Theories of Economic Growth

10

Unit highlights:

- ⇒ **Ecomomic growth and its importance The classical model with AD-AS frame work**
- ⇒ **Stylised facts of economic growth The keynsion model**
- ⇒ **Technical progress Aggregate demand and equlibrium output**
- ⇒ **Harrod-Domar growth model The multiplier**

Lesson 1: Concept, Importance and Sources of Economic Growth

Lesson Objectives:

After reading this lesson you should understand the following:

- Precise meaning and importance of economic growth
- Basic questions of the theories of economic growth deal with and how theories of economic growth differ with respect to scope and method as the context changes.
- The different sources of economic growth.

Introduction:

Concept of Economic Growth and Its Importance

Economic growth essentially means increase in national income or output over time. In simple terms rate of economic growth at the beginning of a period (a year or a quarter) may be defined as the ratio of increment in output experienced in that period to the total level of output in the previous period.

Both politicians and policy makers are found to be concerned with growth rates of gross national product in different time spans characterized by different policy measures. International comparison of growth rate of gross national product of different countries is also important. One region may appear to be more successful then another in terms of rate of economic growth achieved. Political leaders usually and with justification in some cases take pride in the higher growth rate achieved during their term and exploit the success to get re-elected. A modest increase in economic growth rates of some of the underdeveloped countries by a few percentage points may produce enormous changes in national output over a period of two or three decades. This may enable them to acquire the same per capita GNP levels as currently prevail in developed countries provided that the present rate of economic growth of the developed countries remain unchanged in the future.

Economic growth is essential for the viability of an economy. Rate of economic growth is an indicator of the performance of an economy and success of policy measures taken during a time period. Despite increased attention to distribution and environmental problems rate of economic growth still remains a matter of major concern to influential sections of population.

Until the 1970s economic growth was largely considered as a panacea for all evils and miseries arising form low level of income. Growth first-redistribution later was the slogan of the time. At present issues like quality of life and income distribution pattern are addressed with more attention. On the other hand, environmental problem since 1980s have created an awareness of the availability and quality of some natural resources erstwhile considered to be free and infinite

gift of nature. Notwithstanding the recent increased attention to environment and distribution rate of economic growth still remains a matter of major concern to politicians, policy makers as well as academicians.

Theories of Economic Growth:

What is meant by Economic Growth?

Theories of economic growth as presented in text books on Macroeconomics are actually construed as presenting a certain style and method of analysis rather than analysing the situation of a particular period of time. Models on which these theories are based contain a relatively small number of precisely defined economic variables and relationships between such variables. The basic questions they seek to answer are:

(1) Can an economy simultaneously experience growth and maintain full employment over time?

(2) Does a full employment economy have steady rates of growth for all major variables including real output (steady state growth)?

(3) Is the steady state path income (i.e. the time path of income corresponding to a constant growth rate of income) stable? In other words, if the economy deviates form the path, can it come back to the steady income path?

(4) In what circumstances and how the economy may move from one steady state growth path to another?

One of the major concerns of Development Economics is economic growth.

Macroeconomics theories of economic growth differ from theories of economic growth presented in Development Economics in terms of scope and context as well as method.

Development theories in contrast to so called theories of economics growth, as briefly introduced above intend to handle the particular problems of developing countries. Such countries have enormous unemployment and underemployment problems and are characterised by presence of unorganised markets and instances of market failure. Theories of economic growth of underdeveloped countries must consider both economic and non-economic variables and face serious problems to precisely identify and quantify the variables and the relationship among those.

Modern theories of economic growth, which we will discuss below are more relevant for advanced market economies.

Sources of Economic Growth

Growth of output depends on change of quantity and quality of factors of production such as labour and capital, and improvement in technology. Using a simple production function we can demonstrate how growth can be accounted for by the determinants mentioned above.

Let Y = AF (K,N) ... ... (1)

where Y, K, N and A denote real output level, amount of input of capital amount of input of labour and state of technology respectively.

Differentiating both sides of equation (1) with respect to t and assuming constant returns to scale, we come up with equation (2) presented below:

$$\left(\frac{dY}{dt}\right) = F(K,N)\, dA/dt + MPK \left(\frac{dK}{dt}\right) + MPN\, (dN/dt) \text{ ... ... (2)}$$

Where MPK = marginal product of capital and MPN = marginal product of labour.

