BLOCK 2 GROWTH MODELS: THEORY AND EVIDENCE.

BLOCK 2 INTRODUCTION

The second block of the course is titled **Growth Models: Theory and Evidence**. In the first block, you had studied about the basic idea of what is meant by economic growth and economic development and the relationship among them. Also you were presented with some international comparisons among nations regarding the level of development.

The present block has five units. Unit 3 is titled **Introduction to Growth Models**, and the next one, unit 4 is titled **Harrod-Domar Model**. Unit 5 is titled **The Solow Model.** Unit 6 is titled **Endogenous Growth Model**, and finally, unit 7 is titled **Determinants of Growth**.

Unit 3 provides an overview of various approaches to growth. It discusses many different theories of growth. It begins with Classical growth theory and then presents briefly the Marxian theory of growth. After the classical and Marxian theory unit 3 also discusses some stages-of-growth theories like those of Rostow and Kuznets. The unit also discusses structural change models and dependency theories. You will also be familiarized with neoclassical theories as well as endogenous growth theories. Finally it briefly discusses new theories called unified growth theories.

The subsequent three units in this Block take up for discussions the various theories one by one. Unit 4 discusses the fixed-coefficient production function using Harrod-Domar model. Unit 5 discusses one of the central models of economic growth in the literature on growth theory, namely, the Solow growth model. Unit 6 discusses the endogenous growth models, that is models where growth is determined within the system, as are the factors causing growth.

Finally, unit 7 examines the determinants of growth. It discusses the concept of convergence, that is, whether poorer countries are catching up with the richer countries. The unit discusses different determinants like labour, capital, technology and total factor productivity. The unit examines the concept of path dependence as well.

UNIT 3 INTRODUCTION TO GROWTH MODELS*

Structure

3.0 OBJECTIVES

After going through the unit you will be able to:

- Explain the concept of economic growth ,development and growth models;
- Describe the background and evolution of growth models;
- Identify the sources of growth in various models of growth; and
- Discuss the structure of the various growth models

3.1 INTRODUCTION

Economic growth is the study of the causes and consequences of sustained growth in real GDP per person. One can define economic growth as the increase in the inflation-adjusted value of the goods and services produced by an economy over time. Economists refer to an increase in economic growth caused by more efficient use of inputs that is labour, capital, land etc. as intensive growth. GDP growth caused only by increases in the amount of inputs available for use (increased population, or new machinery) counts as extensive growth. The "rate of economic growth" refers to the geometric annual rate of growth in GDP over a

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period of time. This growth rate represents the trend in the average level of GDP over the period, and ignores any fluctuations in the GDP around this trend. Economic Development is a much wider concept in terms of scope vis-a-vis growth and is defined as a combination of social, economic and institutional processes that secure the means for obtaining a better life. It should be perceived as a multidimensional process involving the reorganisation and reorientation of economic and social systems.

While economists in the 20th century viewed development primarily in terms of economic growth, sociologists instead emphasized broader processes of change and modernization. Development and urban studies scholar Karl Seidman summarizes economic development as "a process of creating and utilizing physical, human, financial, and social assets to generate improved and broadly shared economic well-being and quality of life for a community or region". Daphne Greenwood and Richard Holt distinguish economic development from economic growth on the basis that economic development is a "broadly based and sustainable increase in the overall standard of living for individuals within a community", and measures of growth such as per capita income do not necessarily correlate with improvements in quality of life. Economic development is a wider concept and has qualitative dimensions. Economic development implies economic growth plus progressive changes in certain important variables which determine well-being of the people, for example, health and education.

Economic development is the primary objective of the majority of nations across the world. The universal features of economic development-health, life expectancy, literacy and so on-follow in some natural way the growth of per-capita GNP. If we see it as purely economic, we can say it is synonymous to Economic growth. But in addition to rising income it implies fundamental changes in the structure of the economy as well. Economic growth is one of the most important notions in the global economy. Despite the criticism that the level and rate of growth does not always reflect the real level of a population's living standards, it remains the primary measure of prosperity. However, as a measure describing the dynamics of economic processes in the country it has some drawbacks. First, it does not record the volume of production obtained from the informal market, known as the "black market", which means that not all economic transactions are included in the total volume of generated output. In addition, economic growth does not take into account changes in the amount of time spent on work, which obviously affects the welfare of society. Also the measure of economic growth does not include the negative processes associated with economic activities, such as environmental pollution, its progressive degradation, or noise pollution. However, despite all these drawbacks economic growth remains the primary measure of the socio-economic conditions of the citizens of a country. A model of economic growth is based on economic theory to establish basic fundamental assumptions that allow proposing an interaction between the factors of production in order to explain the determinants of economic growth. The principal theories of economic growth include:

Mercantilism-At the beginning of the Industrial Revolution , wealth of a nation was determined by the accumulation of gold and running trade surplus. It was not a growth theory but argued that a country would be better off by accumulating gold and by increasing exports.

Classical Theory- Adam Smith with whom the classical school started placed emphasis on the several factors which enable increased economic growth:

a) Role of markets in determining demand and supply.

b) Productivity of labour that is the state of the skill, dexterity and judgement with which labour is applied in any nation.

c) Role of Trade in enabling greater specialisation.

d) Role of increasing returns to scale.

While David Ricardo developed the classical model that assumed technological change as constant and increasing inputs that could lead to diminishing returns, Thomas Malthus could notthe capacity of technological improvements to increase food yields .The theory states that food production will not be able to keep up with growth in the human population, resulting in disease, famine, war, and calamity .

Neo-Classical Theory- Neoclassical growth theory is an economic theory that outlines how a steady economic growth rate results from a combination of three driving forces—labor, capital, and technology.

Endogenous growth theories- The Endogenous Growth Theory states that economic growth is generated internally in the economy, i.e., through endogenous forces, and not through exogenous ones. The theory contrasts with the neoclassical growth model, which claims that external factors such as technological progress, etc. are the main sources of economic growth.

Keynesian Demand side Theory: Keynes criticised the Classical school of thought and argued that Aggregate Demand could play a role in influencing economic growth in the Short and medium, -term. Though most growth theories ignore the role of Aggregate Demand, some economists argue recessions can cause hysteresis effects and lower long-term growth.

Limits to growth-An environmental perspective leads some to argue that in the very long-term economic growth will be constrained by resource degradation and global warming.

3.2 CLASSICAL GROWTH THEORY

Analysis of the process of economic growth was the primary feature of the work of classical economists viz. Adam Smith, Thomas Malthus and David Ricardo. They may be regarded as the main precursors of the modern growth theory.

Specifically, they were confronted with the facts of social and economic changes taking place in the contemporary English society living on the 18th and 19th Centuries on the eve of or in the throes of the Industrial Revolution.

Thus, their research was against the background of the emergence of the new economic system-the system of the Industrial Capitalism.

“Progress” was an essential component for the development of a society as it was seen as growth of national wealth. Hence, the principal of national advantage was regarded as an essential criterion of economic policy. Progress was also conceived within a framework of a need to preserve private property and hence, the interests of the property-owning class from this perspective, they endeavoured to show that the exercise of individual initiative under freely competitive conditions to promote individual ends would produce results beneficial to the society as a whole. Conflicting economic interests of different groups could be reconciled by the operation of competitive market forces and by the limited activity or role of Government.

They were able to provide an account of the broad force that influences economic growth and the mechanisms underlying the growth process. They recognised that the accumulation and productive Investment of a part of the social product is the main driving force behind economic growth and that under capitalism this takes place in the form of reinvestment of profits. Their critique of feudal society was based on the observation that a large part of social product was not invested but consumed unproductively. The explanation of the forces underlying the accumulation process was seen as the heart of the problem of economic growth. Associated with accumulation is technological change as expressed in the dimension of labour and change in methods of production. To these basic forces in economic growth they added the increase in supply of labour through growth of population. Their analysis on the operation of these forces led them to the common view that the process of economic growth under the conditions they identified raises obstacles in its own path and is ultimately retarded, leading to a ” stationery state”, which is the ultimate end of economic growth.

Adam Smith posited a supply-side driven model of growth. Population growth, Smith proposed in the traditional manner of the time, was endogenous: it depends on the sustenance available to accommodate the increasing workforce. Investment was also endogenous: determined by the rate of savings (mostly by capitalists); land growth was dependent on conquest of new lands (e.g. colonization) or technological improvements of fertility of old lands. Technological progress could also increase growth overall: Smith's famous thesis that the division of labor (specialization) improves growth was a fundamental argument. Smith also saw improvements in machinery and international trade as engines of growth as they facilitated further specialization. Smith also believed that "division of labor is limited by the extent of the market" - thus positing an economies of scale argument. As division of labor increases output (increases "the extent of the market") it then induces the possibility of further division and labor and thus further growth. Thus, Smith argued, growth was self-reinforcing as it exhibited increasing returns to scale. Finally, because savings of capitalists is what creates investment and hence growth, he saw income distribution as being one of the most important determinants of how fast (or slow) a nation would grow. However, savings is in part determined by the profits of stock: as the capital stock of a country increases, Smith posited, profit declines - not because of decreasing marginal productivity, but rather because the competition of capitalists for workers will bid wages up. So lowering the living standards of workers was another way to maintain or improve growth (although the counter-effect would be to reduce labor supply growth). Despite increasing returns, Smith did not see growth as eternally rising: he posited a ceiling (and floor) in the form of the "stationary state" where population growth and capital accumulation were zero.

Smith's model of growth remained the predominant model of Classical Growth. David Ricardo (1817) modified it by including diminishing returns to land. Output growth requires growth of factor inputs, but, unlike labor, land is "variable in quality and fixed in supply". This means that as growth proceeds, more land must be taken into cultivation, but land cannot be "created". This has two effects for growth: firstly, increasing landowner's rents over time (due to the limited supply of land) cut into the profits of capitalists from above; secondly, wage goods (from agriculture) will be rising in price over time and this then cuts into profits from below as workers require higher wages. This, then, introduces a quicker limit to growth than Smith allowed, but Ricardo also claimed (at first) that this decline can be happily checked by technological improvements in machinery (albeit, also with diminishing productivity) and the specialization brought by trade, although he also had stationary states.

Malthusianism is the idea that population growth is potentially exponential while the growth of the food supply or other resources is linear, which eventually reduces living standards to subsistence levels.. Thomas Robert Malthus, in his 1798 writings, *An Essay on the Principle of Population* believed there were two types of "checks" that are continuously at work, limiting population growth based on food supply at any given time:

- *preventive checks*, such as moral restraints or legislative action — for example the choice by a private citizen to engage in abstinence and delay marriage until their finances become balanced, or restriction of legal marriage or parenting rights for persons deemed "deficient" or "unfit" by the government.
- *positive checks*, such as disease, starvation, and war, which lead to high rates of premature death — resulting in what is termed a Malthusian catastrophe. Such a catastrophe inevitably has the effect of forcing the population (quite rapidly, due to the potential severity and unpredictable results of the mitigating factors involved, as compared to the relatively slow time scales and well-understood processes governing unchecked growth or growth affected by preventive checks) to "correct" back to a lower, more easily sustainable level.

3.3 MARXIAN THEORY OF GROWTH

The *Karl Marxian model of economic growth* is available in his famous book *"Das-Capital"*. He rejects the salient features of classical model of economic growth. He rejected the law of diminishing returns and says that the final outcome of stationary state in classical model is not a natural process, it is due to human arrangements. He also rejects Malthusian theory of population.

Marx's theory seeks to combine economics and sociology and views economic development as a continuous change in the social, cultural and political life of society. In this theory, economic systems reach higher stages through strained relations between the dynamic forces of production and slowly evolving social and political organisation which permits production. The stages of development: a) primitive-communal society b) feudalism c) capitalism d) socialism e) communism.

He predicted that capitalism is characterised by a class struggle. Growing conflicts between labour and capitalists would eventually lead to a revolution in which capitalism based on private ownership would be transformed into socialism based on public ownership.

This theory gives an important insight to the problems faced by most developing economies that have been relying on investment in the modern Industrial sector to achieve development- basically the increases in employment have been much slower due to labour-saving technologies (also in contrast to output growth as a result of Investment).However, increase in labour force has been more due to growing population and thus, what can be observed is growing inequality and social instability.

Followers of Marx have highlighted how the International capitalist system has aggravated the gap between rich and poor countries and that there is a need to restructure the world capitalist system to help least developed countries become less dependent and vulnerable given the subservient position this system has put them in.

Check Your Progress 1

1. Discuss the Classical Theory of Economic growth.

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Q2. How do you explain the Marxian criticism of the Classical Theory of growth?

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3.4 STAGES OF GROWTH THEORIES: ROSTOW AND KUZNETS

3.4.1 Rostow's Theory

Walt W. Rostow has explained the transition from underdevelopment to development in terms of a series of steps or stages through which all countries must proceed. His work"The Stages of Economic Growth" explains in detail the growth process via these stages:

a)The traditional society b)The preconditions for take-off c)The take-off d)The drive to maturity e)High mass consumption.

Thus, as an economy takes on the path of growth there are economic, social and institutional changes that kick-start growth rather slowly and then the economy grows rapidly before it saturates to a high income level.

3.4.2 Kuznet's Theory

Simon Kuznets gave the concept of Modern Economic Growth and defined the economic growth of a country as "a long-term rise in capacity to supply increasingly diverse economic goods to its population, this growing capacity based on advancing technology and the institutional and ideological adjustments that it demands." He defined six basic characteristics of Modern Economic Growth:

1.High rates of growth of per capita output and population

2.High rates of increase in Total Factor Productivity

3.High rates of structural transformation of the economy

4.High rates of social and ideological transformation

5.The propensity of economically developed countries to reach out to the rest of the word for markets and raw materials

6.The limited spread of economic growth to only one-third of the world's population

Kuznets observed these for a large number of developed countries.. He said that the six characteristics are mutually reinforcing and inter-related.

He developed an approach to the analysis of economic growth over long historical periods he called as an "economic epoch". The innovation/scientific knowledge and its application define an epoch and thus, economic growth and structural change.

3.5 STRUCTURAL CHANGE MODELS

3.5.1 Lewis Model and Patterns of development analysis

Structural change models are based on the popular notion of "Dualism", which in Development Economics is a relevant concept to understand the dynamics of growing economies. Dualism in Economics is the coexistence of two contrary forces in an economic set up. It can be of various types viz, organisational, technological or structural dualism on the basis of classification of an economy. W Arthur Lewis in the 1950's is one of the most famous structural change models which focuses on the changes in a growing economy where a traditional agricultural or rural sector paves way for the modern industrial urban sector which then is responsible for growth via capital accumulation. His model was based on the unlimited supply of labour in underdeveloped economies mostly in the traditional agriculture sector and how this surplus labour can be used in the modern industrial sector that grows and provides employment and higher wages to labour. Also this sector then kick starts economic growth as it accumulates capital and as Investment happens.The process of modern sector self-sustaining growth is assumed to continue till all surplus labour is absorbed in the industrial sector. The balance of the economy lies in the equilibrium of both agriculture and industrial economic activities.

The patterns-of-development analysis of structural change focuses on the sequential process through which the economic, industrial and institutional structure of an underdeveloped economy is transformed to accommodate new industries as an engine of growth. Increased savings and Investment here are taken to be necessary but not sufficient conditions for growth. In addition to accumulation of capital both physical and human, there is a need for a set of interrelated changes in the economic structure of the economy for the transition.These changes occur both at domestic and International level. Thus, growing economies can benefit(or lose) by being part of the integrated International system is what this analysis recognises unlike other models that look at structural change as a domestic process only.

3.5.2 The International Dependence Model and the Dualistic-Development Thesis

The International Dependence Revolution models view developing countries as engulfed in domestic and International rigidities and thus, caught up in a dependence and dominance relationship with developed countries. The dependence model divides the world into a "centre" and a "periphery" where there is an unequal set up of power dynamics. The developed countries are the dominant Centre whereas the developing countries are the dependent periphery governed by the dominance and vulnerability of the Centre, thus paving way for impoverishment of the periphery.

The Dualistic-development Thesis envisages the concept of Dualism such that rich and poor countries and rich and poor people have inherent differences at various levels and thus there is the existence and persistence of divergence between these. The economic systems are characterised by different sets of conditions which are elements of dualism and this coexistence is chronic in nature. Also this dualism is responsible for gaps between rich and poor that don't decrease but rather increases with time. Hence, the increasing gaps between rich and poor.

3.6 THE NEOCLASSICAL COUNTER REVOLUTION AND TRADITIONAL NEOCLASSICAL GROWTH THEORY

The 1980's saw the emergence of the Neoclassical Revolution in the developed countries where they favoured the supply-side macroeconomic policies, rational expectations theories and privatization of public corporations. You have read about these in your courses in microeconomics and macroeconomics.

Free-market analysis argues that markets alone are efficient and thus, any kind of Government intervention is distortionary and counterproductive.

Public-choice theory (new political economy approach) goes further to argue that Government does nothing right. This is because this approach assumes that politicians, bureaucrats, people and states all pursue their selfish interests and hence, the overall result is misallocation of resources. Thus, minimum Government intervention is best.

The Market-friendly approach accepts the notion of Market-failure and unlike the Free-Market approach and Public-Choice Theory, recognises the role of Government intervention to correct these failures. This approach however focuses on market-friendly interventions. All these theories are applied to all areas of economic life, including economic growth. Hence, these are, strictly speaking, not theories exclusively of economic growth, but rather approaches to economic policies and the role of government in the economy.

