UNIT 1 INTRODUCTION TO ECONOMIC GROWTH

Structure

1.0 OBJECTIVES

The goal of this unit is to understand the concept of economic growth and examine how different countries have performed in terms of their growth over the years. After going through the unit you would be able to :

- Define the concept of economic growth;
- Contrast between economic growth and economic development;
- Describe the growth performance of the world economy; and
- Explain the importance of the study of economic growth.

1.1 INTRODUCTION

> *The question of growth is nothing new but a new disguise for an age-old issue, one which has always intrigued and preoccupied economics: the present versus the future*
>
> *- James Tobin*

If you speak to your parents and grandparents about their life when they were young, you will find that your standard of life is much higher than theirs. The material standards of living have substantially improved for most of the people in the last few decades in most countries. This improvement in standard of living has come from rising levels of incomes and which has made it possible for people to consume higher quantities of goods and services as well as they are of better quality.

Economists have always known that growth is an essential ingredient for economic development. Economic growth and change are part of the normal experience of economic life of societies. This course attempts to explain how economic theory can be used to gain better understanding of the process of economic growth and change. Though there are no universal laws which govern the process of economic growth but there are many economies that face a relatively small set of dominating constraints on their process of growth and structural change. While economics by itself cannot offer a satisfactory explanation of either particular historical experiences

or some general phenomena, such as technical progress, it can offer valuable insights into the fundamental process of growth in these economies (Chaudhuri, 1989, p 1).

Paul Romer (1996) has tried to explain the process of economic growth using an interesting analogy. In his words, '*Economic growth occurs whenever economic agents take resources and rearrange them in ways that are more valuable. A useful metaphor for production in an economy comes from the kitchen. To create valuable final products, we mix inexpensive ingredients together according to a recipe. The cooking one can do is limited by the supply of ingredients, and most cooking in the economy produces undesirable side effects. If economic growth could be achieved only by doing more and more of the same kind of cooking, we would eventually run out of raw materials and suffer from unacceptable levels of pollution and nuisance. Human history teaches us, however, that economic growth springs from better recipes, not just from more cooking. New recipes generally produce fewer unpleasant side effects and generate more economic value per unit of raw material*'. Each successive generation tends to perceive the limits to growth that finite resources and undesirable side effects would pose if no new recipes or ideas were discovered. But every generation has also underestimated the potential for finding new recipes and ideas. Human beings consistently fail to grasp how many more ideas are yet to be discovered. Possibilities do not add up, they multiply with time and people as they interact.

1.2 WHAT IS ECONOMIC GROWTH?

Today economic growth is everybody's concern and in such a milieu growth process and growth theory has received particular attention of economists and policymakers. Yet surprisingly, there is no universally acceptable definition of the term. Different economists have used the term 'economic growth' to convey different meanings.

In very simple English 'economic growth' occurs whenever people take resources and rearrange them in ways that are more valuable to the society. Economic growth may be defined as a rate of expansion that can move an underdeveloped country from a near subsistence mode of living to substantially higher levels in a comparatively short period of time, i.e. in decades rather than centuries. Historically, rapid economic growth has been accompanied by greater industrialization. But more precisely the process of economic growth can be described in terms of greater commercialisation of economic activities. Though this concept is correct in essence, it lacks precision and makes its measurement difficult.

Economic growth Defined: A simple definition is that it is an increase in the level of output of goods and services that is sustained over a long period of time, measured in terms of value added.

Process of economic growth is essentially a dynamic concept and refers to a continuous expansion in level of output, i.e. it refers to forces that generate a positive rate of change over time and not the forces that lead to discrete (or one shot) change from a lower to higher level of output which are temporary and short lived.

The term output expansion, however, is subject to ambiguity in the sense that does it mean growth in total output or growth in output per capita. An increase in the former is referred to as 'extensive' growth whereas an increase in the latter is called the 'intensive' growth. The latter one is important in the context of increase in the standards of living of the population of the country whereas the former is extremely significant when one wants to examine the aggregative phenomenon such as economies of scale etc (Chaudhuri, 1989, p. 2).

Here distinction needs to be made between level of output and output capacity. Most growth theories implicitly deal with changes in output capacity, whereas actual changes in output over time are influenced by the ability of an economy to utilize the existing capacity effectively. In this context it is important to keep in mind that for a particular economy, growth of output at two points in time may be significantly

influenced by different degrees of utilisation of capacity for relevant periods. In the analysis of long term one cannot ignore the effects of the short run completely.