Dividing both sides of equation (2) by Y and multiplying the first term, second term and the third term of the right hand side of the equation by A/A, K/K and N/N respectively we derive

$$\left(\frac{dY/dt}{Y}\right) = [\{A.F(K,N)\ (dA/dt)\}/(AY)] + \{(K.MPK)(dK/dt)/(kY)\} +$$

$$\{N.MPN(dN/dt)/(NY)\} \text{ ... ... (3)}$$

Equation (3) can be rewritten as

$$\frac{dY/dt}{Y} = \frac{dA/dt}{A} + \frac{dK/dt}{K} + \alpha\left(\frac{dk/dt}{K}\right) + \beta\left(\frac{dN/dt}{N}\right) \text{ .... (4)}$$

Where $\alpha = \frac{K.MPK}{Y}$ and $\beta = \frac{N.MPN}{Y}$

Equation (4) can be further simplified to obtain equation

$$\hat{Y} = \hat{A} + \alpha\, \hat{K} + (1-\alpha)\hat{N} \text{ ... ... (5)}$$

where,

α = share of capital in total output = (MPN.N/Y)

$\beta = (1-\alpha)$ = share of labour in total output = (MPK.K/Y)

$\hat{Y}$ = rate of growth of real output = $\frac{dY/dt}{Y}$

$\hat{K}$ = rate of growth of capital = $\frac{dK/dt}{K}$

$\hat{L}$ = rate of growth of labour = $\frac{dN/dt}{N}$

$\hat{A}$ = rate of technical progress = $\frac{dA/dt}{A}$

Growth accounting equation decomposes growth rate of output into components contributed by labour, capital and technical progress.

Equation (5) may be called growth accounting equation. The equation shows that rate of growth of real output is the sum of rate of technical progress (which may be called rate of growth of total factor productivity in this case) and sum of the product of growth rate of each input multiplied by its share to the total output. Even if amount of inputs used remain the same, real output will grow at the growth rate of technical progress or rate of growth of total factor productivity. It may be noted here that equation (4) has been obtained from equation (3) by using marginal productivity theory of distributions.

In order to emphasize the contribution of education and training to economic growth, human capital may be incorporated into the production function and using similar method the following growth accounting equation can be derived:

$$\hat{Y} = \hat{A} + \alpha \hat{K} + \hat{\beta} L + \gamma \hat{H} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where γ and $\hat{H}$ denote share of human capital to total output and rate of growth of human capital respectively.

Lesson-2: Facts of Economic Growth, Technical Progress and Harrad-Domar Growth Model.

Lesson Objectives:

After Studying this lesson you will understand the following:

- Stylised facts of economic growth and to what extent those are explained by different growth models.
- Various concepts pertaining to technology, especially Harrod-neutral technology which is used in growth models.
- How Harrod-Domar growth model derives the condition for a steady growth rate of output that ensures equilibrium in both product and labour market as well as full utilization of production capacity.
- Existence and stability problems of equilibrium growth path in Harrod Domar model with or without technical progress.

Stylised facts of Economic growth

Some important variables are observed to have steady growth rates in advanced market economies. Stable relationship between growth rates of some variables is found to hold in the long run. These observations are relevant for growth accounting equations. They are more so for growth models. In order to qualify as good theories, growth models should be able to explain those observed relationships or stylised facts. Those stylised facts are:

Stylised facts are relevant for growth accounting. They can be used to assess the practical utility of growth models.

(1) Long tern growth rates of real output and labour inputs are fairly steady. The growth rate of the former however exceeds that of the latter resulting secular rise of labour productivity.

(2) Capital stock grows at a steady rate. This rate is found to exceed the growth rate of labour. Thus a persistent increase of capital per worker is also observed in the long run.

(3) The growth rate of the capital stock is about the same as the growth rate of real output. Hence capital-output ratio is found to be roughly static in the long run.

(4) Rate of profit on capital is also found to be static.

(5) Constant capital output ratio and steady rate of profit on capital together imply a constant share of capital in total income. If capital and labour are broadly defined, the above result also implies a constant share of wage in income.

There are substantial difference in the rate of growth of output and labour productivity across countries.

Technical Progress:

What is meant by Technical Progress?

As said earlier one of the major sources of growth is technical progress. We may define technology as the stock of knowledge of production of goods and service at the disposal of the society. Technological changes occur when this pool of knowledge increases. Technical progress is considered to be the effect of the technological change, When we have technical progress we come across either of the or any combination of the following situations:

(1) More output using same level of inputs implying lower cost of production i.e.. more efficient production method.