The Neoclassical Growth Theory is an economic model of growth that outlines how a steady economic growth rate results when three economic forces come into play: labor, capital, and technology. Solow Model of growth is the most popular neoclassical model of growth. It extended the

Harrod-Domar model of growth, which laid the foundation of growth(given constant returns)on the process of capital accumulation. The mobilisation of savings into Investment would help a country achieve growth via accumulation of capital in this model. Solow Model added to this by introducing the role of labour in the given framework and extended it further to technological advancements. Diminishing returns to individual factors of production is Solow's twist to the Harrod Domar Model. The model predicts the convergence of long run growth across countries via the Stady state.

3.7 THE THEORY OF ENDOGENOUS GROWTH

As the predictions of the neoclassical models didn't work exactly the way they were expected to and many developing countries could not grow rapidly despite surge in investment and liberalization, the growth theory moved to New Growth models that relied on explaining growth with factors that played their role from *within* the system and hence the term Endogenous growth models. These models relied on examining growth beyond the exogenous factors as used in neoclassical models.

Endogenous growth theory holds that investment in human capital, innovation, and knowledge are significant contributors to economic growth. The theory also focuses on positive externalities and spillover effects of a knowledge-based economy which will lead to economic development.

Paul Romer has made a significant contribution to Endogenous Growth theory. In choosing Romer as one of the 2018 economics laureates, the Royal Swedish Academy of Sciences stated that he had shown how knowledge can function as a driver of long-term economic growth and earlier studies had not modelled how economic decisions and market conditions determine the creation of new technologies. Paul Romer solved this problem by demonstrating how economic forces govern the willingness of firms to produce new ideas and innovations.

Robert Lucas along with Paul Romer heralded the birth of endogenous growth theory and the resurgence of research on economic growth in the late 1980s and the 1990s.

Key Policy Implications of Endogenous Growth Theory

- Government policies can raise an economy's growth rate if the policies are directed towards enforcing more market competition and helping stimulate innovation in products and processes.
- There are increasing returns to scale from capital investment in the "knowledge industries" of education, health, and telecommunications.

- Private sector investment in Research and Development is a vital source of technological progress for the economy.

  You will study more about endogenous growth theory in unit 6.

3.8 UNIFIED GROWTH THEORY

Oded Galor founded the theory of unified growth, or unified growth theory that explores the process of development over the entire course of human history and identifies the historical and prehistoric forces behind the differential transition timing from stagnation to growth. It also explores the divergence in income per capita across countries and regions

He has made significant contributions to the understanding of the process of development over the entire course of human history and the role of deep-rooted factors in the transition from stagnation to growth and in the emergence of the vast inequality across the globe. He has pioneered the exploration of the impact of human evolution, population diversity, and inequality on the process of development over most of human existence.

Check Your Progress 2

1. How do you explain the Neoclassical counterrevolution in explaining growth?..

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2. Examine the neoclassical growth theories and the emergence of Endogenous growth in the light of these.

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3.9 LET US SUM UP

This unit sets the ball rolling about theories of growth. The unit gave an overview on approaches to growth, some of which you will study in detail in the next few units, and some others in the next course on development economics that you will meet in the next semester. The unit familiarised you about the concept of growth and what a theory of economic growth means. You learnt the evolution of theories of growth from the time of classical economists like Adam Smith.

The unit began with an exposition of classical theories of growth Special emphasis was laid on Adam Smith's theory. Then the unit briefly explained the theories of Malthus and David Ricardo. The theory of economic growth as expounded by Marx was discussed. We saw that Marx had talked about certain stages through which society passes. The unit also discussed the stages of growth theories of Rostow and Kuznets. The unit then discussed economic theories which were about structural change. The unit mentioned the Lewis growth model and other dualistic theories as also international dependence theories.

Subsequently, the unit went on to touch upon free-market espousing neoclassical theories as well as traditional neoclassical theory. You will study about neoclassical growth theory put forward by Robert Solow in unit 5. Finally, the unit dwelled upon endogenous growth theory, and unified growth theory put forward by Oded Galor.

3.10 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1. See section 3.2
2. See section 3.3

Check Your Progress 2

1 See section 3.6

2 See section 3.7

UNIT 4 HARROD DOMAR GROWTH MODEL*

Structure

4.0 OBJECTIVES

After reading this unit you should be able to:

- Describe the context and background in which this model came to be developed by two different economists, each working independently enters at the others, but still reaching the same results;
- Discuss the role of savings and investment in the growth process, as expounded by Harrod, and the implication of this relationship;
- Identity the similarities and dissimilarities between the Harrod Model and the Domar Model;
- Develop an integrated view of the Harrod Model and the Domar Model; and
- Analyse the strengths and limitations of this integrated model.

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4.1 INTRODUCTION

Economic growth, as you have seen in Unit 3, refers to a process of sustained increase in real national income of a country. A number of theories have tried to study the process of economic growth as it has unfolded in the past especially within the free market framework. These theories are economic growth are also referred to as growth models, especially when the quantitative interrelationships among the critical variables in the process of economic growth are set out in a rigorous form. In the remaining units of this block and the subsequent two blocks you will study in depth about different models of economic growth as formulated by different economists at different point of time. Each of these models emphasises upon a different sector or a set of factors that in the opinion of their exponents is the major factor that influenced economic growth. In this unit, we begin with an in-depth analysis of what had come to be known as the Harrod-Domar Model (HDM) of growth.

4.2 BACKGROUND TO THE HARROD-DOMAR GROWTH MODEL

This model of growth was developed by two different economists, each working independently of the other, but almost con-currently. These two economists were R.F. Harrod and E.D. Domar. Harrod, of course, published his theory earlier than Domar. Harrod's book *Towards a Dynamic Economics* was published in 1948, while Domar's book *Essays in the theory of Economic Growth* was published in New York in 1957. Harrod Model and Domar Model may differ in details, but the ideas contained in both of the models are so similar that the two models have got integrated and more generally are presented as a single united model, known as the Harrod-Domar Model (HDM).

HDM integrated the classical and Keynesian analysis of economic growth. In the HDM, capital accumulation plays a crucial role in the process of economic growth. Both the classical economists and the Keynesians had recognised the critical role of capital accumulation in the process of economic growth. But the classical economists considered only the capacity of the capital accumulation, and, believing that supply created its own demand, did not pay attention to the demand side. Keynesians, on the other hand, erred in the opposite direction. Concerned primarily with the short-period, they considered only the adequacy of demand and neglected the problem of increase in capacity through investment in the long run. HDM considered both the sides of the investment process.

4.2.1 Essence of the Model

Starting from a full employment equilibrium level of income, the HDM postulated that continuous maintenance of this equilibrium required that the volume of spending generated by investment must be sufficient to absorb the increased output resulting from investment. Given the marginal propensity to save, the more the capital is accumulated and the larger the initial national income. The larger must be the absolute volume of net investment, maintenance of full employment, therefore, required an ever-expanding amount of net investment. This, in turn, required a continuous growth in real national income. Capital accumulation and growth of income must go side by side.

An increase in capital expands the productive capacity of the economy. If it is not accompanied by an increase in income, any of the following things may happen:

- The new capital may remain untitled.
- The new capital may replace old capital depriving the latter of its labour and/or markets.
- The new capital may be substituted for labour (and possibly other factors).

Thus, increase in capital unaccompanied by an increase in income would result into unemployment of capital and /or labour. Excessive capital accumulation may result into overproduction and consequently into a fall in investment leading to depression.

4.2.2 Assumption of the Model

The HDM is based on the following assumption:

1. An initial full-employment level of income exists.
2. There is no government interference in the functioning of the economy.
3. The exogenous factors do not influence the growth variables, i.e., it is a closed economy model.
4. There are no lags in adjustment, i.e., the economic variables like savings, investment, income, expenditure adjust themselves in the same period. Any change in saving brings about the corresponding change in investment in the same period.
5. The average propensity to save(S/Y) and marginal propensity to save($\Delta S/\Delta Y$) are equal to each other, i.e,. the absolute change in saving is equal to the relative change in saving.
6. Propensity to save and "capital coefficient"(capital-output ratio) are constant. The law of constant returns operated because of the fixity of capital-out ratio.
7. Income, investment and savings are all defined in the net sense. It implies that these variables exclude depreciation.
8. Saving and investment are equal in ex-ante and ex-post sense, i.e., accounting and functional equality between saving and investment the equality can be expressed as:

$$S_0 = I_0 \text{ (accounting equality)}$$

$$S_e = I_e \text{ (functional equality)}$$

S_0 and I_0 are observed saving and investment. S_e and I_e are expected saving and investment.

All these assumptions are not necessary for the final solution of the problem; nevertheless, they serve the purpose of simplifying the analysis.

4.3 THE HARROD MODEL (HM)

R.F. Harrod tries show in his model how steady (i.e., equilibrium) growth may occur in an economy. Once the steady growth is interrupted and the economy falls into disequilibrium, cumulative forces tend to perpetuate this divergence thereby leading to either secular definition or secular inflation. In other words, Harrod's growth model concentrated largely on the following question:

- How can steady growth-rate be achieved with fixed capital-output ratio (capital coefficient) and fixed saving-income ratio (propensity to save)?
- How can the steady growth-rate be maintained or what are the conditions for maintaining the stable growth?
- How do natural factors put a ceiling on the growth-rate of the economy?

The model seeks to provide answers to these questions.

4.3.1 Statement of the Model

The Harrod model is based on three growth rates. *One*, there is the **actual growth rate** denoted by G. It is determined by the saving ratio and the capital-output ratio. It shows short-run cyclical variation in the rate of growth. *Two*, there is the **warranted growth rate** denoted by G_w. It is the full capacity growth rate of income in an economy. *Three*, there is the **natural growth rate** denoted by G_n. This is regarded as 'the welfare optimum'. It may also be called the potential or the full employment rate of growth.

1. **Actual Growth Rate (G)** - The first fundamental equation in the HM is as follows:

   $$GC = s \qquad \text{........................(1)}$$

   where

   G = actual rate of growth (or $\Delta Y/Y$)

   C = the marginal capital output ratio[or $(I/\Delta Y)$]

   s = saving income ratio [or (S/Y)]

The eq.(1) explains the simple truth that savings and investment are equal to each other in terms of ratio. Substituting the values of G,C and s in eq.(1) explains this phenomenon:

$$GC = s$$

Substituting the values, we get

$$(\Delta Y/Y) \times (I/\Delta Y) = S/Y$$

$$\text{or} \quad \frac{\Delta Y}{Y} \times \frac{I}{\Delta Y} = \frac{S}{Y}$$

$$= \frac{I}{Y} = \frac{S}{Y}$$

$$\text{or} \quad I = S$$

The equality between saving and inves

tment (export sense) is thus a necessary condition for achieving steady growth. It is also called the dynamic equilibrium.

2. **Warranted Growth Rate (G_w)** - It is the full capacity growth rate of income in an economy. It is also known as 'full employment growth rate' or 'potential growth rate'. The equation for warranted growth can be stated as follows:

$$G_w C_r = s \qquad \text{.....................(2)}$$

where,

G_w = warranted growth rate

C_r = amount of capital required to maintain the warranted growth rate

s = saving-income ratio

Eq.(2) states that if the economy is to advance at the steady rate of G_w that will fully utilise its capacity, income must grow at the rate of s/C_r per year, i.e., $G_w = s/C_r$. If income grows at the warranted rate, the capital stock of the economy will be fully utilised; the entrepreneurs will be willing to continue to invest the amount of saving generated at full potential income. G_w is therefore, a self-sustaining rate of growth and if the economy continues to grow at this rate, it will follow the equilibrium path shown in.

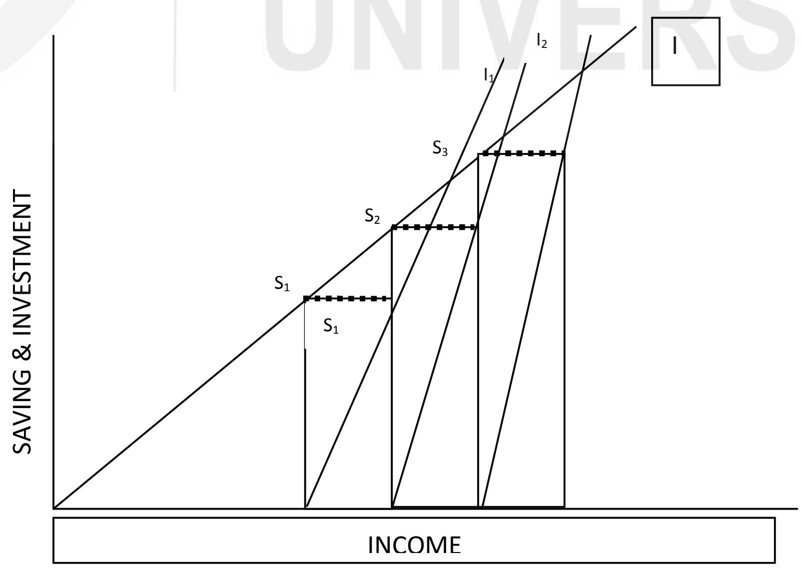

Fig.4.1.

In Fig.4.1, income is measured along the horizontal axis, and saving and investment are measured along the vertical axis. It would be seen that the change in income from Y_1 toY_2 induced investment would be to equal savings S_1 at $A(Y_2)$. This investment, in turn, raised income to Y_3 and Y_3 induced I_2 to equal S_2 at $B(Y_3)$. I_2 in turn raised income to Y_4 and Y_4 induced I_3 to equal S_3 at C(Y_4 income). In this way, the economy moves on the growth path.

The point of intersection of the investment line and the line running parallel to the Y-axis indicated the required investment that is forthcoming.

The greater proportion of savings, the greater must be the rate of increase in output to induce sufficient investment to maintain equilibrium if we assume no change in the investment co-efficient.

In brief, the warranted growth rate equation in the model implies that actual investment (ex-post investment) must be equal to expected investment (ex-ante investment), if an economy is to achieve stable growth. In such a situation, the following equalities will obtain:

$$G = G_w, \text{ and}$$

$$C = C_r$$

The economy would be in equilibrium.

If these equalities do not obtain, the economy will be pushed into a state of disequilibrium if either of the following situations obtain.

A. $G > G_w$

or

$C < C_r$

B. $G < G_w$

or

$C > C_r$

A. State if disequilibrium when $G > G_w$

Under this situation, growth rate of income is higher than the growth rate of output. It means that the demand for output(because of higher lever of income) would exceed the supply of output (because of lower level of output). The economy would experience inflation.

Stated another way, if $C<C_r$, the actual amount of capital falls short of the required amount of capital. This will lead to the deficiency of capital. This, in turn, would adversely affect the goods to be produced. Fall in output would affect the goods to be produced. Fall in output would affect the goods to be produced. Fall in output would result in scarcity of goods, and hence inflation.

Either of the two ways lead to inflation. And growth under inflationary situation is not stable.

B. State of disequilibrium when $G < G_w$

In this situation, the growth rate of income is less than the growth rate of output. There would be more goods for sale but the income would be insufficient to purchase these goods. There would be deficiency of demand and the economy would face the problem of over production.

Similarly, when $C>C_r$, actual amount of capital would be larger than the required amount of capital for investment. The larger amount of capital available for investment. The larger amount of capital available for investment would lower the marginal efficiency of capital in the long-period. Secular decline in the marginal efficiency of capital would lead to depression and unemployment.

Economic growth under the situation of depression cannot be stable.

Harrod stated that once g departs from G_w, it will further depart away from equilibrium. He writed: 'Around that line of advance which it adhered to would alone give satisfaction, centrifugal forced are at work, causing the system to depart further and further form the required line of advance." Thus, equilibrium between G and G_w is a knife-edge equilibrium. It follows that one of the major tasks of public policy is to bring G and G_w together in order to mainatain long-run stability.

For this purpose, Harrod introduces his third concept of natural rate of growth.

3. Natural Growth-rate (G_n).

It is the maximum growth rate that an economy can achieve with its available natural resources. The equation for the natural growth rate can be state as follows:

$$G_n \, C_r = \text{or} \neq s \qquad \text{................(3)}$$

It stated that the natural growth rate is determined by macro variables like population, technology, natural resources and capital equipment. These factors, place a ceiling beyond which expansion of output is not possible.

Interaction between G, G_w and G_n

Comparing G_w and G_n, it may be concluded that G_n may or may not be equal to G_w. In case G_n happen to be equal to G_w, the condition of steady growth would prevail. But such a possibility is remote one because a variety of factors (influencing G_n and G_w) come into play and make balance between these two growth-rated difficult. There exists a greater probability of inequality between G_n and G_w. It may take two terms:

(a) $G_w>G_n$

(b) $G_n>G_w$

(a) **$G_w>G_n$:** It G_w exceeds G_n, G would lie below G_n for most of the time.

In this situation, there would be a tendency for cumulative recession. A downward trend would set in, resulting in unemployment and depression. However, downward trend cannot continue indefinitely. The reason is that lower limit to depression is set by the minimum consumption level. The consumption cannot fall below a minimum level. The minimum consumption requirements can be made possible by reducing the working capital. The entrepreneurs may not reduce fixed capital in the hope that future might entail bright prospects for investment. These two factors would gradually set the wheels of recovery in motion. The economy would experience upward trend.

(b) **$G_n > G_w$:** In this situation, G would also exceed G_w for most of the time,

There would be a tendency for cumulative boom and full employment. Such a situation will create inflationary trend. To check this trend, savings should be encouraged, as these would ensure a high level of employment without inflationary pressures.