Another important issue in the context of growth process is the incorporation of the changes in the quality that tends to be integrated part of the growth process. Factor as well as commodity markets both are characterised by theses changes. For instance in the commodity markets economic growth leads to not only increased output but also to newer and, many times, better products. In the factor markets economic growth brings improvements in skills of workforce and/or more efficient and/or safer types of machinery. The process of economic growth may also lead to changes in the form of economic activity which referred to as structural shift in the economic structure of an economy. This means that the economy moves away from being largely rural and agriculture based to urban and industry dominated. The most fundamental change by far that economic growth creates is the widening of range of choices that become available to an economy. Economic growth creates the potential for the society to usher in healthier, better educated population and improve the quality of life for its citizens. Here it must be kept in mind that the current state of theories of economic growth is far from adequate in incorporating the qualitative aspects of the phenomenon of economic growth (P. Chaudhuri, 1989, p. 3).

1.3 ECONOMIC GROWTH AND DEVELOPMENT: A CONTRAST

As discussed above, in the recent literature the term *economic growth* refers to increases over time in a country's real output of goods and services. Output is generally measured by gross or net domestic product (GDP or NDP), though other measures can also be employed. The term *economic development*, in contrast, is much more comprehensive. It implies progressive changes in the socio-economic structure of a country. Viewed in this way, economic development involves a steady decline in agriculture's share in the GDP and a corresponding rise in the share on industrial sector as well as of the economic (productive) services. This transformation in the economic structure is invariably accompanied by a shift occupational structure of labour force and an improvement in its skill and productivity.

Compared to the objective of development, economic growth is far easier to realise. This is because process of development is far more pervasive. Apart from a rise in output, it involves changes in the composition of output as well as a shift in the allocation of productive resources so as to ensure social justice.

Many times in the discussions we tend to use growth and development interchangeably. A growth in the real income is supposed to contribute to general rise in the standard of living of the people in general. But growth and development need not be the same. The average per capita income figures are derived by dividing total real income by the population of the country. But it does not say anything about the distribution of income, occupational structure, share of agriculture and industry in economic activity (Ghatak, 2003, p. 23).

Check Your Progress 1

1) What is the definition of Economic Growth?

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2) What is the difference between economic growth and economic development?

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3) How is 'extensive' economic growth different from 'intensive' economic growth?

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4) Which is a better indicator for assessing the growth performance of an economy and why?

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1.4 GROWTH PERFORMANCE OF THE WORLD ECONOMY

From the earliest historical times until around the beginning of the 19th century, the number of people in the world and the volume of goods and services they produced grew at roughly equal and slowly increasing rates. The living standards of ordinary people in the 18th century Europe were about the same as those of people in contemporary China or ancient Rome or of people in the poorest countries in the world today. Then during the last two centuries, both production and population growth accelerated drastically with production growth outpacing the growth in population. It was for the first time in history that living standard of the ordinary people began to undergo sustained growth. This was made possible by the rapid economic growth in the world economy in this period

In 1800, incomes per capita differed by perhaps a factor of two between the richest and poorest nations. It was to explain this difference in income that Adam Smith undertook the task of writing *Wealth of Nations*. Today the difference between the per capita income of the richest and poorest country is about 300 times (see Table 1.1). This gives the indication of how little we know about growth dynamics and much more we need to stress on study of the process of economic growth.

Economic growth in the second half of the twentieth century has been miraculously different from any earlier period in history that our previous generation may find it difficult to believe it. Production in the world as a whole grew at more than 4 per cent per year whereas the population grew at around 2 per cent. The real income of an average person has more than doubled since the World War II

The growth in per capita income has been uneven across countries over the years. Some countries have grown at very fast pace while others have lagged behind. In any given year, one could observe large differences in the standard of living among countries. Table 1.1 shows GDP and GDP per capita in the world's 22 countries across different continents in 1990 and 2000. As we can see from this table that China's has grown at the fastest rate of over 10 per cent per annum in the nineties. India has also grown at a relatively fast pace in this period of around 6 percent. Although India's growth is much slower than that of China's as also the population growth in India's higher than that of China's. Due to this the per capita income has grown at even slower pace in former. The highest per capita are Japan and the U.S. with per capita GDP of US $ 36828 and 35046 respectively.

Table 1.1: GDP and GDP per capita across countries – 1990 and 2000

↓Countries	**G.D.P.** ($ million)	**GDP** per capita ($)	**G.D.P.** ($ million)	**GDP**-per capita ($)	**CARG* GDP**
Year →	**1990**		**2000**		**1990-2000**
Ethiopia	4020.7	78.9	6304	99	4.6
Kenya	8456.6	357.3	10410	347	2.1
Pakistan	42885.2	397.8	61673	447	3.7
India	**267696.7**	**314.9**	**479404**	**472**	**6.0**
China	**405182.0**	**354.9**	**1079954**	**856**	**10.3**
Egypt	62716.6	1194.5	98333	1537	4.6
Iran	69501.4	1272.8	98990	1547	3.6
Tanzania	6865.0	266.1	9316	274	3.1
Namibia	2327.8	1489.9	3479	1740	41
Russia	410642.0	2756.9	251092	1720	-4.8
Brazil	441462.0	2984.2	587553	3456	2.9
South Africa	103271.2	2927.6	125887	2928	2.0
Korea, Republic	262648.2	6172.9	457219	9728	5.7
New Zealand	37192.0	10372.9	49983	12496	3.0
Sweden	190218.8	21996.2	227369	25263	1.8
United Kingdom	1104170.8	19152.4	1413432	23557	2.5
Japan	4110381.3	33349.4	4677099	36828	1.3
France	1086717.2	19169.1	1286252	21801	1.7
Germany	1611434.9	20249.2	1870136	22807	1.5
Australia	263641.8	15633.8	394023	20738	4.1
Canada	518097.4	18461.3	689549	22244	2.9
United States	7074185.8	28263.9	9882842	35046	3.4

Note: CARG* refers to compound annual rate of growth.