(2) Qualitative improvement of existing products

(3) Totally new products are produced.

Types of Technical Progress

Technical progress manifests itself in either of the or any combination following: Lower cost of production, improvement in the quality of production and totally new products.

Technical progress may be either embodied or disembodied. Disembodied technical progress occurs when all existing capital goods regardless of their age have increased efficiency. In case of embodied technical progress only new capital goods have increased efficiency.

Concepts of Neutral Technical Progress

In the discussion of growth models we will only consider disembodied technical progress not because it is more realistic (the opposite is true) but because its use will keep our task of examining the impact of technical progress on variables in growth models relatively easy. Furthermore we will consider the impact of neutral disembodied technical progress for similar reasons. There are three different concepts of neutral disembodied technical progress: (1) Hicks-neutral technical progress, (2) Solow-neutral technical progress, and (3) Harrod-neutral technical progress. Hicks defines a technical progress to be neutral, if at a constant capital-labour ratio the ratio of the shares of capital and labour to total real income $\Pi = rK/wL$ where r is rate of return on capital and w is the wage) remains unchanged following the technical progress. Harrod, on the other hand defines a technical progress to be neutral if at a constant capital-output ratio Π remains unchanged. Solow defines a technical progress to be neutral if at a constant labour-output ratio Π remains constant. Those concepts are found to be simultaneously valid for production functions homogeneous of degree one. Among all those types of technical progress only Harrod-neutral technical progress is found to be

compatible with steady state growth (i.e. growth at a fixed rate). To keep our exposition simple we will use only Harrod-neutral technical progress.

Harrod-neutral technical progress.

Harrod-meutral technical progress is important because it is consistent with steady state growth. This type of technical progress is labour augmenting.

Harrod-neutral technical progress is labour-augmenting in the sense that effective labour increases as a result of the technical progress. Even if physical amount of capital and labour used do not change, output increases through increase of productivity of labour due to the technical progress. It appears, as if labour supply itself has been augmented. When Harrod neutral technical progress takes place, the effective labour supply grows at a rate which is the sum of rate of technical progress and rate of growth of physical labour force (on head count).

The Harrod-Domar growth model:

Introduction

Harrod-Domar Model can be considered as an extension of Static Keynesian Model.

The Harrod-Domar approach emerged during the triumphant era of Keynesian reveloution and, hence, incorporated many special features of Keynesian approach. This approach may be considered as an extension of Keynesian short run macroeconomics in that it relies on equality between aggregate saving and investment at all points of time as a necessary condition for equilibrium in a dynamic context. While this approach recongnises the impact of level of investment on income through the multiplier process, it also takes into account the effect of investment on productive capacity. Full employment equilibrium in the Harrod-Domar model requires that saving must be equal to ex ante investment, productive capacity will be fully exploited and equality between demand for and supply of labour will be maintained persistently over time. This approach seeks the conditions of such a dynamic equilibrium time path. It inquires whether such equilibrium time path exists, and if such time path exists, whether that path is stable or not.

Assumptions

L-shaped isoquants are rarely observed. Such isoquants imply that there is a single production process which may be represented by a positively sloped straight line which moves up and to the right starting

The assumptions on which the Harrod-Domar growth model is based are as follows:

1. The economy has a fixed-coefficient technology V units of capital (K) and U units of labour (N) are required to produced one unit of output (Y). This technology implies a production function of type Y = min [K/V, N/U]. Such a production function generates right-angled (L-shaped) isoquants, with absolute non-substitutability between two factors of production-labour and capital.

Fixed co-efficient technology also implies constant return to scale and constant capital output ratio (V) and capital labour ratio (U).

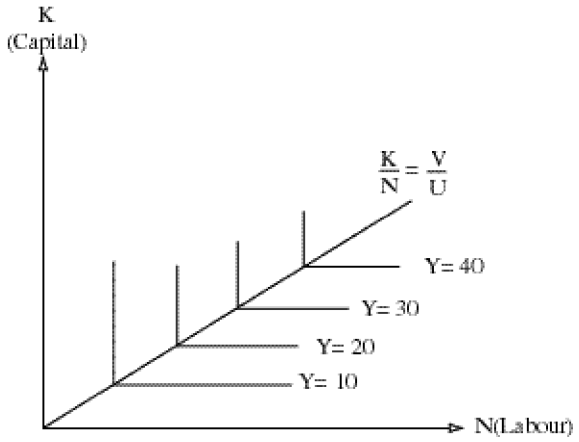


Figure 10.1: Fixed Coefficient Technology

In figure 10.1, we have shown L shaped isoquants. In a situation where both labour and capital units are just fully utilised (there is no excess labour or capital) Y = K/V = N/U and hence, K/N = V/U