4.3.2 Assumptions of the model

- The HM is based on the following assumptions:
- The level of ex-ante aggregate saving is a constant proportion of aggregate income. It means propensity to save is assumed to be constant.
- Technical progress has been assumed to be labour argumenting or 'neutral'. This implies that neutral technical progress is the basis of the model.
- The requirements of capital and labour per unit of output are constant, i.e., capital-output and labour-output ratios are assumed constant.
- Constant returned to scale operate. This implies that output increased at a constant rate.

4.3.3 Policy Implications of the Model

The policy implications of the model are simple and straight forward. These can be briefly summarised as follows:

Saving is a virtue in any inflationary gap economy and a vice in a deflationary gap economy. In an advanced economy the saving coefficient, s, has to be moved up or down as the situation demanded.

4.3.4 The Harrod Model and Trade Cycles

Harrod has used his model to explain trade cycles. In the recovery phase, because of the existence of unemployed resources, $G > G_n$. When full employment is reached $G = G_n$. If G_w exceeds G_n at the full employment, slump is inevitable. Since G had to fall below G_w, it will, for the time being, be driven progressively downwards. Further, G itself fluctuated during the course of the business cycle. Savings as a fraction of income, though fairly steady in the long run, fluctuate in the short run. In the short run, savings tend to be residual between the earning and normal consumption. Companies, also, are likely to save a large portion of their short-period increased in net receipts. Thus, even it

G_w is normally below G_n, it is likely to ride above G_n in the later stages of advance, and, if it so happens, a vicious spiral of depression is inevitable when full employment is reached. If G_w does not ride above G_n in the course of advance, there would be continued pressure to advance when full employment is reached; this would lead to inflation and consequently, sooner or later, to a rise of G_w above G_n, resulting ultimately into a vicious spiral of depression. Actually, G may be reduced before the employment is reached because of immobilities, frictions, and bottlenecks and, if it so happens, depression may come before full employment is reached. If G_w is far above G_n, G may never rise far above G_w during the revival and the depression may result long before full employment is reached.

4.3.5 Critique of the Harrod Model

The instability in Harrod's model is due to the rigidity of its basic assumptions, viz. fixed production function, a fixed saving ratio, and a fixed growth rate of labour force. Economists have attempted to relieve this rigidity by permitting capital and labour substitution in the production function, by making the saving ratio a function of the profit rate and the growth rate of labour force as a variable in the growth process.

Check Your Progress 1

1. Why is the model discussed in this unit known as the Harrod-Domar Model?

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2. State in brief the basic formulations of the Harrod model of growth.

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3. How does the Harrod model explain the occurrence of trade cycles?

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4.4 THE DOMAR MODEL (DM)

The fundamental question around which E.D. Domar builds his model can be stated as follows:

Investment leading to an increase in productive capacity and income, what should be the rate of increase in investment which would equalise the increase in income and the increase in productive capacity, so that full employment is maintained?

Domar answers this question by forging a link between aggregate supply and aggregate demand through investment.

4.4.1 Statement of the Model

Domar model is based on the dual character of investment: one , investment increases productive capacity, and two, investment generated income,. The two sides of investment provide solution for steady growth. The following symbols are used in DM.

Y_d = Level of national income or level of effective demand at full employment (demand side)

Y_s = Level of productive capacity or supply at full employment level (supply side)

K = real capital

I = net investment, which implies change in stock of real capital, i.e. ΔK

d = marginal propensity to save, which is the reciprocal of multiplier i.e., (mp λ =1/multiplier)

σ = productivity of capital

We can make use of these notations to frame a set of equations that help formulate the DM.

The demand side of investment can be represented by an equation as follows:

$Y_d = I/d$

This equation explains two things as follows:

(i) The level of effective demand (Y_d) is directly related to the level of investment(I). An increase in investment will result in an increase in effective demand, and vice versa.

(ii) The effective demand is inversely related to the marginal propensity to save (d). An increase in marginal propensity to save will decrease the level of effective demand and vice-versa.

Eq.(1) represents the demand side of investment.

The supply side of investment can be represented by an equation as follows:

$Y = \sigma k$ ....(2)

Eq.(2) explains that supply of output(Y_s) at full employment depends upon two factors, ie.., productive capacity of capital(σ) and the amount of real capital(K). A change in the supply of any of these will result in a corresponding change in the supply of output. For example, an increase in the productivity of capital will result in an increase in output, and vice-versa. Likewise, an increase in the amount of real capital will lead to an increase in output, and vice-versa.

<u>Equilibrium:</u> In equilibrium, the demand and supply should balance. Therefore,

$$Y_d = Y_s$$

or $$I/d = \sigma K$$

By cross multiplication,

$$I = d\sigma K \qquad \text{............................(3)}$$

Eq.(3) explains the condition for steady growth.

Steady growth is possible when:

Investment equals the product of saving-income ratio, capital productivity and capital stock. From this the condition for *maintaining* the steady growth can be explained. For this we have to give increment to the demand and supply conditions presented above.

The demand equation in its incremental form can be stated as follows:

$$\Delta Yd = \Delta I/d \qquad \text{........................(4)}$$

Increments have been shown in the level of effective demand and investment because they are variables, but increment has not been shown in d because it is constant in terms of the assumptions employed.

The supply equation it its incremental form can be stated as follows:

$$\Delta Y_s = \sigma \Delta K \qquad \text{........................(5)}$$

Eq.(5) explains that change in the supply of output (ΔY_s) would be equal to the product of change in real capital (ΔK), and the productivity of capital (σ). The change in real capital is expressed as net investment. Therefore, ΔK represented investment(I). Substituting I in place of ΔK in eq.(5), we get.

$$\Delta Y_s = \sigma I \qquad \text{........................(6)}$$

<u>The equilibrium</u> between eq.(4) and eq.(6) provides us the <u>condition for maintaining</u> the steady growth. In equilibrium

$$\Delta Yd = \Delta Y_s$$

or $$\Delta I/d = \sigma I$$

cross-multiplying , we get,

$$\Delta I/I = \sigma d \qquad \text{.......................(7)}$$

Eq.(7) explains that the growth-rate of net investment $\Delta I/I$ should be equal to the product if marginal propensity to save (d) and productivity of capital (σ). This equality must be maintained to ensure stable and steady growth. Donar gives a numerical example to explain this condition of maintaining steady growth.

Let σ = 25% per year

d = 12%

Y = \$150billion a year

If full employment is to be maintained, an amount equal to $150 \times \frac{12}{100}$ =\$18 billion should be invested. This will raise productive capacity by the amount invested σ times i.e., by $150 \times \frac{12}{100} \times \frac{25}{100}$ =\$4.5 billion, and the national income will have to rise by the same amount. But the relative rise in income will equal the absolute increase divided by the amount itself, i.e.,

$$150 \times \frac{\frac{12}{100} \times \frac{25}{100}}{150} = \frac{12}{100} \times \frac{25}{100} = 3\%$$

Thus in order to maintain full employment, income must grow at a rate of 3% per annum. This is the equilibrium rate of growth. Any divergence from this "golden path" will lead to cyclical fluctuation when $\Delta I/I$ greater than σ d the economy would experience boom. The economy would suffer from depression, it $\Delta I/I$ is less than σ d.

4.4.2 Assumption of the model

The Domar model is based on the following assumption.

1. Income is determined by investment through multiplier. For the sake of simplicity, saving-income ratio is assumed constant.

2. Productive capacity is created by investment according to the potential social average investment productivity. For the sake of simplicity this is also assumed to be constant.

3. Investment is induced by output growth together with entrepreneur confidence.

4. Employment depends upon the 'utilisation ratio' expressed as the ratio between actual output and productive capacity.

5. Past and present investment can greater productive capacity at a given ratio.

4.4.3 Policy implication of the model

An economy always faced a serious dilemma if sufficient investment is not forthcoming today, unemployment will occur today; but if enough in invested today, still more will be needed tomorrow in order to increase demand so that the expanded capacity can be utilised and excessive capital accumulation avoided tomorrow; otherwise the excessive accumulation will cause a fall in investment leading to a depression day after tomorrow. To stay at the same place, therefore, the economy must move faster and the economy must move faster and faster, otherwise it will slip downward.

Check Your Progress 2.

1) Discuss the principal features of the Domar Model of growth.

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2) State the conditions necessary for steady growth.

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3) State the conditions necessary for maintaining for maintaining steady growth.

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4.5 COMPARISON OF HARROD MODEL AND DOMAR MODEL

Harrod model and Domer model show both similarities and dissimilarities with each other. Let us have a look at these.

4.5.1 Similarities

The two models are similar in substance. Harrod's is domar's d. Harrod's warranted rate of growth (G_w) is Domar's full employment rate of growth ($d\sigma$). Harrod's $G_w = s/C_r \equiv$ Domar's $d\sigma$).

To prove it

$$d = \frac{S}{Y} \text{ or } S = dY \qquad \text{................(1)}$$

$$\sigma = \frac{\Delta Y}{I} \text{ or } \Delta Y = I\sigma \qquad \text{................(2)}$$

Since S=I, and substituting S for I in eq.(2), we have

$$\Delta Y = dY\sigma \qquad [\because S=dY]$$

or $$\frac{\Delta Y}{Y} = d\sigma \qquad \text{................(3)}$$

$$\therefore \quad G_w = d\sigma \qquad (\text{since } G_w = \frac{\Delta Y}{Y})$$

In other words, Harrod's Gw is the same as Domar's $d\sigma$, but in reality, Domar's rate of growth r=ds ¬'s Harrod's G_w, and Domar's r = $d\sigma$ is Harrod's natural growth rate. In Domar's model s is the annual productive capacity of newly created capital which is greater than σ which is the net potential social average productivity of investment. It is the lack of labour and other factors of production which reduced Domar's growth rate from r=ds to r $d\sigma$. Since labour is involved in σ therefore Domar's potential growth rate resembled Harrod's natural rate. We may also say that the excess of s over σ in Domar's model expresses the excess of G_w over G_n in Harrod's model.

4.5.2 Dissimilarities

Both the models, no doubt, are based on similar assumptions, yet there are differences in the two models. These dissimilarities can be presented as below:

Dissimilarities between the Domar Model and Harrod Model.

	Parameter	Domar	Harrod
1.	Long-run difficulty	"Under-investment sapping growth"	Labour shortage deflecting growth
2.	Position of labour input	Shortage of certain labour may trigger scrapping and the inhibition of investment; optional element	Determinant of natural rate of growth: key element
3.	Centrifugal force from equilibrium	Continuously undermined investment incentives	Unstable adjustment process
4.	Reason for fixed rate, capital output ratio etc.	Assumed for inconvenience	Due to fixed interest low substitutability,

5. State of economy Idle capacity prevalent Labour unemployment common place

Further differences between the two models are revealed when we discuss their policy implications. Domar's model explains the technological relationship between the capital accumulation and full employment growth rate of output. Harrod model shows the behavioral or psychological relationships between the capital accumulation and full capacity growth rate of output. Domar's analysis is based on the principle of multiplier, whereas Harrod's analysis is based upon the principle of acceleration. Domar's model suggests the role of planned investment in the economic development, while Harrod's model stresses on induced investment.

4.6 HARROD-DOMAR GROWTH MODEL

You have read about the Harrod Model (HM) and the Domar Model (DM) separately. By now, you would have understood that the two models are similar in substance, although they may differ in details as also in policy implications. Now we have reached a stage in our study where we can integrate these two models in the form of what has come to be known as the Harrod-Domar Growth Model (HDM).

4.6.1 Substance of the Model

The main points of the HDM can be summarised as follows:

1. Investment is the central theme of the HDM. It plays a dual role. ON the one hand it generates income and on the other it creates productive capacity.

2. The increased capacity results in greater output and greater employment, depending on the behaviour of the income.

3. Condition regarding the behaviour of income can be expressed in terms of growth-rates, i.e., G Gw and Gn. The equality between these growth rates would ensure full employment of labour and full utilisation of capital stock.

4. These conditions, however, designate only a steady-line of growth. The actual growth rate may differ iron the warranted growth rate. If the actual growth rate is higher than the warranted rate of growth, the economy will experience cumulative inflation. If the actual growth-rate is lower than the warranted growth-rate, the economy will hurtle towards cumulative deflation.

5. The business-cycles are viewed as the deviations from the path of steady growth. These deviations cannot go on indefinitely. There are constraints on upper and lower limits. The "full employment ceiling" acts as an upper limit and autonomous investment and consumption act as a lower limit. The actual growth-rate fluctuates between these two limits.

4.6.2 Limitations of the Model

HDM throws light on the important determinants (and policy implications) of economic development, yet they are not free from criticism. The HDM has been criticised on the following grounds:

1. The HDM assumes key parameters, like the propensity to save and the capital-output ratio, to be constant. In reality, these are likely to change over the long run. Changes in these parameters would change the requirements of steady growth.

2. The HDM includes only aggregates as variables. A model constructed on the basis of such aggregates cannot show the inter-relations between the sectors and as such is not meant for demonstrating the structural changes which constitute a basic aspect of the economic development of a developing economy. Harmonious growth of different sectors of the economy is very important for steady grwoth. Deviations from steady growth may be caused by a lack of harmony between the growth of different sectors even when aggregative requirements for stability are fulfilled.

3. The HDM assumes the production function to be fixed and therefore there is no scope for substitution between different factors. Actually different factors of production, at least to a limited extent, can be substituted for each other. Substitutability between different factors increases the flexibility of the economy and thereby decreases the possibilities of cumulative deviations from the path of steady growth.

4. The HDM pays attention only to the requirements of steady growth and neglect the rate of growth. It is more useful for developed countries whose main aim is stability and not the rate of growth. In contrast, developing countries are interested more in the rate of growth. They would not mind following policies, which create fluctuations if these considerably raise the rate of growth.

5. The HDM is purely laizzez-faire only based on the assumption of fiscal neutrality and designed to indicate the conditions of progressive equilibrium for a developed economy. The policy implications, therefore, are not very relevant to the developing economies.

Despite these limitations, the HDM is an important model because it represented a stimulating attempt to dynamise and secularise Keynes' static short-run saving and investment theory.

Check Your Progress 3

1) State the similarities between the Harrod Model and the Domar Model.

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2) State the differences between the Harrod Model and the Domar Model.

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3) What are the basic features of the Harrod-Domar Model of growth? Also state the limitations of this model.

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4.7 LET US SUM UP

The Harrod-Domar growth model was developed separately, but concurrently, by two economists. Both the Harrod Model and the Domar Model brought out the importance of saving and investment in the process of economic growth. Both the models sought to lay out the conditions for steady growth; the non-fulfilment of these conditions would lead to disequilibrium, resulting in inflationary and deflationary gap. Although both the models differed in details, they were the same in substance. Therefore, both the models stand out integrated, and are known as the Harrod-Domar Model of Growth. The model was developed in the context of advanced market economies. But it has been widely used in formulating plan models in developing economies.

4.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1. See Section 4.2
2. See Section 4.3.1
3. See Section 4.3.4

Check Your Progress 2

1. See Section 4.4.1
2. See Section 4.4.1
3. See Section 4.4.1

Check Your Progress 3

1. See Section 4.5.1
2. See Section 4.5.2
3. See Section 4.6.1 and 4.6.2

UNIT 5 THE NEOCLASSICAL GROWTH MODEL*

Structure

5.0 OBJECTIVES

After going through the unit, you will be able to:

- apply some essential techniques to study growth models in general;
- discuss the neo-classical growth model ;
- point out the difference between the Harrod-Domar model and neo-classical model(s);
- apply the neo-classical growth models in the analysis of certain economic topics like savings, fiscal policy, poverty, and so on;
- explain the comparative growth experiences of nations using the neo-classical model; and
- examine how the concepts of money and monetary processes have been brought into the neo-classical model.

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5.1 INTRODUCTION

The previous two units of this block have introduced you to the concepts of economic growth and development, as well as the Harrod-Domar growth model. You saw how important economic growth is, how it differs from development, why we should study growth models and what the limitations of economic growth can be. The Harrod-Domar model was presented to you both as a unified model, as well as separately the models of Harrod and Domar. You became familiar with the model's assumptions, its structure, limitations as well as some applications, including application in Indian economic planning.

This unit presents for discussion a model which was put forward by Robert Solow and Trevor Swan, independently of each other, in 1956, although brief anticipations of the basic idea was carried out by James Tobin. However it is commonly known as the Solow-Swan model, or even as the Solow model. Solow has done a lot to popularise the model through subsequent papers and books. The Solow model has proved to be one of the most used most robust, and standard models in all of economic theory. Several economists of more than one generation have built upon, extended and refined the Solow model. Even when some have put forward new models, they did so referring to the Solow model as the model that they critiqued and found limitations with. Empirical economists spent lots of time, effort, energy to examine data sets and use statistical tools to see if predictions which can be generated out of the Solow model, have actually been matched by the performances of group of countries. Solow justly received a Nobel Prize for his contribution to growth theory, and as he remarked with a touch of pride during the address he gave at the time of receiving the prize, his model started a "cottage industry [of model- building in growth theory]".

In this unit we study the neoclassical growth model. We begin by acquainting you with some tools and techniques you are going to need to study growth models, not only in this unit, but in subsequent units as well. Once you have familiarised yourself with these concepts, you will be introduced to the basic neoclassical model, with the assumptions stated and the structure spelled out and elaborated. Some applications and extensions of the model are presented , following which we bring in monetary factors into the basic neoclassical model. We close the discussion with a study of the very important and relevant topics of convergence and poverty traps.

