factor productivity.

## 2 Solow model of long-term economic growth

Model characterizes stable (permanent) status, relationships between savings, capital accumulation and economic growth. Settled by savings shape resources, which are then used for capital formation (capital accumulation), which in turn leads to higher economic growth and improving living standards.

Stable (steady) state of the economy is a situation of long-term steady economic growth.

a) Savings and basic equation of capital accumulation

The starting point of the analysis of this problem is the equality of total gross domestic investment (I) and gross domestic savings (S).

Furthermore, the increase in capital will be equal investments (savings made by forming a fixed proportion of the potential product) reduced by amortization (wear).

Population growth and the growth rate of the labor force are identical and are growing at a constant rate, which is determined by factors outside the model, i.e. exogenously.

The basic equation of capital accumulation:  $\Delta v = s. q - (n + d). v$ 

With regard to the above equation, we can specify the characteristics of stable (permanent) state:

Stable (steady) state = a situation where capital intensity (capital per worker) reaches equilibrium values, its level remains unchanged, that is capital grows at the same rate as the labor force.

Prerequisite for the achievement of this situation is that the savings per capita is just equal to the savings on expansion capital and savings used to compensate for wornout capital, i.e.  $\Delta v = 0$  and that relationship will shape: s. q = (n + d). v

Stable (steady) state:

The growth rate of capital = potential GDP growth rate = growth rate of population

Regardless of baseline level of capital intensity (facilities), growing economy converges to a stable (steady) state as a state of long-run equilibrium growth, which, under certain preconditions equal to population growth.

In a stable (steady) state the level of labor productivity per capita (product per unit of labor input) does not change.





Once the economy reaches stable (permanent) steady growth of the economy have the same potential growth rate regardless of the amount of their propensity to save and accumulate capital (the impact of the law of diminishing returns from capital to labor productivity decline in average), see Fig. 7.1.1.

Increase in national savings rate:

i. it leads to an increase in the growth rate of potential output over population growth and long-term permanently increase the level of average labor productivity (and hence living standards) and also increases the coefficient of capital intensity (facilities);

ii. however, in the new stable state (at a higher savings rate), the rate of growth of potential output equals the growth rate of the labor force and this means that the growth rate of labor productivity in the new stable (still) does not change the state of the economy.

b) Optimum growth and the golden rule of capital accumulation

We have set equality of investment and savings. Problem savings is but one of the parties consumption behavior of households, because if you increase the savings rate, thus reducing the rate of consumption. This creates a problem of choice: it is better to save more in the presence or maximize the present consumption of the population regardless of future growth? The answer to this concept provides optimal growth of potential output.

Optimum growth of potential GDP growth rate is such that compensates victims endured population that, on the one hand, in the present period of more dispute arise, and the cost of capital accumulation and benefits (benefit) in the form of an increase in consumer standard in the future on the other.

Stable (steady) state with the highest per capita consumption is called the golden rule level of capital accumulation, respectively the golden rule of capital accumulation. Its algebraic expression is: MPK = n + d.

According to the golden rule of capital accumulation in stable (steady) state consumption is maximized when the per capita consumption marginal product of capital (MPK) is equal to the growth rate of the labor force (n) and the wear rate of capital (d).

c) long-term economic growth expanded by technological progress

Now leave the premise constant level technology used and we will consider increasing the (changing) the level of technology used, respectively introduction of technological progress as the main source of economic growth. The starting point remains the model by R. M. Solow, who worked primarily with technological progress.

From the analysis of long-term economic growth (and its modeling using tools implemented Solow) concluded that:

- technological progress (implemented technological change) is a critical factor in growth of average labor productivity and thus a decisive factor for growth in living standards;
- capital accumulation is in the process of growth of average labor productivity less significant role;

In a stable state the capital ratio remains constant.

If the economy is experiencing the technological progress expansion work, then the capital intensity ratio will increase even if the economy is in stable (steady) state of growth (see Fig. 7.1.2).





#### Summary for this chapter:

1) Long-term equilibrium rate of growth of potential output in a stable (steady) state equals the sum of the growth rate of technological progress expanding job and population growth;

2) In a stable (steady) state are output to work effectively, respectively workers and capital to work effectively, respectively worker unchanged, i.e. the growth rate is 0 %.

3) Capital intensity is increasing growth rate ( $\psi$ ), i.e. the growth rate of technological change;

4) In a stable (steady) state increasing production per capita, respectively average labor productivity at a rate equal to the rate (rate) growth of technological progress. Technological progress is the reason that production per capita is still growing. Solow model thus shows that the only source of technological progress is constantly increasing standard of living.

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