V/U line presents different combinations of labour and capital which produces different levels of output maintaining just full utilisation of services of capital and labour input all the way. Capital labour ratio remains unchanged along V/U line. Any point above V/U line will mean excess capital. Any point below V/U line will mean unemployed labour. Another implication of such a production function is that output cannot grow at a rate exceeding the minimum of the growth rate of labour and that of capital for a long period of time.

2. The labour force, L, is assumed to grow at a constant exogenous rate called the natural rate. For this to hold growth of labour force can be expressed by the following function:

The assumption contradicts Malthusian theory of population which recognises the relationship between rate of output growth and population growth rate.

$$N_t = N_o e^{nt} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (a)$$

where subscription 0 and t refer to the initial point of time and another specific point of time respectively.

Taking logarithm on both sides of equation (a) we have the following expression

$$\log N_t = \log N_0 + \log e^{nt} = \text{a constant} + \log e^{nt} \ldots \ldots \ldots \ldots \quad (b)$$

differentiating both sides with respect to t, we have

$$\frac{dNt/dt}{Nt} = \frac{n.\ e^{nt}}{e^{nt}} = n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(c)}$$

Equation (c) shows that the labour force grows at a constant and exogenously given rate n.

This specific assumption implies that rate of growth of labour force is no way influenced by what happens in the model.

3. For the sake of simplification it is assumed at this stage that there is no technical progress and the capital stock does not depreciate.

Saving-Income ratio is actually observed to vary in the short run over different phases of business cycles. In the long run this ratio is fount to be stable.

4. We also assume that savings, S is a constant proportion of income at all points of the time irrespective of the level of income. Harrod himself did not assume that s was constant and he noted that in crucial cases saving as a proportion of income might not be constant. However this assumption facilitates the exposition of what Harrod did want to demonstrate.

5. In order to handle the aggregation problems faced for capital and output we may assume that the economy produces a single commodity which can be both consumed and saved to be used later as capital good. But such an assumption damages the flavour and result of the model. The better way out is to assume that relative prices of goods and services remain constant so that aggregates used in this model are value-based aggregates.

Condition of steady state growth

We first derive the condition for equilibrium in the product market (S=I in the exante sense) and full utilisation of capital stock.

Starting from a situation where capital is fully utilised (i.e. K = VY) and there is full employment, for small increments of output (Y) and capital K. We require

$$\left(\frac{dK}{dt}\right) = v\left(\frac{dY}{dt}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

or, $$I = V\left(\frac{dY}{dt}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

to guarantee full utilisation of capital.

We assume that entrepreneurs correctly foresee change in income or output and accordingly invest.

In order to have product market equilibrium we further require the condition

$$I = S = sY \quad \ldots (3)$$

Combining those two conditions we obtain

$$V\left(\frac{dY}{dt}\right) = sY \quad \ldots (4)$$

Dividing both sides by Y we obtain

$$V\left(\frac{dY}{dt}\right)/Y = s \quad \ldots (5)$$

$$\text{Or, } \hat{Y} = s/V \quad \ldots (6)$$

$$\text{where } \hat{Y} = \frac{dY}{Ydt}$$

Equations (6), (10) and (11) imply that all important variables of the economy-real output, capital stack, labour force, investment, saving- all will grow at natural rate, n. So steady state growth leads to balanced growth. This result implies that ratios involving different pairs of those variables would

Equation (6) means that income should grow at a rate equal to the ratio of average or marginal saving propensity (s) and capital output ratio (V). As is obvious capital should grow at the same rate too.

Furthermore it follows, from equation K = VY and equation (4) that

$$dK/dt = V\,(dY/dt) = sY \quad \ldots (7)$$

$$\text{Or, } I = sY \quad \ldots (8)$$

$$\text{So, } dI/dt = s(dY/dt) \quad \ldots (9)$$

Dividing LHS of equation (9) by I and the RHS by sY we obtain (I=sY)

$$(dI/dt)/I = (dY/dt)/Y \quad \ldots (10)$$

hence in the above situation investment would also grow at the same rate as output.