5.2 SOME CONCEPTS AND TOOLS TO STUDY GROWTH MODELS

If we assume a constant rate of growth, the formula used for calculating the growth rate for more than one year is as follows:

$Y_t = Y_o (1+r)^n$

=) $\log Y_t = \log Y_o + n \log (1+r)$

$$=)\ \log(1+r) = \frac{\log y_t - \log y_o}{n}$$

$$\text{or } \log(1+r) = \frac{\log(y_t/y_o)}{n}$$

$$=)\ 1+r = \text{antilog}\left[\log\frac{(y_t/y_o)}{n}\right]$$

$$\therefore\ \ r = \left\{anti\log\left[\frac{\log(y_t/y_o)}{n}\right]-1\right\}$$

This assumes constant rate of growth. r (as in a constant rate of interest in compound interest formulations)

When the r.o.g is not constant, it is say

$x_1, x_2, ...x_i............x_t$ in t=1,2,.......i,......t

then r = $(x_1, x_2, ...x_t)^{1/t}$

It is geometric mean.

Calculation of Growth Rates

Consider the following data on rice production:

Year	Rice Production (in lakhs of tonnes)
1990	8
1991	9
1992	13
1993	12
1994	13
1995	20
1996	19
1997	18
1998	18
1999	18
2000	23
2001	23
2002	26
2003	28
2004	27
2005	24

(i) A crude interpretation of the growth rate is given as an average percentage change from first year to the last year, in this example, average growth rate would be

$$\frac{\left(\frac{24-8}{8}\right)}{16}\times 100$$
$$= 13.3\%$$

This method overemphasises original and terminal values of data. Also, it does not use all observations.

(ii) Linear growth rate : The estimated regression using the given data turn out to be:

$$y_t = 8.1 + 1.2.45\ t$$

Three different growth rates may be completed by making following manipulations:

(a) growth rate = $\frac{\hat{\beta}}{y_0}\times 100 = \frac{1.245}{8}\times 100$
$= 15.57\%$

(b) growth rate = $\frac{\hat{\beta}}{\bar{y}}\times 100 = \frac{1.245}{18.6875}\times 100$
$= 6.66\%$

(c) growth rate = $\frac{\hat{\beta}}{HM(y)}\times 100 = \frac{1.245}{16.286}\times 100$
$= 7.64\%$

(iii) Compound growth rate: Value of $\hat{\beta}$ in the log-linear relation:

$$\ln\ y_t = \ln\alpha + \beta t$$

Growth

As an example, let's model population growth

$$\frac{dp}{dt}.\frac{1}{p} = \frac{dp/dt}{p}$$

$\frac{dp}{dt}$ is called the absolute growth rate,

$\frac{dp}{dt}/p$ is called relative growth.

US population in millions 1790-1990

Example: U.S. Population in million 1790-1990

Year	**Population**
1790	3.9
1800	5.3
1810	7.2
1820	9.6
1830	12.9
1840	17.1
1850	23.1
1860	31.4
1870	38.6
1880	50.2
1900	76.0
1910	92.0
1920	105.7
1930	122.8
1940	131.7

Suppose we went to estimate relative growth ($\frac{dp}{dt}/p$) from 1790 to 1860 let us take one particular year, say 1830. If we want to estimate $\frac{dp}{dt}/p$ in 1830 we take the rate of change in the population, and divide it by the population itself:

$$\frac{1}{p}\frac{dp}{dt} = \frac{1}{pop.in1830}\frac{popin1840 - popin1830}{10\,years}$$

$$= \frac{1}{12.9}.\frac{17.1-12.9}{10} = 0.0326 = 3.26\%$$

$$P_{10} = P_0(1+3.47)$$

$$P_{10} = P_0(1+0.347\times 10)$$

Similar calculations for 1790, 1800,………, 1850 give percentages as shown below

Year	Relative growth rate
1790	3.59%
1800	3.58%
1810	3.33%
1820	3.44%

1830	3.26%
1840	3.57%
1850	3.53%

How do we calculate average relative growth rate for the period?

The simplest model is to answer that the relative growth rate is constant, i.le.

$$\frac{1}{p}\frac{dp}{dt} = k$$

1. Arithmetic growth (simple growth): growth by a constant amount in each time period.
2. Geometric growth (exponential growth): growth by a constant proportion in each time period.
3. Nominal rate of interest & effective rate of interest; compounding period.

   If we have a photo & enlarge it 3 times, new are is $9\times$(old area).

   Correct are the following

   New area is 9 times the area of the original

   New area is 9 times as large as the original

   New area is 9 times as great as the original

   Incorrect are

   New area is 9 times greater than the original

   New area is 9 times more than the original

   New area is 9 times larger than the original

   "9 times greater than" means "10 times as great as".

B. An increase from 1 to 9 is an increase of 800%, Not 900%. If support for a political party decreases from 60% to 30% it has dropped 30 percentage points but decreased 50%.

C. When speaking of reductions also we must be careful. A reduction from 9 to 1 means the new amount is $1/9^{th}$ as much, $8/9^{th}$ less than, 11% as much as in89% less than the original.

Growth and change

Let x be an economic variable.

Let x_0 be the initial value.

x_1 be the subsequent value.

The proportional change in going from x_0 to x_1 is simply

$$\frac{x_1 - x_0}{x_0} = \frac{\Delta x}{x_0}$$

The percentage change in going from x_0 to x_1 is simply 100 times the proportionate change:

$\% \Delta x = 100\ (\Delta x / x_0)$

If x is itself in percentage it becomes tricky.

If unemployment decreases from 15% to 12% it is a reduction of 3 percentage points, but a $\frac{15-12}{15} \times 100 = \frac{\cancel{3}}{\cancel{15}_{5}} \times \cancel{100} = 20\%$ fall in unemployment.

Time as regressor

A linear trend relationships would be depicted as:

$$y = \alpha + \beta T + \mu \qquad (1)$$

where T indicates time. One has to appropriately define the origin

<u>Constant growth covers</u>

$$y_t = \alpha + \beta T + \mu_t$$
$$y_{t-1} = \alpha + \beta T - 1 + \mu_{t-1}$$
$$\Rightarrow y_t - y_{t-1} = \beta + (\mu - \mu_{t-1})$$
$$\Delta y_1 = \beta + \mu_1 - \mu_{t.......1}$$

Ignoring the disturbances, the series increases (decreases) by a constant amount each period. For an increasing series ($\beta > 0$), this implies a decreasing growth rate, and for a decreasing series ($\beta < 0$), the specification gives an increasing decline rate.

If we wish to study a series with a constant growth rate, the formulation (1) is inappropriate. The appropriate specifications expresses the logarithm of the series as a <u>linear</u> function of time.

This can be seen as follows without disturbances, a constant growth series is given by the equation.

$$y_t = y_0 (1+g)^t \qquad (2)$$

where g = $\frac{(y_t - y_{t-1})}{y_{t-1}}$ is the constant proportionate rate of growth per period

Taking logs of both sides of (2) given

$$\ln y = \alpha + \beta t \qquad (3)$$

where $\alpha = \ln y_0$ and $\beta = \ln(1+g)$

If one suspects that a series has a constant growth rate, plotting the log of the series against time provides a quick check. If the series is approximately linear, (3) can be fitted by least squares, regressing the log of y against time. The resultant slope coefficient then provides as estimates $\hat{g}$ of the growth rate, namely, b= ln(1+$\hat{g}$) giving $\hat{g}$=e^b-1

The β coefficient of (1) represents the continuous rate of change $\partial \ln y_t / \partial t$, whereas g represents the discrete case. Formulating a constant growth series in continuous time gives

$$y_t = y_0 e^{\beta t}$$
$$\ln y_t = \alpha + \beta t$$

Note that taking first difference of equation (1) given

$$\Delta m y_t = \beta = \ln(1+g)\ ;\ \ g$$

Thus, taking first difference of logs given the continuous growth rate, which in turn is an approximation to the discrete growth rate. This approximation is only reasonably accurate for small values of g.

<u>Example</u>

Bituminous coal O^t in the U8 1841-1910

Decade	**Av.annual O^t**	**lny**	**t**	**t(my)**
1841-1850	1837	7.5159	-3	-22.5457
1851-1860	4868	8.4904	-2	-16.9809
1861-1870	12411	9.4904	-1	-9.4263
1871-1880	32617	10.3926	0	0
1881-1890	82770	11.3238	1	11.3238
1891-1900	148457	11.9081	2	23.8161
1901-1910	322958	12.6853	3	38.0558
Sum		**71.7424**	**0**	**24.2408**

Plotting the log of output against time, we find a linear relationship. So we will fit a constant growth and estimate the annual growth rate. Setting the origin for time at the centre of the 1870s and taking a unit of time to be 10 years, we obtain the t series shown on the table. From the data in the table

$$a = \frac{\sum \ln y}{n} = \frac{71.7424}{7} = 10.2489$$

$$b = \frac{\sum t \ln y}{\sum t^2} = \frac{24.2408}{28} = 0.8657$$

The r^2 for this regression is 0.9945, confirming the linearity of the scatter. The estimated growth rate per decade is obtained from

$$\hat{g} = e^b - 1 = 1.3768$$

Thus the constant growth rate is almost 140 per cent per decade. The annual growth rate (agr) is then found from

$(1+\text{agr})^{10} = 2.3768$

which gives agr = 0.00904, or just over 9 per cent per annum. The equivalent continuous rate is 0.0866 or time as regressor, see Russell Davidsos and James G. Mackinon. Estimation and _______________ in Econometrics, OUP, 1993 pp 115-118

Growth Rates

Compound rates - geometric growth $\rightarrow$ continuous compound growth $\rightarrow$ exponential growth

$$v_t = v_o(1+g)^t$$

$$\Rightarrow \left(\frac{v_t}{v_o}\right) = (1+g)^t$$

$$\Rightarrow \left(\frac{v_t}{v_o}\right)^{1/t} = 1+g$$

$$\therefore g = \left(\frac{v_t}{v_o}\right)^{1/t} - 1$$

Let v_o equal the value of the variable in year 0 (the fast year) & v_t equal the value of the variable t years later. Further, let g equal the average compound annual growth rate. Then

$$v_t = v_o(1+g)^t$$

$$\Rightarrow g = \left(\frac{v_t}{v_o}\right)^{1/t} - 1$$

If the growth rate is continuously compounded, then

$$v_o e^{gt} = v_t$$

$$e^{gt} = \frac{v_t}{v_o}$$

$$g = \frac{1}{t}\ln\left(\frac{v_t}{v_o}\right)$$

Geometric mean growth rate is the same thing as compound growth rate.

Illustrations

Take company X's sales for 6 years

Year	(Net sales)	Annual growth
1979	216,283	
1980	260,404	20.4%
1981	294,145	13.0%
1982	285,954	-2.8%
1983	303,498	6.2%
1984	318,842	5.1%

Annual growth rate in year t

$$= \frac{S_t - S_{t-1}}{S_{t-1}} = \frac{S_t}{S_{t-1}} - 1$$

where S is sales. (t=1,2,3,4,5,)

= 1980

The average compound (geometric mean) annual growth rate over the 5 years from end of '79 to end of 84' for Co. X's net rates is

$$g = \left(\frac{S_t}{S_o}\right)^{1/t} - 1$$

$$\Rightarrow \left(\frac{S_5}{S_o}\right)^{1/5} - 1$$

$$= \left(\frac{318,842}{216,283}\right)^{1/5} - 1$$

$$= (1.474)^{1/5} - 1$$

$$= 1.081 - 1 = .081 = 81\%$$

The geometric mean growth rate is calculated as

$$\left[\pi_{t=1}^{n}(1+g_t)\right]^{1/n} - 1$$

In the above example,

$$g = \left[(1.204)(1.130)(0.972)(1.062)(1.051)\right]^{1/5} - 1$$

$$= (1.474)^{1/5} - 1$$

$$= 0.81$$

The arithmetic mean of the five annual growth rates (arithmetic mean growth rates)

$$\overline{g} = \frac{\sum_{t=1}^{n} gt}{n}$$

$$= \frac{1}{5}(20.4 + 13.0 - 2.8 + 6.2 + 5.1)$$

$$= 8.4\%$$

The arithmetic mean growth rate 8.4% is > the geometrics mean growth rate (8.1%). In fact values all give the same, A.M.G.K. will be > G.M.G.R.

Only if gi-n are constant, will amgv=gmgr.

5.3 THE SOLOW MODEL

5.3.1 Assumptions of the Solow model

1. The economy produces one composite good which can either be consumed or accumulated as a stock of capital. This is a simplified picture of reality. while we do not deny that lots of goods are produced in the economy, we consider, for purposes of building a model – a model, after all, is a parable or a fable-- only one 'composite' or 'aggregated' good.
2. Labour supply is homogeneous. In other words, we do not distinguish between workers with different skills or between say, blue- and white-collared workers.
3. There is a stock of capital which has been accumulated from the past. This capital and the labour are the factors of production, inputs to the production process.
4. The production function exhibits constant returns to scale. This means that if labour and capital are increased by a certain proportion, say λ, output increases by the same proportion λ. If labour and capital are doubled, output is doubled. Thus there is an aggregate production function which is continuous and which displays constant returns to scale.
5. The labour force grows at an exogenously given growth rate $g_L = n$. Thus labour force at time t is equal to $L_t = L_0e^{nt}$.
6. People save a constant proportion of Income. If S denotes saving then

   S = sY. This assumption is the same as in the Harrod-Domar model. Some people feel that Solow made this deliberately to make a comparison with Harrod-Domar model.
7. There is no foreign trade
8. The government does not intervene in the economy; there are no taxes or government purchase

5.3.2 Structure of The Model

Since we have assumed there is no depreciation, we consider the model here in the absence of depreciation. Later on, we shall discuss the case when there is depreciation of capital. To begin with consider the aggregate production function.

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

We have assumed that there are constant returns to scale. This means that if K & L are increases by a proportion λ, Y increases by the same proportion. The function F is homogenous of degree one.

$$Y = F(\lambda K, \lambda L) \text{ for all } \lambda > 1$$

For simplicity, let $\lambda = 1/L$

Then $\frac{Y}{L} = F\left(\frac{K}{L}, \frac{L}{L}\right)$

Or $\frac{Y}{L} = F\left(\frac{K}{L}, 1\right)$

Let in denote quantities divided by L, by lower-case letters

So $y = F(k, 1)$

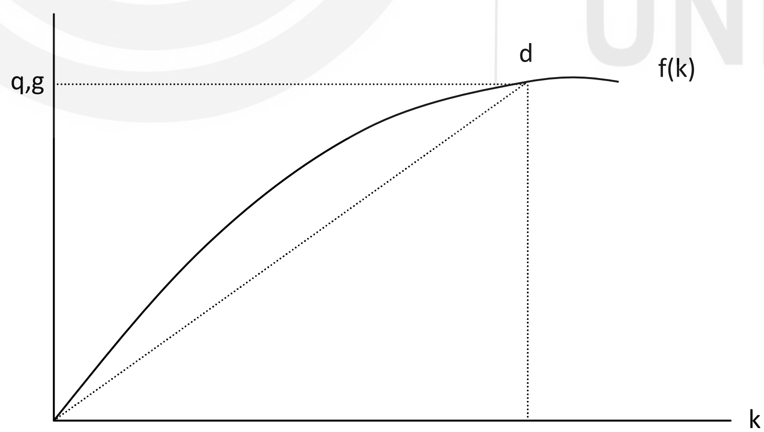
Or $y = f(k)$

This gives output per person as a function of capital labour ratio.

Sometimes income is used synonymously with output. Denoting output by Q and output-labour ratio by q, we have

$q = f(k)$

If we draw a picture of above the relationship we can show it as follows:



A ray od to any point d on the curve has a slobe that gives the ratio of output to capital. This is because the of this ray is $= \frac{Q/L}{K/L} = \frac{Q}{K}$

This is the is verse of capital output ratio v. Each point on the production function is the slow model is that ………….Harrad-Domar model, l is not fixed or exogenous different points on the production function show different, capital output ratios.

Equilibrium Growth

We have $k = K/L$

Taking natural logarithms (denoted by Ln), we get

$$\ln(\text{k}) = \ln\left(\frac{\text{K}}{\text{L}}\right)$$

$$\ln \text{k} = \ln \frac{\text{K}}{\text{L}}$$

or, $\ln \text{k} = \ln \text{K} - \ln \text{L}$

Differentiating with respect to figure, gives the proportional growth ratio:

$$\frac{d}{dt}(\ln k) = \frac{d}{dt}(\ln k) - \frac{d}{dt}(\ln L)$$

$$\frac{dk}{dt}.\frac{1}{k} = \frac{dK}{dt}.\frac{1}{K} - \frac{dL}{dt}.\frac{1}{L}$$

$$or\ \hat{k} = \hat{K} - \hat{L}$$

Now $\frac{dK}{dt}$ on the right hand side is equal to investment I

Investment = facing in equilibrium. So

$$\frac{dK}{dt} = \dot{K} = S$$

$S = SQ_t$ (as we have assumed)

$So \frac{dK}{dt} = sQ_t$ (t is the subscript denotes Q at a point of time)

The Second term on the right hand side is $\hat{L} = \frac{dL}{dt}.\frac{1}{L}$ which shows the proportional growth rate of labour. Which we have denoted n. So our equation

$$\hat{k} = \hat{K} - \hat{L}$$

can be written

$$\hat{k} = \frac{sQ}{K} - n$$

Dividing Q and K by L we get

$$\hat{k} = \frac{sq}{k} - n = \frac{sf(k)}{k} - n \text{ ………………………………………….(A)}$$

This gives $\hat{k}$, the rate of growth of k, is term of k itself.

Equation (A) is the fundamental equation of the Solow model.