For full employment to prevail we further need that $\hat{Y} = n$ (11) i.e. growth rate of output or income is equal to growth rate of labour force. Combining (6) and (11) we have the condition s/V = n (12) which ensures equilibrium in the product market, full utilisation of production capacity as well full employment. If this condition continues to be met the economy will have steady state growth. If such a situation occurs, the economy is said to move along a steady state path. Since all the variables grow at natural rate n, ratios between variables will remain unchanged implying balanced growth.

Existence Problem

Now the pertinent question is whether such a condition is actually met. The condition is much more stringent than it appears. Firstly, there is no guarantee that entrepreneurs can actually predict the change in income and consequent increase in demand. Failure to accurately predict this will mean either excess production capacity or capacity deficiency. Secondly population growth rate and rate of increase of supply labour force are determined by a host of biological and sociological factors. V is technologically fixed. Saving ratio, on the other hand, depends on inter alia, level and distribution of income and wealth, prevalence or withdrawal of systems of social insurance, old age unemployment benefits etc. It is, hence, highly improbable that s and n will assume that specific values required for the equality between s/V and n. That is why the hypothetical era, which experienced equilibrium growth rate depicted by Harrod-Domar model is called golden age (an era that is heard from others or told as stories but is scarcely or not at all observed by anybody).

Growth with equilibrium in both product and labour market and full utilisation production capacity is highly improbable in Harrod-Domar

Stability Problem

Harrod also made an attempt to show that deviations of actual rate of growth from the warranted rate s/V far from being self-correcting are cumulative in effect. This problem is referred to as knife edge property of the model. Harrod used not a very satisfactory method to show the instability problem. Sen used a more sophisticated method to show the inherent instability of the model. But his result depends upon a specific pattern of generation of expected growth rate of income. He assumed that entrepreneurs revise their expectation upward (downward) when they find that their expected growth rate is exceeded (falls short of) by actual growth rate. It may be conjectured that incorporation of different pattern of expectation generation may come up with different results.

Harrod-Domar Model and Technical Progress

Another important question that may be asked at this stage is what happens to steady state growth condition and the problem of existence and stability of the steady state path when technological progress is incorporated in the Harrod-Domar model. It may be recalled that condition for steady state growth is s/V = n. If this condition is met, the economy will grow at a constant rate, n and full utilisation of production capacity and full employment of labour force will be

Incorporation of Harrod-neutral technical progress only changes the steady state growth condition. It does not have any impact on the existence and stability problems of Harrod-Domar

ensured. If we incorporate Harrod-neutral technical progress in Harrod-Domar model, the condition now becomes $s/V = m+n$ where m represents rate of technical progress. Incorporation of technical progress of this type does not solve the existence and instability problem of Harrod-Domar model.

Lesson 3: Neoclassical Growth Model

Lesson Objectives:

After reading this lesson you should understand the following:

- Equilibrium growth condition set by Neoclassical growth model.
- Stability of equilibrium growth path in Neoclassical growth model.
- Impact of change of saving ratio and the key role of capital-output ratio in Neoclassical growth model.
- The relationship between stylised facts and growth models.

Neoclassical Growth Model:

In contrast with Harrod-Domar growth model Neoclassical growth model dispenses with the assumption of non-substitutability between factors of production. Hence in this model capital/labour and capital/output ratio have the freedom to change. The model however makes the assumption that production function is homogeneous of degree one. Such a production function implies constant returns to scale. If inputs of capital and labour are increased by x times, output will also be increased by x times-and in this specific case capital/labour, capital/output ratio would remain unchanged. If a specific production function based on two inputs labour and capital is homogeneous of degree one then output per worker, y can be expressed as a function of capital per worker, k.

Let the production function be

$$Y = F(K, N) \quad \ldots (1)$$

Dividing both sides of (1) by N we can write,

$$\frac{Y}{N} = F(K/N, 1) \quad \ldots (2)$$

Since there if constant returns to scale, equation (2) enables us to write

$$y = f(k) \quad \ldots (3)$$

where, $y = Y/N$ and $k = K/N$

Secondly, the neoclassical growth model does not have any investment function. What savings is done is automatically channeled into investment. One good economy, hence, would be more appropriate or consistent with such a vision of investment. As discussed earlier one good economy rules out the problem of aggregation.

Other assumptions, e.g. labour force grow at a constant exogenously determined rate, no technical progress, saving is a constant proportion of income as made in the previous model (see assumptions 2, 3 & 4 in lesson 2) are retained.

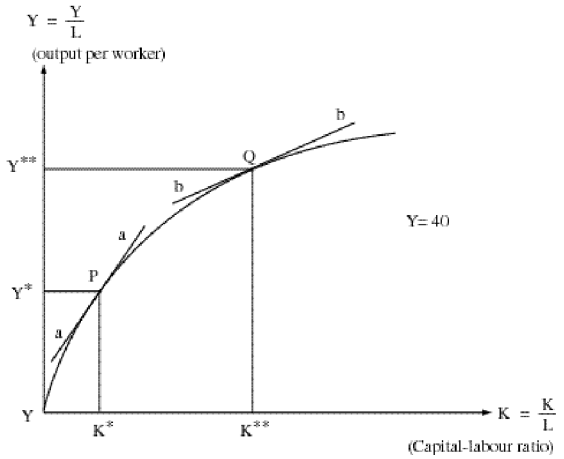
Some additional assumptions about per worker output function (y =*f*(*k*) mentioned above are needed. These are:

(a) $f'(k) > 0$

(b) $f''(k) < 0$

(c) $f(0) = 0$

(d) $f(\infty) = \infty$



Picture 10.2: Output per worker function

Assumption (a) and (d) together emply that per worker output will rise whenever per capital labour increases irrespective of the level of capital labour ratio. In figure 10.2 OC curve depicts the positive relationship between output per worker (y) and capital per worker. Assumption OC in diagram (c) implies that at zero capital-labour ratio nothing will be produced. That is why OC curve starts from the origin. Assumption (b) implies that addition to output/worker keeps on falling as capital/ labour ratio rises. This implies that slope of the tangent to OC curve falls as capital-labour ratio rises.

Steady state growth rate condition

Saving-Investment equality requires that $S = sY = I = dK/dt$ (1)

as $k = K/N$

growth rate of capital-labour ratio $\hat{K} = \left(\frac{\hat{K}}{N}\right)$ (2)

or $\hat{K} = \hat{K} - n$ (3)

but $\hat{K} = (dK/dt)/K = I/K \; sY/K$ (4)

Dividing both the numerator and denominator of the last term in the expression (4) by N we have

$\hat{K} = s\,(y/k)$ (5)

Using (5) for $\hat{K}$ in equation (3) we derive the relation $\hat{K}$ =(sy/k)-n (6)

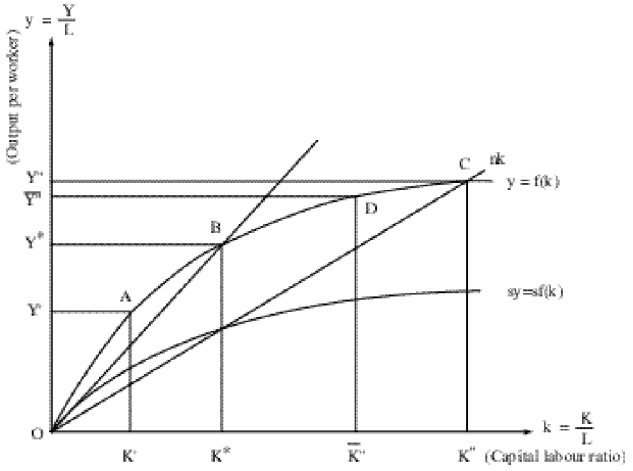
Steady growth rate condition requires that, $\hat{K}$=0 (capital accumulation per worker does not change i.e. capital-labour is constant).

This condition can be met when sy = nk or sf(k) = nk. We will have a specific value of capital labour ratio Ok* at which sf(k) = sy=nk or f(k) = y=(n/s)k. See figure 10.3

Constancy of capital per worker ratio means that capital has to grow at the same rate (n) as labour. Since we have constant returns to scale output will grow at the same rate. So in this case we have both steady state growth and balanced growth.

Stability of steady state path

Unlike the Harrod-Domar model, the steady state path in Neo-classical growth model is stable. If the economy is not on steady state path the capital/labour ratio, k would be either less or greater than Ok*. If the economy has capital labour ratio Ok less than Ok* (and output per worker oy') i.e. the economy is at point A on OC (in figure 10.3)



Picture: 10.3 stability of steady state solution of nea-classical growth model.