The equilibrium value of k is the one for which $\frac{dk}{dt}.\frac{1}{k} is - 0,\ i.e.\ \frac{dk}{dt} = 0$ or where k, once it reaches that value, does not change. Setting $\hat{k} = 0$ in the equation above, we get

$$\hat{k} = 0 = \frac{sf(k^*)}{k^*} - n$$

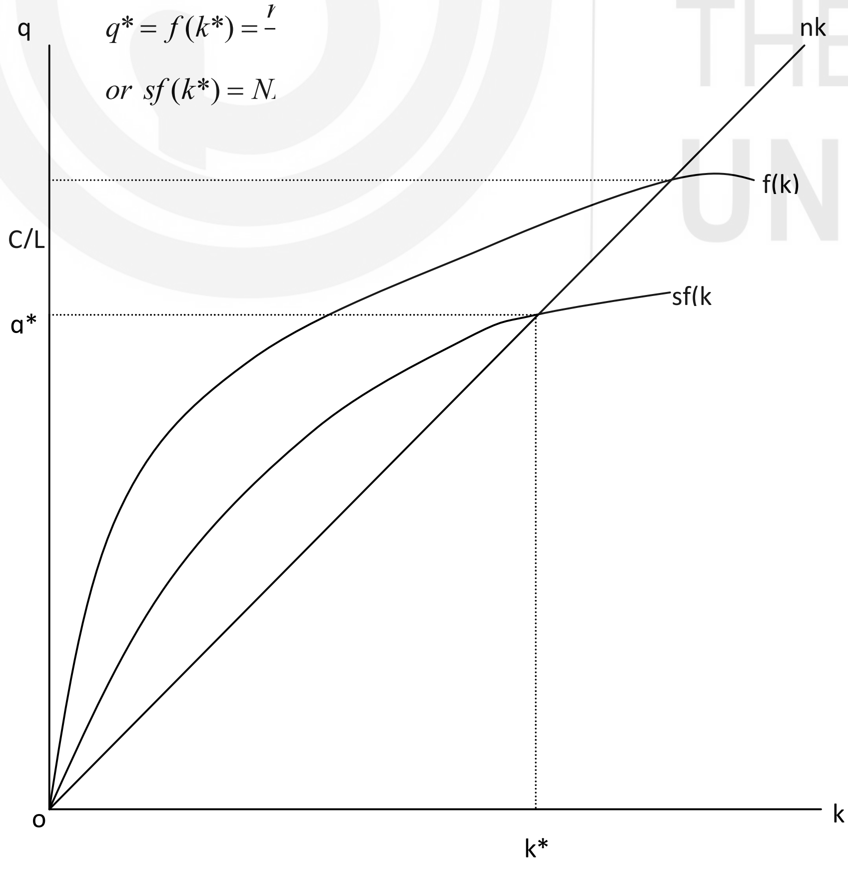
$$or\ \frac{sf(k^*)}{k^* = n}$$

where an * above k denotes its equilibrium value.

The equilibrium q value is obtained as

$$q^* = f(k^*) = $$

$$or\ sf(k^*) = N$$



At any point to the left of k*, where k<k*,

$$f(k)\rangle\left[\left(n/s\right)k\right]$$

This implies

$$\frac{sf(k)}{k}\rangle n$$

And from equation (A), we can sea that in this case $\hat{k}\rangle 0$, which mean that when $k\langle k^*, \hat{k}\, increase$

Similarly we can show that whenever k>k* (to the right of k*), $\hat{k}$ is rising and where k>k*, $\hat{k}$ is falling. Thus k* is a stable equilibrium point.

In equilibrium, when k equals k*, q reaches an equilibrium q*. As q* is a constant,

$$\frac{d\theta}{dt}.\frac{1}{t}=\frac{dL}{dt}.\frac{1}{t}=n$$

The economy thus converges to a steady state growth where $\hat{\theta}=\hat{K}$ and capital output ratio v is constant. However, $\hat{\theta}\, and\, \hat{K}$ are not greater than $\hat{L}$ but equal to it.

The equilibrium condition in the Solow model

$$\frac{sf(k^*)}{k^*}=n$$

can be written as

$$\frac{n}{s}=\frac{f(k)}{k}=\frac{q}{k}=\frac{Q/L}{K/L}=\frac{Q}{K}=\frac{1}{V^*}$$

Where V is the capital output ratio.

So we have $n=\dfrac{S}{V^*}$, the Harrod-Domar condition for balanced full employment growth. However the Solow model allows V to vary and explains how the economy will turn toward a growth bath along with the Harrod-Domar condition is and there in the Solow model, the capital output ratio V* emerges as an equilibrium value, and not as a necessary technology assumption.

CONSUMPTION IN THE SOLOW MODEL

We know that in a closed economy with no government intervention in equilibrium

$$Y=C+I$$

Where Y is aggregate output , C is aggregate consumption and I is investment.

Writing in per-worker ………., we have

$$\frac{Y}{L}=\frac{C}{L}+\frac{I}{L}$$

We know $\frac{Y}{L}=y=f(k)$

So $f(k)=\frac{C}{L}+\frac{I}{L}$ …………………………………..(B)

Now consider capital labour ratio

$$k=K/L$$

We have seen $\frac{dk}{dt}.\frac{1}{k}=\frac{dK}{dt}.\frac{1}{k}-\frac{dL}{dt}.\frac{1}{L}$

Or $\hat{k}=\hat{K}-\hat{L}$

Where $\wedge$ denotes proportional growth rate. We had already denoted $\hat{L}$ *by n*

So we have

$$\hat{k}=\hat{K}-n$$

or $\frac{\dot{k}}{k}=\frac{\dot{K}}{k}-n$ where $\dot{X}$ *denotes* $\frac{dX}{dt}$ Multiplying both sides by K/L we get

$$\frac{\dot{k}}{k}.\frac{K}{L}=\frac{\dot{K}}{K}.\frac{K}{L}-\frac{nK}{L}$$

or $\dot{k}=\frac{\dot{K}}{L}-nk$

Alternatively putting it;

$$\frac{\dot{K}}{L}=\dot{k}+nk \text{ ……………………………………………..(C)}$$

Since one of the assumptions we had made was that there is no depreciation, hence

$$\dot{k}=\frac{dK}{dt}=I$$

So we may write equation (C) as

$$\frac{I}{L}=\dot{k}+nK$$

In equation (B) we can replace $\frac{I}{L}$ by the right hand side of the above equation.

Equation (B) then becomes

$$f(k) = \frac{C}{L} + \dot{k} + nK \text{ ....(D)}$$

This equation states the following: Output per worker (since we are taking θ as equal to Y and hence q=y) is put to three uses which are shown on the right hand side. First, consumption per worker $\frac{C}{L}$; a portion of investment nk, that maintains the capital labour ratio constant in the face of growing labour force; and a portion of investment, $\dot{k}$ which increases the capital labour ratio. When capital goods increase faster then the increase in labour, so that the capital-labour ratio rises, it is called capital deepening, while when capital goods rise merely to keep pace with the rise in labour force so that the capital labour ratio remains constant, it is called capital widening. Thus output per worker, in equation D, is divided among consumption per worker, capital deepening and capital widening.

We can arrive at equation D by a different route, from our fundamental equation of the Solow Model.

Recall that the fundamental equation, equation (A) is

$$\hat{k} = \frac{sf(k)}{k} - n = \frac{sq}{k} - n$$

Since $\hat{k} = \frac{\dot{k}}{k}$, hence multiplying the above equation throughout by k, we get

$$\dot{k} = sq = nk$$

Recall our assumption that q = y. We have

$$\dot{k} = sy - nk$$

Since $y = \frac{Y}{L}$, we have $\dot{k} = \frac{sY}{L} - nk$

We had made the assumption that S = sY

Now in equilibrium S =Y-C = I

Hence we have $\dot{k} = \frac{Y}{L} - \frac{C}{L} - nk$

Now switching back in rotation f(k) for $\frac{Y}{L = y}$, we have

$$\dot{k} = f(k) - \frac{C}{L} - nk$$

or $f(k) = \frac{C}{L} + \dot{k} + nk$

which is equation (D).

What are the basic proposition and conclusion that we get from the Solow model? Does it provide some guidelines for studying the growth trajectories of actual economies? We give below some theoretical conclusions that emerge from the Solow model.

First, given the assumptions as stated earlier, there exists a steady state (balanced growth) solution for the model. The balanced growth solution is stable. Stability is there in that whenever the initial values of all the variables, the economy eventually mark to the study state equilibrium value of y and k. We have already seen this from the diagram.

The second conclusion we get that the balanced rate of growth (all ……….. grow at the same rate) is the constant exogenous grow the of labour force, which is n.

THE SOLOW MODEL WITH DEPRECIATION

We know that in absence of depreciation

$\dot{K} = I$ Here I denote grow investment.

Let us now answer that a certain proportion δK of capital depreciates (through wear and ………). We can now write

$I = \dot{K} + \delta K$

Where I now is net investment and δ is the constant rate of depreciation of capital stock.

Dividing by L, we obtain

$\frac{I}{L} = \frac{\dot{K}}{L} + \frac{\delta K}{L}$ …………………………………………..(E)

We know from equation (C), which we …………….earlier, that

$\frac{\dot{K}}{L} = \dot{k} + nk$

Substituting this expression for $\frac{\dot{K}}{L}$ into equation (E), we obtain

$\frac{I}{L} = \dot{k} + nk + \delta k$

$or \frac{I}{L} = \dot{k} + (n+\delta)k$

Writing $\frac{I}{L}$ as $\frac{S}{L}$ (in equation) and they as sy or sf(k)

We have $sf(k) = \dot{k} + (n+\delta)k \;\; or \;\; \dot{k} = sf(k) - (n+\delta)k$

Or $\dot{k} = \frac{sf(k)}{k} - (n+\delta)$

This is a modified form of the fundamental equation of the Solow model. The fasic analysis that we studied, carrier over for the case of depreciating capital; we merely need to replace n by (n+δ).

Poverty Traps

Empirically, the convergence by pother is has not held up very well. The neo-clinical model has not been very successful an showing why rates of growth differ across nations. One fact was staring everyone in the face: many rations of the world were poor. In a sense, what was going on was the exact opposite of what was suggested by the convergence hypothesis: Some countries were shifting stagnant growth, while other were progressing very fact. This idea that the poorer nations were actually caught is a traphas come to be called poverty trap. It is a trap because inspite of efforts. These nations stay a low-level 'equilibrium'.

There are two types of poverty traps: technological-Induced and population induced. They can both be demonstrated in the Solow system.

(a) Technological trap:

If we consider the Solow production function y = f (k), or $Y/L = F\left(K/L\right)$, and suppose there is a certain range where for certain values of L, K, the production function exhibits increasing returns to scale, then there will be multiple equilibrium. For certain values of k, say k* if the economy sports at a level lower than k*, the economy will slump back towards a very low income and outp0ut level because the level k* may show a unstable equilibrium.

The idea behind technological trap is that has such a hypothetical country received an initial injection of capital so as to give a value of k larger k*, it would have been pushed over the level. This idea is sometimes called the 'Big push Theory'of which you will read later in block 4. The idea of poverty trap being caused by low savings, low technology is sometimes called the vicious circle of poverty, about which you will read in block 4.

The second way in which poverty traps can arise is induce by population growth. In the neo-classical model, the rate of population growth was given exogenously. However for classical writers population growth was given endogenously. Robertr Methus in his 1798 work, of which you will study in block 4, suggested that the rate of growth of population depends on per capita income. As per capita income rises, the rate of population growth rises ever faster. This has come to be knows as the theory of demographic transition.

We can bring in the idea of demographic transition into the neo classical model. Recall that is the neo classical model population grows exogenously at a rate n. …………,now suppose population growth rate is dependent on y, as suggested by the theory of demographic transition. We know that y is a function of capital per person. $y = f(k/l)$. Thus n, the population growth rate indirectly becomes a function of the capital labour ratio:

$$n = g\left(k/l\right)$$

We may think of some interval $k_2 - k_1$ where for values of k below k_1, n is <0, but for values of k in the range $[k_2, k_1]$ n is >0; again for values of k > k_2, n may become <0. Historically, in olden time in societies where k was below k_1, population was last theory wars, disease etc.

In our analysis, consider the range $k_2 - K_1$. Even here, n, although >0, can itself increase or fall. In other words, although the population is increasing. The rate of increase may itself vary. The idea is that, this leads to a situation where the saving (or investment) curve changes shape and may turn out to be S shaped. Then, we may have multiple equilibrium points of k most of which are unstable: any movement from these points pushes the system far then away rather than bringing it back into equilibrium. We have considered the interval (or range of values between) $[k_2, K_1]$. Supposing we can two equilibrium points k_a and k_b. Let k_a lie between k1 and k_2, i.e. $k_2 > k_a > k_1$. Let k_b be greater than k_2. Here k_a is the stable equilibrium while k_b is the unstable one. n is the stable equilibrium which creates the problem here. For any value of k leather k_2, the economy is pulled back to equilibrium level k_a. Only if an injection of capital is gives which pushed the k level above k_b (where the equilibrium is unstable) will the k level be given a "Big Push" and sent to higher and higher values and thus raising the level of y via the f-function.

We mentioned the demographic transition which roughly says that n depends only. But in the last century, due to advance is health care and ………., low y did not necessarily lead to low n. As death rates dropped, population increased. On the other hand sub-Saharan African nation like Ethiopia did see n very low (other nations are under populated) due to very low levels of y.

5.4 LET US SUM UP

The neoclassical growth model is the central, 'base-line' model which has saved on the spring board for almost all most researches into growth theory. The no-classical model, associated with the name of Robert Solow, presented the first major extension to the Harrod-Domar model, by endogenusing the capital output ratio.

In this unit, we learnt some concepts and tools useful for studying growth theory, and then we studied the structure of the neo-classical model, along with the assumptions. We extended the Solow model to consider depreciation and variable savings. We their process led to apply the Solow model to look at some applications, like convergence and poverty tragss. We also looked at some implications of the Solow model namely technical progress is more important than capital accumulation, and raising the savings ratio in the short run is not going to help. In the Solow model, technological progress and consequently, output growth is exogenous. When we get to unit 9 on endogenous growth, we will look at models that endogenous these.

UNIT 6 ENDOGENOUS GROWTH MODELS*

Structure

6.0 OBJECTIVES

After going through the Unit, you will be able to:

- Describe the emergence of Endogenous growth models;
- List the assumptions of endogenous growth models;
- Analyse the basic ideas on which these models rest and function in the context of real world;
- Discuss and evaluate the working of endogenous growth models;
- Identify the limitations of these models; and
- State the policy implications of these models.

6.1 INTRODUCTION

Endogenous growth theory was developed as a reaction to omissions and deficiencies in the Solow (neoclassical) growth model. It is a new theory which explains the long run growth rate of an economy on the basis of endogenous factors as against exogenous factors of the neoclassical growth theory.

The new growth theory of the 1990s was labeled "endogenous growth theory" because it attempted to explain technical change as the result of profit-motivated research and development (R&D) expenditure by private firms. This was driven by competition along the lines of what Schumpeter called product innovations (as distinct from process innovations). In contrast to the Harrod-Domar model,

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which viewed growth as exogenous, or coming from outside variables, the endogenous theory emphasizes growth from within the system. This approach enjoyed, and still enjoys, an enormous vogue, partly because it seemed to offer governments a new means of promoting economic growth—namely, national innovation policies designed to stimulate more private and public R&D spending.

While the neo-classical growth models explain the long run growth rate of output based on exogenous variables namely rate of growth of population and rate of growth of technical progress (independent of savings rate), the new growth theory extends this by introducing endogenous technical progress in growth models. The Endogenous growth models emphasize on technological progress resulting from the rate of Investment, size of capital stock and stock of human capital. The concept of economic growth here is thus, internal to the economy. The theory is built on the idea that the improvements in innovation, knowledge and human capital lead to increased productivity, positively affecting the economic outlook.

The Endogenous growth theory challenges the idea of predicting growth without incorporating technological advancements. Since economic growth is derived from the growth rate of economic output per person, it would depend on the productivity levels and these would in turn depend on the progress of technological change. The endogenous growth theory considers these factors *viz*. innovation and human capital as internal to the economy.

Models of Endogenous growth bear some structural resemblance to their neoclassical counterparts but they differ considerably in their underlying assumptions and conclusions drawn. The most significant theoretical differences stem from discarding the neoclassical assumptions of diminishing returns to capital investments, permitting increasing returns to scale in aggregate production and frequently focusing on the role of externalities in determining the rates of return on capital investments. By assuming that public and private investments in human capital generate external economies and productivity improvements that offset the natural tendency for diminishing returns, endogenous growth theory seeks to explain the existence of increasing returns to scale and the divergent long-term growth patterns among countries. While technology still plays an important role in these models, exogenous changes in technology are no longer necessary to explain long run growth.

The new growth theory reemphasizes the importance of savings and human capital investments for achieving rapid growth just like Harrod-Domar model, but it leads to several implications for growth that are in direct conflict with traditional theory: a) there is no force leading to the equilibration of growth rates across closed economies, it remains constant or differs according to savings rates and technology levels and b)there is no tendency for per capita income levels in poor countries that are capital scarce to catch up with rich countries. The best part about this theory is that it seeks to explain the anomalous international flows of capital that exacerbate wealth disparities between rich and poor countries.