Note: Capital labour ratio, in fact, cannot be raised to OK" level or beyond that and kept there for a long period of time.

sf(k) > nk ... ... … … (1)

or, sy > k ... ... … … ..(2)

or, s(Y/N) > n(K/N) ... ... (3)

multipling both sides of the inequality (3) we have,

sY>nK ... ... … … … (4)

or, S/K>n ... ... … … … (5)

i.e. I/K>n ... ... … … … (6)

or, (dK/dt)/K>n

or, K>n ... ... … … … .. (7)

Neoclassical growth model recognises substitutability between factors of production. Smooth, continuous and convex to he origin isoquants found in Microeconomics text books require the existence of a very large number of production processes. This requirement can hardly be met in an one-good economv.

So an economy having capital labour ratio less than Ok* will experience capital accumulation (on per worker basis) and subsequently higher income per worker. This will continue untill capital labour ratio rises to Ok* and economy moves to B. As the economy moves from A to B output-capital ratio falls, i.e. capital-output ratio rises. On the other hand if an economy is at point C having capital-labour ratio Ok" to the right of OK*, capital per worker will decline. This would lead to fall in output per worker as well as capital-output ratio.

Corresponding to Ok* equilibrium level of output per worker is Oy*. Oy* can be obtained by putting the value of Ok* in f(k). Oy* can be directly obtained from the equation y = (n/s)k. the equation is derived form the equilibrium condition sy = nk. We may divide both sides of this equation by s to derive the above equation. Though capital output ratio may change in this model under disequilibrium condition steady state growth path is attained when we have a specific value of capital-output value which is equal to s/n [to derive this value divide both sides of the equation y = (n/s)k by k and then take the reciprocals on both sides].

Impact of change of saving ratio

Let us assume that the economy is initially on steady state path with per worker income, Oy* and capital labour ratio, Ok* as in fig 10.4. If for some reason whatsoever s increases to s' then sf(k) or sy will move upward to s'*f*(k) or s'y and $\left(\frac{n}{s}\right)k$ will move downward to $\left(\frac{n}{s'}\right)k$ [note that s'>s]. At capital labour ration Ok*, positive capital accumulation per worker will occur as s'*f*(k)>nk at Ok*

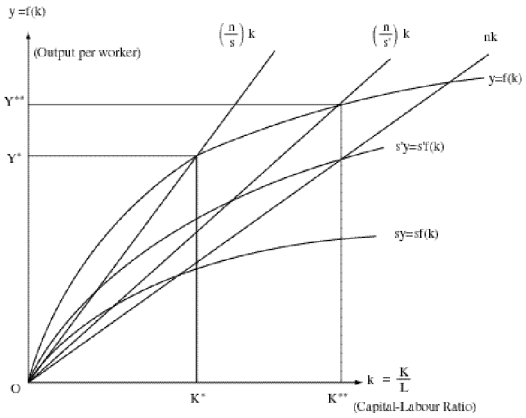


Figure 10.4: Impact of change of saving ratio on steady state solution

Hence output per worker and capital per worker will move to Oy** and Ok** respectively. But since rate of growth of labour force remains n, both capital and output will grow at the rate n once new equilibrium point B is reached. Equilibrium capital/ output ratio and capital ratio both will be higher than before.

Technical Progress and Steady State path

What happens when technical progress is incorporated in Neoclassical growth model? As before we will consider only Harrod-neutral technical progress. Due to this type of technical progress, as we have told earlier, effective, supply of labour force would grow at the rate (m+n) where m denotes rate at which labour is augmented and n represents actual (physical or biological) growth rate of labour force also called natural rate. Steady state growth condition now becomes $s\bar{y}$ = (m+n) $\bar{k}$, where $\bar{y}$ stands for output per unit of effective labour and $\bar{k}$ stands for capital per unit effective labour. When this condition is met output, capital and effective labour all would grow at the same rate (m+n) and hence output per unit of effective worker as well as, capital per unit of effective labour will remain unchanged. Absolute output, capital will grow at the rate (m+n). If we consider actual number of workers rather than effective units of workers output per worker and capital per worker both would grow at the rate m.

Change in saving ratio affects the equilibrium levels of capital per worker and output per worker. But it would not affect the growth rates of capital, labour and real output.

Stylised Facts and Growth Models

It may be recalled that stylised facts, among others, show steady growth rates for real output, capital and labour, constancy of capital output ratio and secular rise of capital-labour and real output-labour ratios.

Harrod-omar and simple classical th model technical gress are grossly

Harrod-Domar model is based on various assumptions including the assumptions of constant capital-output and labour-output ratio. It works out the condition for steady state growth. But it was shown earlier lesson 2 how highly improbable the steady state growth path is in this model. Besides, this model uses the assumption of constant output-labour ratio. This assumption violates one of the stylised facts. Incorporation of Harrod-neutral technical progress in the model does not improve its ability to explain the stylised facts since the problem of existence of steady growth path remains.

The simple Neoclassical growth model with technical progress was introduced earlier in this lession. This model is found to be inconsistent with stylised facts in that it produces a stable equilibrium path which implies a constant level of output per worker and capital per worker. This equilibrium path, however, ensures a constant capital-output ratio and steady growth rate for real output and capital. Incorporation of Harrod-neutral technical progress removes the inconsistency to a significant extent. Earlier in this very present section we have seen that stable steady state growth path as obtained in the Neo-classical growth model incorporating Harrod-neutral technical progress allows capital-labour and output-labour ratio to rise over time. Labour, it may be noted, in both the ratios is measured in physical units rather than efficiency or effective units.

Concepts for Review

Economic Growth	Fixed Coefficient Technology
Rate of Economic Growth	Steady State Growth
Growth Accounting Equation	Balanced Growth
Stylised Facts	Existence of Equilibrium
Embodied Technical Progress	Knife-Edge Problem
Disembodied Technical Progress	Stability of Equilibrium
Neutral Technical Progress	Homogeneous Production Function
Effective Labour Supply	Constant Returns to Scale

Exercises

1. Put tick (√) marks in the appropriate boxes to show whether the following statement are true or false. If a particular statement is found to be false write the appropriate correct statement.

a. Modern economic theories of economic growth consider both economic and non-economic variables.
   True ❑ False ❑
b. At present less emphasis is placed on rate of economic growth than before.
   True ❑ False ❑
c. Along a steady state growth path all major variables (output, capital, employment, savings and consumption) increase at fixed rates which are not necessarily identical
   True❑ False ❑
d. Balanced growth occurs when all the major variables grow at the same rate in a period. But the growth rate may vary across periods.
   True ❑ False ❑
e. Growth accounting equation decomposes total real output to contributions made by different inputs and technology.
   True ❑ False ❑
f. Disembodied technical progress is observed to occur more frequently than embodied technical progress.
   True ❑ False ❑
g. Different concepts of neutral technical progress keep the ratios, K/L, Y/L and Y/L at constant levels and, examine whether the ratio of share of capital to that of labour remains constant or not when technical progress occurs.
   True ❑ False ❑
h. Fixed coefficient technology implies smooth and convex-to-the origin isoquants.
   True ❑ False ❑
i. Steady state growth condition of Harrod-Domar model ensures full utilisation of production capacity.
   True ❑ False ❑
j. Incorporation of Harrod-neutral technical progress in Harrod-Domar model drives away the existence and instability problems of the model.
   True ❑ False ❑
k. In a disequilibrium situation both K/L and K/L ratio will vary in the Neoclassical growth model with technical progress.
   True ❑ False ❑
l. Once and for-all change in saving ratio destroys the stability of steady state growth path of Neoclassical growth model.

True ❑ False ❑

m. In the Neoclassical growth model incorporating Harrod-neutral technical progress, along the steady state path real output, capital and labour (measured in physical units) have the same growth rate.

True ❑ False ❑

n. Harrod-Domar growth model is grossly inconsistent with the stylised facts.

True ❑ False ❑

o. Incorporating Harrod-neutral progress in Neoclassical growth model improves its status with respect to being consistent with the stylised facts.

True ❑ False ❑

2. Answer briefly the following question:

a. Why does the 'existence problem' occur in Harrod-Domr model?

b. 'If somehow the condition s/v=n can be met we will have both steady state growth and balanced growth'. Explain the comment.

c. Present a brief account of different concepts of neutral technical progress.

d. Find the distinction between Embodied and Disembodied technical progress. Which one is more realistic and why?

e. What are the stylised facts? How far are they true in Bangladesh?

f. Show that the steady state growth path in Neoclassical growth model is stable.

g. In the Neoclassical growth model incorporating Harrod-neutral technical progress capital-output ratio will remain unchanged along the steady state path. If labour is measured in physical units, output per worker will increase overtime. Explain why this is so?

Explain why incorporation of Harrod-neutral technical progress in Neoclassical growth model make it more consistent with stylised facts.