The potentially high rates of return on investment offered by developing economies with low capital-labour ratios are greatly eroded by lower level of complementary investments in human capital (education and health), infrastructure of R&D. Hence, poor countries benefit less from the social gains associated with these. Since individuals do not internalize these gains by positive externalities, the free market leads to sub optimal accumulation of complementary capital in the society. The state can play a key role here by improving the efficiency of resource allocation by provision of public goods/infrastructure and encouraging private investments in knowledge-intensive industries where human capital can be accumulated.

6.2 ASSUMPTIONS OF NEW GROWTH THEORIES (ENDOGENOUS GROWTH MODELS)

In general, the new growth theories rest on the following basic assumptions

- There are many firms in the market.
- Technological advancement or knowledge is a non-rival good.
- Increasing returns to scale to all factors taken together prevails when constant returns to a single factor exists.
- Technological advancements come from things people do. It is based on creation of new ideas.
- Increasing returns to scale in production leads to imperfect competition and thus, many individuals and firms have market power and earn profits from their discoveries.
- Emphasis is on the need of the Government to provide incentives and subsidies for businesses in the private sector.
- Investments should also be made to improve infrastructure and manufacturing processes to achieve innovation in production.

Check Your Progress 1

1. How does endogenous growth theory explain persistent growth without the assumption of exogenous technological progress How does this differ from the Solow model?

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2. How is endogenous growth different from exogenous growth?

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6.3 ENDOGENOUS GROWTH MODELS

6.3.1 Arrow's Theory of Learning-by-doing

Learning-by-doing is a concept in economic theory by which productivity is achieved through practice, self-perfection and minor innovations. Kenneth Arrow used this concept in his design of Endogenous growth theory to explain the effects of innovation and technological change. Arrow's classical paper "The Economic Implications of Learning by doing" published in 1962 showed how this idea fits into the modern theory of economic growth and used it as a springboard for a critical consideration of spectacular recent developments. He introduced the increases in per capita income that cannot be merely explained by increases in capital-labour ratio. Identifying the role of technological change in economic growth and providing an explanation of the concept of knowledge which underlies a production function, he examined how knowledge has to be acquired.

He therefore suggested an endogenous theory of the changes in knowledge which underlie inter-temporal and international shifts in production functions. The acquisition of knowledge called "learning" might be interpreted in different ways yet it accepted by all schools of thought; learning is a product of experience. It can only take place through the attempt to solve a problem and therefore, takes place only during an activity. He generalized from many of the classical learning experiments that learning associated with repetition of essentially the same problem is subject to diminishing returns. There is an equilibrium response pattern for any given stimulus, towards which the behaviour of the learner tends with repetition. To have steadily increasing performance, then, implies that the stimulus situations must themselves be steadily evolving rather than merely repeating.

He emphasized the role of experience in increasing productivity that had yet to be absorbed into the main corpus of economic theory. He thus, advanced the hypothesis that technological change in general could be ascribed to experience that is the very activity of production which gives rise to problems for which favourable responses are selected over time. Hence, learning by doing is an example of knowledge accumulation from the production process. As individuals produce goods, ways of improving production processes happen inevitably. The improvement in productivity occurs as a byproduct of normal production activity and not as a result of deliberate efforts.

When learning by doing is the source of technological progress, the rate of growth/accumulation of knowledge depends not on the proportion of GDP devoted to R&D but from how much new knowledge is generated by traditional productive activity. The production function can be written as

$$Y(t) = K(t)^{\alpha} [A(t) L(t)]^{1-\alpha} \qquad \text{---------------------------------(1)}$$

Where K=Capital, L=Labour, Y=Output, A=Stock of knowledge and α = a parameter that lies between 0 and 1

The simplest case of learning by doing is found in those situations where learning occurs as a side effect of the production of new capital. Since, the increase in knowledge is a function of increasing capital, the stock of knowledge is a function of the stock of capital. There is only one stock variable whose behaviour is endogenous here

$A(t)=B\,K(t)^{\beta}$ B and β are both greater than 0 --------(2)

If we put this in Equation (1) we get

$Y(t)=K(t)^{\alpha}\,B^{1-\alpha}\,K(t)^{\beta(1-\alpha)}\,L(t)^{1-\alpha}$

In the presence of learning, the contribution of capital is larger than its conventional contribution: increased capital raises output not only through its direct contribution to production [term $K(t)^{\alpha}$] but also by indirectly contributing to the development of new ideas and making all other capital more productive [term $K(t)^{\beta(1-\alpha)}$].

In a simplified form, the model is represented as the following:

$Y_i = A(K)\,F(K_i, L_i)$

Where for a firm i

Y_i is output, K_i is the aggregate stock of capital and L_i is the stock of labour

A is the technical factor and K represents the aggregate stock of capital

6.3.2 The Levhari-Sheshinski Model

Levhari and Sheshinski have generalized and extended Arrow's model. They stress on the spillover effects of increased investment as the source of knowledge. They assume that the source of knowledge or learning by doing is each firm's investment. An increase in a firm's investment leads to a concomitant increase in its level of knowledge. An increase in a firm's investment leads to a parallel increase in its level of knowledge. The model assumes that the knowledge of a firm is a public good which other firm can have at zero cost. Thus, knowledge has a non-rival character which spills over across all the firms in the economy. This is when each firm operates under constant returns to scale and the economy as a whole is operating under increasing returns to scale.

This model explains endogenous technological progress in terms of knowledge or learning by doing that is reflected in an upward raising of production function and economic growth in the context of aggregate increasing returns being consistent with competitive equilibrium.

6.3.3 The King-Robson Model

King and Robson in a paper published in 1993 emphasised learning by watching in their technological progress function. Investment by a firm represents innovation to solve the problems it faces. If it is successful, the other firms will adopt the innovation to their own needs. Thus, externalities resulting from learning by watching are a key to economic growth. This study shows that innovation in one sector of the economy has the contagion or demonstration effect on the productivity of other sectors, thereby leading to economic growth. Multiple steady state growth paths exist, even for economies having similar initial endowments and policies that increase investment should be pursued.

6.3.4 Romer Model

Romer in his first paper on endogenous growth in 1986 presented a variant on Arrow's Model which is known as learning by investment. He assumed creation of knowledge as a side product of investment. He took knowledge as in input in the production function of the following form:

$$Y = A(R)\, F\, (R_i, K_i, L_i)$$

Where Y = Aggregate output, A(R) = public stock of knowledge from R&D

R_i = stock of results from expenditure on R&D by firm i , K_i = capital stock of firm i and L_i = labour input of firm i

He assumed the function F is homogenous of degree1 in all its inputs R_i, K_i, L_i and treats R_i as a rival good.

Romer took three key elements in his model: externalities, increasing returns in the production of output and diminishing returns in the production of new knowledge. It is the spillovers from research efforts by a firm that leads to the creation of new knowledge by other firms. New research technology by a firm spill over instantly across the entire economy. In this model, new knowledge is the ultimate determinant of long run growth which is determined by investment in research technology. Research technology exhibits diminishing returns which means that investments in research technology will not double knowledge. Also, the firm investing in research technology will not benefit exclusively from the increase in knowledge. Other firms also benefit from new knowledge due to inadequacy of patent protection. Hence, the production of goods from increased knowledge displays increasing returns and competitive equilibrium is consistent with increasing aggregate returns owing to externalities. Romer took investment in research technology as endogenous factor in terms of the acquisition of new knowledge by rational profit maximizing firms.

6.3.5 The Lucas Model

Robert Lucas utilized a model of endogenous growth developed by Uzawa. Uzawa developed an endogenous growth model based on investment in human capital. Lucas assumed that investment on education leads to the production of human capital which is the crucial determinant in the growth process. He classified this as: internal effects of human capital where the individual worker undergoing training becomes more productive and external effects which spillover and increases the productivity of capital and of other workers in the economy.it is the investment in human capital rather than physical capital that have spillover effects that increase the level of technology.

Thus, the output for firm i takes the form

$$Y_i = A(K_i).\ (H_i)H^e$$

Where A is the technical coefficient

K_i and H_i are the inputs of physical and human capital used by firm i to produce output Y_i

H is the economy's average level of human capital and e is the parameter that represents strength of the external effects from human capital to each firm's productivity

In the Lucas model, each firm faces constant returns to scale, while there are increasing returns to scale for the whole economy. Learning by doing or on the job training and spillover effects involve human capital. Each firm benefits from the aggregate of human capital. Thus, it is not the accumulated knowledge or experience of other firms but the average skills and knowledge in the economy that are crucial for economic growth.

6.3.6 Romer's Model of Technological Change

In 1990, Romer gave the model of endogenous technological change that identified a research sector specializing in the production of ideas. This sector invokes human capital along with the existing stock of knowledge to produce ideas or new knowledge. The importance of ideas over resources is the cornerstone of his analysis where he quotes Japan as an example, a country with few natural resources but open to new western ideas and technology.

In this model, new knowledge enters into the production process in three ways-

a) A new design is used in the intermediate goods sector for the production of a new intermediate input

b) In the final sector; labour, human capital and available producer durables produce the final product

c) A new design increases the total stock of knowledge which increases the productivity of human capital employed in the research sector.

The model is based on the following assumptions:

- Economic growth comes from technological change
- Technological change is endogenous
- Market incentives play an important role in making technological changes available in the economy
- Invention of a new design requires a specified amount of human capital
- The aggregate supply of human capital is fixed
- Knowledge or a new design is assumed to be partially excludable and retainable by the firm who invented it (patented design that cannot be made or sold without the agreement of the inventor) but investment in R&D can be done by other firms and benefits can be accrued thereof.
- Technology is a non-rival input.

- The new design can be used by firms and in different periods without additional costs and without reducing the value of the input.
- The low cost of using an existing design reduces the cost of creating new designs.
- When firms make investments in R&D and invent a new design, there are externalities that are internalized by private agreements.

Technological production function in the model is given by

$$\Delta A = F(K_A, H_A, A)$$

Where ΔA is the technology production function for technology (Δ stands for change in value; thus ΔA stands for change in technology)

K_A is the amount of capital invested in producing the new design or technology

H_A is the amount of human capital (labour) employed in R&D of the new design

A is the existing technology of designs.

The production function shows that technology is endogenous. When more human capital is employed for R&D of new designs, then technology increases by a larger amount that is A is greater. Since it is assumed that technology is a non-rival input and partially excludable, there are positive spillover effects of technology which can be used by other firms. Thus, the production of new technology (knowledge or ideas) can be increased through the use of physical capital, human capital and existing technology.

Check Your Progress 2

1. Explain the learning by doing model by Kenneth Arrow?

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2. Examine the relevance of Paul Romer's model of technological change in explaining long run growth across countries.

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6.4 CRITICISM OF ENDOGENOUS GROWTH MODELS

Many economists have criticized the new growth theory on their respective considerations, some based on the general suggestion that endogenous growth theory is not novel, such as

- Scott and Auerbach think that the main ideas of the new growth theory can be traced to Adam Smith and increasing returns of Marx's analysis.
- Srinivasan does not find anything new in the new growth theory as increasing returns and endogeneity of variables have been taken from neoclassical and Kaldor models of growth.
- Fisher criticizes it for depending only on the production function and steady state.
- Olson feels that it lays too much emphasis on the role of human capital and neglects the role of institutions.
- In various models of new growth theories, the difference between physical and human capital is not clear.

However, a few general limitations can also be highlighted,

- Endogenous growth theory is impossible to be validated through empirical evidence.
- It is accused of being based on assumptions that cannot be accurately measured.
- These theories have collectively failed to explain conditional convergence reported in empirical evidence.
- An important shortcoming of the new growth theory is that it remains dependent on a number of assumptions of the traditional neoclassical theory that are often inappropriate for developing and underdeveloped economies.
- In developing countries, economic growth is frequently impeded by inefficiencies due to poor infrastructure, inadequate institutions and imperfect capital and goods markets. The endogenous growth theory fails to incorporate these factors.
- The theory particularly looks at long run growth and ignores short- and medium-term growth.

6.5 POLICY IMPLICATIONS FOR DEVELOPED AND DEVELOPING COUNTRIES

- This theory suggests the convergence of growth rates per capita of developing and developed countries can no longer be expected to occur. The increasing returns to both physical and human capital imply that the rate of return to investment will not fall in developed countries relative to developing countries. Therefore, capital need not flow from developed to developing countries and actually the reverse may happen.
- The measured contribution of both physical and human capital to growth may be larger than suggested by the Solow Model. Investment in education or R&D has not only a positive effect on the firm itself but also spillover effects on the other firms and economy as a whole. This suggests that the residual attributed to technological change in the Solow growth accounting may be actually smaller. Recent growth accounting

exercises have suggested that the percentage of growth accounted for by the 'unexplained residual', is much smaller for the less advanced economy. This may of course simply reflect capital in these countries. Alternatively, it may reflect other considerations generally excluded from growth theory but which possess particular relevance for the developing economies. Stern (1991) for example, has stressed the importance of management, organization, infrastructure, and sectoral transfer as key elements in the growth process of third world economies

- It is not necessary that economies having increasing returns to scale must reach steady state level of income growth as suggested by Solow-Swan Model. With positive externalities of Research and Development, growth of income does not slow down and economy does not reach steady state. An increase in savings rate can lead to a permanent increase in the growth rate of the economy.
- Countries having greater stocks of human capital and investing more in R&D will enjoy a faster rate of economic growth. This may be the reason for slow growth of many developing countries.
- Potentially, it is the less developed economy which stands to gain the most from international trade becoming freer since by doing so it can draw upon the stock of world knowledge. But technological flows from rich to poor economies are by no means automatic which raises the issue of the role of multinational corporations and how they respond to incentives for technological transfer. This leads naturally into the question of policy. The essence of modern statements of endogenous growth is that the technical progress residual is accounted for by endogenous human capital formation. But if the latter can be influenced by government policy world growth may be changed accordingly. For example, if a country possessed of a comparative advantage in R & D activity were to subsidize research, world growth would increase. In the same way, a similar subsidy introduced by an economy relatively more efficient in manufacturing as opposed to innovating may cause world growth to decline. Trade policies which afford protection to the manufacturing sector may promote the transfer of skilled labour from research activity into manufacturing which will retard innovation. Ceteris paribus, trade policy will affect a shift of resources from research to manufacturing in policy active countries and in the opposite direction in policy inactive countries.
- Implications also emerge for the international product cycle. Traditionally, invention and new products occur in the advanced economy where R& D activity is well developed. Later, either by imitation or technology transfer they will be produced in the less advanced country and ultimately production of these goods will migrate to the low wage economy. Accordingly, trade in manufactured products takes place on the basis of exchange between the latest innovative goods produced only in the advanced economy and the more traditional goods now produced

predominantly by the less advanced. The product cycle accounts for an ever-evolving pattern of international trade with the advanced economy importing the very same goods that initially it exported. In the context of the product cycle model, international trade always emerges as a contributor to faster economic growth in both advanced and less advanced economies. In the former, the migration of production from the advanced to the less advanced economy frees resources for use in growth enhancing product development activity. At the same time, growth occurs faster in the less advanced economy since the resources needed for learning and adapting the techniques imported from the advanced economy are far fewer than those needed for autonomous new product development. In both cases, the subsidization of learning activities (innovation in the advanced economy, imitation in the less advanced) may be expected to enhance long run growth rates.

- Finally, it would appear clear that trade policy has the potential for influencing long run growth paths for the world economy. However, numerous difficulties present themselves. The identification of growth influencing knowledge sectors is itself a major difficulty ex ante if not ex post. Secondly, the fact that conclusions deriving from the model analysis can be so easily overturned by the alteration of the conditions or assumptions underlying the analysis - which for the most part are unlikely to be resolved empirically - weakens one's confidence in growth prescription. Moreover, in the context of international trade and the world economy, the outcome and effects of policy measures are themselves interdependent with the policy actions of others. This would point to the need for the coordination of national policies or at least the consideration of second-best outcomes.

An endogenous growth theory implication is that policies that embrace openness, competition, change and innovation will promote growth. Conversely, policies that have the effect of restricting or slowing change by protecting or favouring particular existing industries or firms are likely, over time, to slow growth to the disadvantage of the community.

Check Your Progress 3

1. What are criticisms of endogenous growth theory?

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2. Discuss the policy implications of endogenous growth for developing and developed countries

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6.6 LET US SUM UP

Endogenous growth is long-run economic growth at a rate determined by forces that are internal to the economic system, particularly those forces governing the opportunities and incentives to create technological knowledge. In the long run the rate of economic growth, as measured by the growth rate of output per person, depends on the growth rate of total factor productivity (TFP), which is determined in turn by the rate of technological progress. The neoclassical theory implies that economists can take the long-run growth rate as given exogenously from outside the economic system. Endogenous growth theory challenges this neoclassical view by proposing channels through which the rate of technological progress, and hence the long-run rate of economic growth, can be influenced by economic factors. It starts from the observation that technological progress takes place through innovations, in the form of new products, processes and markets, many of which are the result of economic activities. For example, because firms learn from experience how to produce more efficiently, a higher pace of economic activity can raise the pace of process innovation by giving firms more production experience. Also, because many innovations result from R&D expenditures undertaken by profit-seeking firms, economic policies with respect to trade, competition, education, taxes and intellectual property can influence the rate of innovation by affecting the private costs and benefits of doing R&D.

The central tenets of endogenous growth theory and policy implications thereof include:

- Government policy's ability to raise a country's growth rate if they lead to more internal competition in markets and help to stimulate product and process innovation.
- There are increasing returns to scale from capital investment especially in infrastructure and investment in education, health and communications.
- Private sector investment in R&D is a crucial source of technological progress.
- The protection of property rights and patents is essential in providing incentives for businesses and entrepreneurship to engage in R&D.
- Investment in Human capital is a vital component of growth.

- Government policy should encourage entrepreneurship as a means of creating new businesses and ultimately as an important source of new jobs, investment and further innovation.

6.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1. See section 6.1
2. See section 6.2

Check Your Progress 2

1. See sub-section 6.3.1
2. See sub-section 6.3.6

Check Your Progress 3

1. See section 6.4
2. See section 6.5

UNIT 7 DETERMINANTS OF GROWTH*

Structure

7.0 OBJECTIVES

After going through this unit you should be able to :

- Explain the meaning of growth accounting;
- Discuss the influence of technology on growth;
- Analyse the concept of convergence and whether empirically growth rates of developing nations and developed nations are converging;
- Examine the role of institutions, human capital, geography and culture in determining economic growth; and
- Explain the ideas of path dependence and historical lock-ins.

7.2 GROWTH ACCOUNTING

Total Factor Productivity (TFP) or we may call it productivity is an important concept in the context of economic Growth of a nation particularly developing countries. Productivity contributes to industrial growth and to the competitiveness in international markets. It refers to the rate at which employment is generated from the employed resources. Increased productivity result in better utilisation of resources and reduces the cost and the prices of industrial products, which in turn, lead to a faster growth in demand in both domestic and international markets. Ever since Robert Solow) decomposed output growth into the contribution of input growth and a residual productivity term; the concept has gained popularity and is used as a benchmark to rank firms or countries. Such rankings get credibility once productivity is correlated with other indicators of success such as employment growth, export status, or

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technology adoption. Concept like low productivity is also found useful to predict exit of the firms in an economy, the ultimate performance standard. Its importance can also be gauged from the attention it receives as a criterion to evaluate policy interventions or firms' decisions. The concept has relevance and different meaning in different branches of economics. In industrial economics, for example, a large literature investigates the effect of R&D on productivity and the resulting impact on industry structure. In international economics, the efforts to evaluate the impact of trade liberalization range from estimating changes in price-cost margins to productivity changes. Fundamentally, the objective of productivity measurement is to identify changes in output that cannot be explained by changes in inputs.

Behind this concept most often stands the understanding that besides the traditional factors of production labour and capital there is something else that leads to the increase in production. Usually this 'thing' is associated with technological progress. The latter concept itself can be interpreted in various ways, but eventually it always implies that the combination of labour force, machines, human knowledge and skills, leads to changes in total income that are not expected by changes in capital or labour considered separately.

Growth (increase in GDP) of an economy is generally attributed to factors that can be clubbed under two broad headings: Capital and Labour. But you will find when you calculate it that Capital and Labour cannot account for all the growth and in fact there is a residual factor that comes into play and accounts for the increase in GDP. This factor is known as Total Factor Productivity. Let us try to understand it on the basis of an equation:

$$Y = A\ f(K,L)$$

Where Y is the output (GDP), K is the stock of physical capital invested and L is the labour (number of man-hours). The letter A stands for Total Factor Productivity.

Total Factor Productivity (TFP) as a concept is also important not only in the context of macro-economic aggregate measures of a country's performance in terms of per capita growth and productivity, but is of equal significance in measuring the determinants of productivity and competitiveness of firms. The hitherto more popular measure – labour productivity or value added per unit labour – suffers from the shortcoming that it does not reveal why the productivity has risen or vice-versa. Is it due to increased inputs of capital, or are there other causes? The TFP approach while analysing performance, attempts to go into the WHY of productivity changes and thus gives deeper insights into the underlying causes and sustainability of growth.

Productivity keeps on changing as production continues. It improves under favourable circumstances and deteriorates when unfavourable changes occur. The changes that lead to higher productivity of inputs are technological improvements, improvement in efficiency, increased education of labour, improvement in the quality of labour due to training, etc. Today, TFP is considered an important source of output growth worldwide due to rapid progress in science and technology and various efficiency-enhancing measures.

In the equation given above a higher value of A means that the same inputs lead to more output and vice versa. It shows how efficiently that input is being used to further the interests of the economy and it is the productivity of the capital and labour investment. Total Factor Productivity is considered to be the actual determining factor in the growth of an economy as both capital and labour cannot continue to be invested indefinitely. Moreover the growth of economy, if depended solely on capital and labour would decline as soon as these investments in these inputs are reduced and vice-versa. Thus it is not a stable growth. Hence increased Total Factor Productivity is the only way that an economy can maintain a stable growth.

Also, the Law of Diminishing Marginal Returns, tells us that a sustained influx of Labour and Capital will not achieve long term growth as the value of the inputs get maximised; they onset to deliver lower returns over a period of time. Thus the only way growth can be ensured and sustained is to maximise the efficiency of these inputs and to work on improving the quality and quantity of returns for the same amount of inputs i.e. to increase Total Factor Productivity.

Productivity is the main reason for economic growth. Some countries do better than others primarily because they are more productive. Also, the more productive a country is the better it is able to compete in the world markets as it can keep cost low while still producing a superior product. A high level of productivity also increases the standard of living of people in that country as they would get better outputs for the same inputs i.e. have better quality products at lower prices.

In order to conduct such an analysis, economists have built up a framework called growth accounting to obtain a different perspective on the sources of economic growth. Later we shall discuss that decomposing growth is essentially a growth accounting exercise. We start with a production function that tells us what output (Y_t) will be at some particular time t is a function of the economy's stock of capital (K_t), its labour force (L_t), and the economy's total factor productivity (A_t). If output changes, it can only be because of the change in the economy's capital stock, its labour force, or its level of total factor productivity. We are referring to the Cobb-Douglas form of the production function, which is:

$$Y_t = A_t\, f(K_t^{\alpha}, L_t^{1-\alpha}) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

In this equation we can see that we would get higher output because of three reasons – if more number of man hours are put in (higher L), if the people have more equipment, etc to work with (higher K) or if capital and labour are used more productively (higher A). The equation at (1) shows that it assumes perfect competition and the constant returns to scale as depicted by the coefficients of K and L. If we decompose the growth in output into each of the three elements allotting 1/3rd of the increase in growth to capital and 2/3rd to labour (which is what is seen in the most developed countries), the equation then becomes

$$Y_t = A_t K_t^{1/3} L_t^{2/3} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Taking logs the growth in output (Y) is shown by the following equation

$$\ln Y = \ln A + 0.33 \ln K + 0.67 \ln L \qquad \text{…………………(3)}$$

Where lnY is the growth in output, lnK is the increase in capital, lnL is the increase in labour and lnA is the increase in Total Factor Productivity (all these are for a particular time period)

We can also use this equation to calculate growth in output per worker i.e. Labour Productivity (Y/L). This can be written as

$$Y/L = A\,(K/L)^{1/3} \qquad \text{…………………(4)}$$

When we apply the growth in output formula to this equation, it becomes

$$\ln Y/L = \ln A + 0.33 \ln K/L \qquad \text{…………………(5)}$$

Where lnY/L is the growth in output per worker, $\delta(K/L)/(K/L)$ is the increase in the amount of capital per worker and $\delta A/A$ is the increase in Total Factor Productivity.

Thus equation (5) shows that the output per worker can rise because of two reasons - increase in Total Factor Productivity and increase in the amount of capital per worker.

So if we consider a real-world situation in which all three—the capital stock, the labour force, and total factor productivity are changing—then the proportional growth rate of output is as given in equation (3), which is the key. If we know the proportional growth rates of output, the capital stock, and the labour force, and if we know the diminishing-returns-to-scale parameter α in the production function, then we can use this growth-accounting equation to calculate the (not directly observed) rate of growth of total factor productivity A, and to decompose the growth of total output Y into (i) the contribution from the increasing capital stock K, (ii) the contribution from the increasing labour force L, and (iii) the contribution from higher total factor productivity A.

Since growth-accounting equation at (3) allows us to break down growth into components that can be attributed to the observable factors of the growth of the capital stock and of the labour force, and to a residual factor—often, in fact, called the Solow residual or a *measure of ignorance*—that is the portion of growth left unaccounted for by increases in the standard factors of production. Changes in the Solow residual or total factor productivity can come about for many reasons explained earlier. Economists often refer to total factor productivity as "technology," but if it is technology it is technology in the widest possible sense. Not just new ways of constructing buildings, newly-invented machines, and new sources of power affect total factor productivity, but changes in work organization, in the efficiency of government regulation, in the degree of monopoly in the economy, in the literacy and skills of the workforce, and in many other factors affect total factor productivity as well.

The approach that has been used here in the measurement of total factor productivity is the so-called growth accounting, which, although being simple with respect to the computation technique, leads to sufficiently illuminating results.

7.3 TECHNOLOGY AND GROWTH

In the growth models that you studied, particularly Harrod-Domar and the Solow model, the discussion was carried out in terms of how the output changed as a result of change in the level of input use. As more of labour and capital was used the output changed. We also discussed the important role of savings and investment. However, the production conditions do not stay the same. As technology improves, as technical progress takes place, inputs can be combined more efficiently. More output can be obtained from the use of the same level of input as before, or to produce the same amount of output as earlier, less use of input is needed. In this section we build upon the discussion in the previous section where we discussed growth accounting. In this section we discuss what we mean by technical progress and analyse how technology is an important determinant of economic growth.

You would have guessed by now that technical change has something to do with

improving the production process, and indeed so it is. We depict the change in technical level by looking at the production function. Let us suppose for simplicity that there is one single 'homogeneous' good in the economy. This good gets produced by using capital and labour. The simplest way to conceptualise technical progress is to understand that technical progress means that more output is produced using the same amount of inputs. If you visualise a production function, you can see that the production function shifting upward over time as technical progress takes place. Another way to look at technical change (improvement) is to say that the nature of the production function changed to a superior one, or that the same amount of output can be produced by using less of one or more factors than before.

The general way we have used to represent technical change as shifts in the production function (it may also be depicted as shifts in the position of each isoquant) can be expressed by bringing in time into the production function explicitiy. The production function now becomes:

$$Y = F(K, L, \boldsymbol{t})$$

The argument t is a production function shifter.

Although the above formulation is the most geileral way of depicting technical progress, there is another way of depicting technical change, where technical progress takes place through shifts in the production hilction even though the inputs used may not have increased. It is as though the factors of production were somehow augmented and they are able to produce more output than before.

To understand technical change, we have to bear in mind that there are several types of technical change. They have mostly to do with the capital-labour intensity, and by implication, on the relative shares of capital and labour in tile total product. This has repercussions on the remunerations of capital and labour, that is, on the wage rate and rental of capital. If the capital labour ratio capital intensity) goes up, it is called **capital deepening.**

Now let us begin our study of the classification of technical change, Before doing so, let us recall our discussion of factor augmented technical progress. We introduce **a** related concept here. Technical change can be **embodied** or **disembodied.** Embodied technical change means that technical change assumes the form in the change in the type of factor of production, usually capital. In other words, embodied technical change is embodied in the form of new types of machines (a new process or new technology).

Disembodied technical progress, on the other hand, means that regardless of the type of machines, new or old, the same amount of factors can produce greater amounts of output, or the same amount of output can be produced using lesser quantities of inputs; in other words, the isoquant shifts inwards. The factor augmenting technical change that we studied in the previous section is a depiction of disembodied technical change. For most of this unit, we will have occasion to consider disembodied technical change. Only in the final section do we touch upon embodied technical change, and once you grasp the concept, you will find greater use of the concept in some of the later units. In embodied technical change, investment in new equipment or new skill is the essential vehicle of improvements in technique.

Another concept with regard to technical change is neutrality. Neutrality broadly means that technical change is neither labour saving nor capital saving.

Sir John Hicks looked at technical progress in terms of the effect of technical change on the ratio of marginal product of capital to that of labour. If after the technical change the ratio increases, in Hicks's terminology it is to be called labour saving. If the ratio stays the same it is neutral and if the ratio falls, it is called capital saving. We can now state the Hicksian classification of technical progress in the following way: A technical progress will shift the per-worker production function upward. This technical progress is said to be **labour-saving** if at any given value of capital-labour ratio, the ratio of marginal product of capital to the marginal product of labour has increased. Ifthis ratio decreases for a given value ofcapital -labour ratio, the technical progress is said to be **capital saving,** and if the ratio stays the same it is **Hicks neutral.**

Sir Roy Harrod put forward a classification of technical progress which was different from Hicks's classification. He defined as neutral a technical change one where the capital coefficient (capital-output ratio) does not change in the presence of a constant interest rate. Broadly, he suggested that if, when the interest rate is constant, the distribution of the total national product between capital and labour stays constant, then it is neutral technical progress. If we consider perfect competition and take interest rate as equal to the rental of capital and hence equal to the marginal product of capital, then Harrod-neutral technical progress is a statement about the relationship between capital-output ratio and the marginal product of capital. Robert Solow's classification of technical progress is similar to Harrod's and Hicks's classification except in one respect. Hicks's classification compares points on different per-worker output curves at points of constant capital-labour ratio and Harrod's scheme compares points on different per-worker output curves at points of constant capital-output ratio. Solow's classification compares points on old and new per-worker production at points at which the labour-output ratio is constant. Thus Solow-neutrality is when at points where L/Y is constant that is, the relative shares of capital and labour remain constant. It can be shown that a Solow-neutral technical progress is capital augmenting.

7.4 CONVERGENCE

In this section we take a look at whether the growth rates and income levels of developing nations are converging to those of developed nations. The convergence hypothesis claims that the poorer economies' per capita incomes tend to grow faster than those of richer countries. The convergence hypothesis is also known as the 'catching up' hypothesis. The hypothesis is claimed on basis of the structure and results of the Solow growth, which you studied in unit 5. In this model, economic growth is driven by the accumulation of physical capital until this optimum level of capital per worker, which is the "steady state", is reached, where output, consumption and capital are constant. The model predicts more rapid growth when the level of physical capital per capita is low; this is sometimes referred to as "catch up" growth. As a result, all economies should eventually converge in terms of per capita income. Let us view the facts from history.

At the dawn of the industrial era, around the middle of the eighteenth century, average real living standards in the richest countries were no more than about three times as great as those of the poorest. However since the last two centuries, a huge gap has emerged in the living standards as well as the rate of growth in developed nations, and the developing nations. Today, the ratio of average real living standards of the rich countries to that of the poor approaches 100 to 1. Economist Lant Pritchett has called this phenomenon of the developed countries as a whole enjoying a far higher rate of growth than developing nations over the last two centuries as The Great Divergence.

The two centuries of exponential increase in productivity and incomes in early industrialising countries, and comparative stagnation in most other countries, led to the "Great Divergence." Some countries experienced almost no gains during this long period. Other countries were among those with the highest incomes throughout this period. Much later, incomes in many other countries where a majority of the world's people live began to rise; and then to start closing the gap, albeit often in fits and starts, and frustratingly slowly, by the turn of the twenty-first century. Yet many people, particularly in the least-developed countries, still have seen almost no improvements in living standards. Japan was the first non-Western country to begin to catch up. China and India, where more than one-third of the world's people live, began a period of high growth rates and entered the catch-up process by the early 1980s, (in the case of China) and early 1990s (in the case of India).

How did the enormous change happen? And why did the benefits go for so long only to people in a small part of the world? Why are some countries still making little progress? And how have many countries finally started to reconverge, in some cases dramatically? Initially, some of these riches were gained through the process of colonialism. But as time went on, an increasing majority of the gains resulted from the productivity advances of the Industrial Revolution.

About 250 years ago, the Industrial Revolution started in England. Production rose through the progressive application of steam power, water power, and other technical advances. Countries that industrialised early—in West Europe and North America—began a transformation that would lead to unprecedented gains in living standards. There emerged a huge difference in the level of technology available in Europe and that in other parts of the world. Europe also saw rise in commerce and trade, other than manufacturing. The process of divergence was underway.

There was a decolonisation wave from the years after World War II to the mid-1970s. There was a massive historical and geopolitical change. Yet for decades following independence of many developing, formerly colonized countries, several observers found it puzzling that most developing countries made rather little progress on productivity and incomes.

If the growth experience of developing and developed countries was similar, there are (at least) two important reasons to expect that developing countries would be "catching up" by growing faster on average than developed countries. The first reason is due to technology transfer. Many companies and governments actively seek to absorb new technologies; in fact, development assistance often attempts to facilitate this goal, particularly in fields such as public health. Today's developing countries do not have to "reinvent the wheel". They do not need to go through the process of technological evolution that today's developed nation did. This should enable developing countries to "leapfrog" over some of the earlier stages of technological development, moving quickly to high-productivity techniques of production. As a result, they should be able to grow much faster than today's developed countries are growing now or were able to grow in the past, when they had to invent the technology as they went along and proceed step by step through the historical stages of innovation. Economic historian Alexander Gerschenkron called this process the advantage of backwardness. In fact, if we confine our attention to cases of successful development, the later a country begins its modern economic growth, the shorter the time needed to double output per worker. For example, Britain doubled its output per person in the first 60 years of its industrial development, and the United States did so in 45 years. South Korea once doubled per capita output in less than 12 years, and China has done so in 8 years. The second reason to expect convergence if conditions are similar is based on diminishing returns to factor accumulation. Today's developed countries have high levels of physical and human capital; in a production function analysis, this would explain their high levels of output per person. But in traditional neoclassical analysis, the marginal product of capital and the profitability of investments would be lower in developed countries where capital intensity is higher, provided that the law of diminishing returns applied. That is, the impact of additional capital on output would be expected to be smaller in a developed country that already had a lot of capital in relation to the size of its workforce than in a developing country where capital was scarce. As a result, we would expect higher investment rates in developing countries, either through domestic sources or through attracting foreign investment With higher investment rates, capital would grow more quickly in developing countries until approximately equal levels of capital and (other things being equal) output per worker were achieved. However, , in practice, this does not always happen or happen quickly.

Given either or both of these conditions, technology transfer and more rapid capital accumulation, incomes would tend toward convergence in the long run as the faster-growing developing countries would be catching up with the slower-growing developed countries. Although it is unlikely that incomes would eventually turn out to be identical, they would at least tend to converge, conditional upon that is accounting for any systematic differences in key variables such as population growth rates and savings rates. As we have just seen, the evidence shows that divergence occurred for two centuries from the start of the industrial revolution. However, the most recent data demonstrate that, on average, (re-)convergence is now underway.

The encouraging convergence trend is not inevitable. Potentially, the trend could be reversed by new technological divides, climate change impacts in some areas, policies that are bad or serve narrow interest groups, and disasters of widespread armed conflict. Least-developed countries could remain stuck for other reasons. Further, these trends in convergence reflect country averages – they do not adjust for inequality or the presence of extreme poverty.

At the heart of the Solow model is the prediction of convergence, but convergence is of more than one type. The strongest prediction is called unconditional convergence. Suppose we postulate that nations, in the long run, have no tendency to display differences in the rates of technical progress, savings, population growth, and capital depreciation. In that case, the Solow model predicts that in all nations, capital per unit of labour will converge to a common value regardless of the initial state of each of these economies, as measured by their starting levels of per capita income (or equivalently, their per capita capital stock).

The exogenous parameters of the model are assumed to be equal, but the initial level of the capital stock or per capita income is not. The claim of convergence is then based on the Solow model: its content is that in the presence of similar parameters governing the evolution of the economy, history in the sense of different initial conditions does not matter.

Empirically, the assertion of unconditional convergence is even stronger. At the back of our minds we base such convergence on certain assumptions regarding the similarity of parameters across countries. However, there is no guarantee that these assumptions hold in reality, so if we were to find convergence, it would be a striking finding, not a trivial one.

Provided that all the parameters of the Solow model are constant across countries, convergence across countries is an implication of that model. Consider the obvious weak link in the prediction of unconditional convergence: the assumption that across all countries, the level of technical knowledge (and its change), the rate of savings, the rate of population growth, and the rate of depreciation are all the same. This notion certainly flies in he face of the facts: countries differ in many, if not all, these features. Although this has no effect on the Solow prediction that countries must converge to their steady states, the steady states can now be different from country to country, so that there is no need for two countries to converge to each other. This weaker hypothesis leads to the notion of conditional convergence.

In the literature on economic growth, the term 'convergence" is sometimes used in two senses. In the first sense, convergence is taken to mean a reduction in the dispersion of levels of income among nations. This is called σ (sigma) convergence. The other sense is called β (beta) convergence. Beta convergence means poor economies grow faster than richer countries. Conditional β convergence takes place when economies experience β convergence, but conditional on other variables being constant. Unconditional β convergence is said to occur when the growth rate of an economy declines as it approaches its steady state.

Check Your Progress 1

1. Explain the meaning of growth accounting.

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2. What do you understand by total factor productivity?

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3. Explain Hicks-neutral and Harrod-neutral technical progress

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4. Explain the concepts of:

(1) Unconditional and conditional convergence and

(2) Sigma and beta-convergence.

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7.5 OTHER DETERMINANTS OF GROWTH

In the earlier sections, we have looked at some factors that determine growth, like accumulation, improvements in total factor productivity, technology and technological advance. Here we would like to look at some other factors. Some factors like human capital were considered in unit 6 on endogenous growth theory. Some other important factors like impact of international trade and finance on growth will be taken up for discussion in the subsequent course on development economics.

Most of the economic determinants of growth, like factors of production, accumulation, technology, productivity growth, and so on, have been viewed by some economists as proximate causes. However, these economic determinants may themselves be influenced and impacted by underlying basic causes, some of which may be non-economic. In this section we study some of these.

7.5.1 Institutions

In recent times institutional economics has assumed considerable importance in the analysis of developing nations.. Recently, the analysis of exchange using tools of microeconomics has been sought to be supplemented by institutional analysis. Even in the study of economic growth, the study of institutions has assumed importance. . We have studied several theories of growth. We saw recently there has emerged a group of theories that see growth as determined by processes that are endogenous. There are differences in factors and endowments among nations, and this is supposed to explain the differences in economic growth of nations. Some economists have suggested that the factors which are supposed to cause economic growth, which are endogenous, are themselves not the causes of, or explanations of growth. They are actually the characteristics or features of growth. The main reason for differences in growth performance is differences in the structure of institutions in various countries. Institutions and differences in them can account for large differences in the performance of countries.

What are institutions? Douglass North, a Nobel Prize winner in economics defines institutions by referring to them, as "the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction." He suggests that institutions shape the constraints in interactions among people. These interactions may be economic, social or political. Economic institutions such as property rights and the degree of perfection of markets influence the structure of economic incentives in society. Economic institutions also determine how efficiently allocations will be allocated in society. Thus it is important to realise that not only are institutions important but also that they are endogenous.

One new strand in economic thought looks at changes in property rights and transaction costs having a great impact on economic development. This view is exemplified by the works of Ronald Coase and Douglass North. Another strand has sought to use the recent developments in information economics, like asymmetric information, imperfect information, moral hazard, adverse selection, signalling and screening, to understand how institutions affect development. They see institutions as filling in gaps in the economy created by missing and incomplete markets, presence of risk, and asymmetry of information. They have used this, for instance, to model agrarian institutions, for instance on these lines. This is seen in works of economists like George Akerlof and Joseph Stiglitz. Interestingly, all four economists have won the Nobel Prize.

The transaction costs school contends that as transaction costs change, institutions emerge to minimise these transaction costs. This is the basis of development. Transaction costs include costs of negotiation, monitoring, coordination, and enforcement of contracts. When transaction costs are high, allocation of property rights becomes crucial. Contracts come to be determined by property relations when transaction costs are high. In the development process there may emerge a trade-off between economies of scale and transaction costs. In simple face to face interaction transaction costs may be low but production costs are high because specialisation and division of labour is limited. The transactions cost school also believes that changes in relative prices cause institutional changes.

The information economics school cast their theories in more rigorous terms and explicitly bring in notions of equilibrium. In addition, institutional quality affects the amount and quality of investments in education and health, via the mediating impact of inequality. In countries with higher levels of education, institutions tend to be more democratic, with more constraints on elites. The causality between education and institutions could run in either direction, or both could be caused jointly by still other factors. It is important to understand why and how a certain institution emerges, and what purpose it may be serving. Even an institution that appears to be negative may be serving some purpose. It is important to realise this to explain its persistence. The institution may not be optimal, indeed, may be dysfunctional and may still persist. It is necessary to observe if there are regularities in the evolution of institutions, as this gives rise to conventions.

7.5.2 Geography

At first glance, geography seems to have had a major influence on development. It is perhaps not a coincidence that many of the poorer nations are situated around and near the Equator. Very hot climate saps the energy to work, so workers' productivity is affected. Low productivity leads to low income, and many of low-productivity workers may not be able to afford adequate amount of nutritious food. Low nutrition levels can further diminish productivity.

Moreover, geography also influences economic development through the factor of location. Geographical factors may lead to industries and factors to be located, or not to be in productive regions. Similarly agriculture, urbanization and some other aspects of the economy can also be affected by geographical condition.

Economists have started paying greater attention to geographical factors.. First, in the very long run, very few economists doubt that physical geography, including climate, has had an important impact on economic history. Geography was once truly exogenous, even if human activity can now alter it, for better or worse. But the economic role played by geography, such as tropical climate, today is less clear. Some research suggests that when other factors, notably inequality and institutions, are taken into account, physical geography adds little to our understanding of current development levels. However, some evidence is mixed. For example, there is some evidence of an independent impact of malaria and indications that, in some circumstances, landlocked status may be an impediment to economic growth. Indeed, a direct link from geography to development outcomes is argued by some economists,

7.5.3 Culture

Cultural factors may also matter in influencing the degree of emphasis on education, postcolonial institutional quality, and the effectiveness of civil society, though the precise roles of culture are not clearly established in relation to the economic factors

The idea that culture is a determinant of national wealth is an old one. Sociologist Max Weber had argued that the rise of a "Protestant ethic," which celebrated hard work and the acquisition of wealth, led to an explosion of economic growth in northern Europe starting in the 16th century. More recently, economists have pondered over whether the rapid growth of such countries as Taiwan, Singapore, and South Korea can be explained by their adherence to "Asian values,"a term coined by *The Economist* magazine in 1980. Despite these examples, however, economists have generally not seen culture as a determinant of development, contrary to anthropologists, sociologists, and historians. Economists do not wish to analyse culture as it is hard to quantify.

If we have to show that culture is important for economic growth, we have to show first that culture has potentially important aspects that vary among countriesand second, that these aspects of culture significantly impactt economic outcomes. Both these things are difficult to show as culture is hard to measure. Not only doesculture have many different dimensions, but even when we restrict ourselves to a single aspect of culture, we often lack any objective (much less quantitative) measure and have to rely on the observers' subjective assessments. Similarly, in some cases there is direct evidence of culture's economic effects, whereas in othercases such effects can only be inferred.

We can just touch upon a few aspects of culture and how it influences economic growth. Some individual aspects of culture: openness to new ideas, belief in the value of hard work, saving for the future, and the degree to which people trust one another. Some broader characterizations of culture could be social capital, conventions and so on. These broader characterizations will be discussed on the subsequent course on development economics. Let us discuss some individual characteristics:

1. **Openness to new ideas**: Scholars who have examined the historical process of economic growth have of- ten stressed the importance of a society's openness to importing new ideas from abroad. Many of the technologies used in any particular country were invented in other countries, so a country that more readily adopted technologies from abroad would be more technologically advanced.
2. **Hard work**: Throughout human history, in every culture, almost all adults have had to work to survive. But cultures have differed in their view of that work: as a necessary evil or as an activity with an intrinsic value. We would expect that in cultures where work was viewed as good in and of itself, people would work harder and produce more output.
3. **Saving rate:** A country's economic growth is strongly affected by its saving rate. We also saw that there are large differences in saving rates among countries. If cultural differences among countries affected their saving rates, then these differences could in turn affect the level of economic growth.
4. **Trust:** Economic interactions often involve reliance on a person to keep his word. Without trust, economic activity would be reduced to a crude level, and huge resources would have to be devoted to making sure that people came through on their promises. Society would lose the advantages gained by creating complex organizations—for example, allowing people to specialize in specific tasks or exploiting gains from trade. Obviously, a society in which one could not rely on others to hold to their commit- ments would be poorer.

7.6 PATH DEPENDENCE

We have studied in an earlier section that one of the issues in economics of development is whether nations converge to a common growth rates. Statements about convergence tend to include propositions about parameters like investment and saving and their relationship with growth. We saw in the previous section that institutions too have a profound impact on the development process. We can now ask, is history itself important? What if a country's history itself, coupled with people's expectations about the future, determines not only the institutional framework but also the parameters of the growth process like saving and investment? We are looking at the persistence of certain patterns over long periods and asking why is such persistence present? People often speak of 'historical forces'. The question is, how do we take these into account? One view is that the course of economic development is determined to a considerable degree on the earlier choices that were made, the basic *path* that was chosen. The development process is path dependent. Path Dependence theory postulates that when we consider the performance of an economy, its position at a certain point of time depends on the whole sequence of events. The whole path is important. We need to look at the entire history of the process.

Some economists have put forward the suggestion that certain inferior outcomes may have got locked-in by historical events. You have studied in the microeconomics course that equilibrium is usually the result of economic agents choosing actions and making decisions while acting rationally by maximizing some objective function. Such equilibria are optimal. However, in reality some inferior outcomes can sometimes emerge and, moreover, may persist. It is these situations that path dependence theory addresses. The question it asks is Why do these situations arise, and how? Moreover, why do they sometimes tend to continue? Why do rational decision- makers who are supposed to make optimal choices not take corrective measures? The interesting thing is that these inferior outcomes emerge even when superior alternatives exist and are available.

One way how this works is through complementarities and network externalities. We shall explain these concepts with some examples from technology. The common typing keyboard layout in typewriters and computers usually has the letters Q, W, E. R. T. Y.... on the top row and this is called a QWERTY-type keyboard. Now, the earliest typewriters were mechanical gadgets where, when a key was struck, a lever with the imprint of the letter would rise and strike the typewriter ribbon that, because it contained the fluid or the ink, the letter would form on the page. If two or three keys were hit with quick succession the lever would jam. The QWERTY keyboard was designed in such a way as to minimise the possibility of such jamming by placing the keys that were likely to be struck in quick succession in terms of spelling of words of the English language were placed far apart. Thus the QWERTY keyboard was designed to slow down speed. An alternative keyboard design introduced in 1932 was realised to be better at promoting speed when it was found that typists trained in the Dvorak system were regularly beating typists trained in the QWERTY system at speed typing tests. The question is, why do we then find the inefficient QWERTY-type layout in most keyboards? The answer is that the QWERTY layout had a historical advantage of emerging first. Given that firms and organisations hired typists coming out of typing schools. Given that these typists were already trained in QWERTY-type keyboard, any *individual* firm would have found it very costly to invest in retraining its typists on the Dvorak system. There is now a clear divergence between individual costs and social gains. This occurs in this case because there are complementarities and network externalities. Externalities take the special form of network externalities because of the complementarities. Let us explain further what network externalities mean. You have already read in the section of market failure what externalities are. Network externalities mean that the cost or benefit of adopting a technology or product depends on how many people already adopted the same technology or product. Say you plan to buy a mobile phone, because among other uses, you think that sending and receiving SMS messages would be very useful. But if only two or three other people whom you know have a mobile, this feature is not going to be too useful. Surely, the more of your friends and acquaintances already have a mobile, the more useful it would be to you. This is an example of network externalities. This is very important in Information and Communication Technology(ICT) like e-mail.

So, to come back to the QWERTY example, we find that complementarities and network externalities create a situation where a suboptimal choice is made and it tends to persist. The important thing to realise is that if we were to look at the average cost (AC) curves (recall from your microeconomics course what these look like) of the Dvorak system and the QWERTY system, we will find that the Dvorak system, because it is more efficient, will have its curve downward sloping, and everywhere below the AC curve of the QWERTY system, which would of course be downward sloping because of scale economies. But for an individual firm which wants to make a switch from QWERTY to Dvorak, the relevant costs (in the two curves) to be compared are at different points corresponding to the horizontal axis, which measures the number of units (typists trained). On the QWERTY curve, the point is far too much to the right since QWERTY has been around for a long time and many typists with QWERTY type training are there. To switch to Dvorak system, we have to consider a point close to the origin on the horizontal axis, because it will be first typist for the individual firm .so this point, on the Dvorak curve will be too much to the left and be of higher average cost than the QWERTY point.

Although some economists and historians of technology do not agree that the QWERTY system is inefficient as compared to the Dvorak system, the basic idea should be clear. There are other such examples. In the 1980s, the format for videotapes chosen was the VHS although the Betamax system was demonstrably superior In computer software, although other operating systems may be available, and may even be superior or cheaper or both, because of complementarities and network externalities, Windows operating system has become the standard. Similarly in the case of microprocessors, although other chips like AMD and RISC chips are available, Intel chips have become the industry standard. The upshot of the discussion is that we find that because of complementarities and network externalities, there may be multiple equilibria.

Which equilibrium gets chosen—and it may be the inferior one, depends on the path chosen by history. When complementarities are present, there may occur historical lock-ins. the same idea can be understood in terms of widespread coordination failure where large-scale investment does not take place because other complementary investments are not forthcoming. Because of coordination failure, each investment is not made because other complementary investments are not made. Investments would be made if each investor expects others to invest. Coordination then depends on the expectations of investors. The problem of coordination can be solved to a great extent if linkages can be created among various sectors of such a developing economy

Check Your Progress 2

1. What are institutions? Discuss some ways in which institutions determine economic growth.

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2. How do geographical factors influence growth?

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3. How do individual aspects of culture impact economic growth?

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4. Explain the concepts of path dependence and historical lock-ins.

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7. 6 LET US SUM UP

This unit was the last unit in this Block, which dealt with economic growth. The first four units had focused on various theories and models of growth, while the current one extended the discussion of the previous four units and sought to identify the actual determinants of growth.

The unit began by discussing growth accounting. This allows us to break economic growth down into the proportion that is caused by individual factors of production like labour and capital, and the proportion that can be attributed to technological growth. Proceeding ahead, you learnt about the nature of technology. The unit explained what is meant by embodied and disembodied technical progress. You were also acquainted with neutral and non-neutral technical progress. The unit went on to discuss the idea of total factor productivity, and how productivity is related to efficiency.

Following this, the unit discussed the very important concept called convergence. In unit 2, you had learnt about development gap between rich countries and developing nations. This unit examined whether the developing countries are catching up with the rich ones. The unit explored the idea of whether faster rates of growth of developing countries as compared to the developed ones will lead to the convergence of growth rates. The unit discussed about the concept of relative and absolute convergence..

Finally, the unit briefly discussed certain other determinants of growth. These are largely non-economic in nature like institutions, geography, and culture,. The unit suggested that these are often underlying factors that may influence economic determinants of growth, and as such may be considered as indirect, albeit underlying determinants of economic growth.

7.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1. See section 7.2
2. See section 7.3
3. See section 7.3
4. See section 7.4

Check Your Progress 2

1. See sub-section 7.5.1
2. See sub-section 7.5.2
3. See sub-section 7.5.3
4. See Sub-section 7.6.4