Source: *World Bank, World Development Report, 1992, 2002, and 2004.*

In the following table we could see the performance of different countries across different categories: High income and low income countries over last four decades. As we can note from the Table 1.2 here also China has been the best performer in this period followed by South Korea and Taiwan. India is also among the high growth countries in the developing world though not growing as fast due to various reasons. The performance of China and India in the last few years has improved further which gets reflected in the previous table (as discussed earlier). There is no doubt that this performance is far superior to many of the countries in the developing world which have contracted in this period, prominent ones being Congo, Sierra Leone, and Niger.

Table 1.2: The growth of per-capita GDP for high-income industrial countries, high-growth LDCs, and low-growth LDCs, (1980–1999)

High-growth *LDC*s		High-income Countries		Low-growth *LDC*s	
China	8.2	Japan	2.2	Congo (Zaire)	-4.7
South Korea	5.8	Australia	2.1	Sierra Leone	-3.5
Taiwan	5.3	United States	1.9	Niger	-2.5
Singapore	4.8	United Kingdom	1.9	Haiti	-2.2
Thailand	4.7	Italy	1.8	Côte d'lvoire	-2.2
Ireland	4.4	Netherlands	1.8	Zambia	-2.0
Hong Kong	3.9	France	1.6	Madagascar	-1.8
India	3.7	Germany	1.5	Nicaragua	-1.8
Malaysia	3.7	Canada	1.4	Central African Republic	-1.3
Chile	3.6	Switzerland	0.9	Nigeria	-1.1

Source: World Bank, *World Development Indicators, 2001*; and Republic of China, *Statistical Yearbook of the Republic of China, 2000*.
NOTE: Only countries with a population of 2 million or more in 1999 are included.

The Table 1.3 further goes in details of growth performance and examines the level of GDP and GDP per capita for these economies from 1950 to 1998, almost half a century. The subdivision of the periods are 1950, 1973 (first oil-shock period), 1990 (spurt in globalization process), and 1998. These numbers are taken from Maddison (2003). We can see in the Table that South Korea, Japan, and China have experienced the fastest growth in terms of GDP as well as GDP per capita from 1950-1998. This data is not for the latest year as the methodology adopted by Maddison (2003) is different as compared to others such as the World Bank. Therefore, the Tables 1.1 and 1.2 are not comparable.

Table 1.3: GDP and GDP per capita across countries – 1950 and 1998

Countries	**G.D.P.** ($ million)	**pcy***	**G.D.P.** ($ million)	**pcy***	**G.D.P.** ($ million)	**pcy***	**G.D.P. ($ million)**	**pcy***	**CARG-GDP**	**CARG-pcy**
	1950		**1973**		**1990**		**1998**		**1950-1998**	
Ethiopia	5394	250	13640	401	18964	372	24883	400	3.24	0.99
Kenya	3982	653	12107	961	26093	1101	30451	1075	4.33	1.04
Pakistan	25366	643	67828	954	182014	1598	261497	1935	4.98	2.32
India	**222222**	**619**	**494832**	**853**	**1098100**	**1309**	**1702712**	**1746**	**4.33**	**2.18**
China	**239903**	**439**	**740048**	**839**	**2109400**	**1858**	**3873352**	**3117**	**5.97**	**4.17**
Egypt	15224	718	36249	1022	112873	2012	140546	2128	4.74	2.29
Iran	28128	1720	171466	5445	199819	3586	274695	4265	4.86	1.91
Tanzania	3362	378	9007	588	13852	556	16933	553	3.43	0.80
Namibia	1002	2159	2895	3484	4619	3278	6158	3797	3.86	1.18
USSR*	510243	2834	1513070	6058	1987995	6871	1132434	3893	1.67	0.66
Russia			872466	6577	1151040	7762	664495	4523	-0.77	-1.06

Brazil	89340	1672	401643	3882	743765	4924	926919	5459	4.99	2.50
South Africa	34465	2534	102498	4167	147509	3965	165239	3858	3.32	0.88
Korea, Rep	16045	770	96794	2841	373150	8704	564211	12152	7.70	5.92
New Zealand	16136	8493	37177	12518	46729	13825	56322	14822	2.64	1.17
Sweden	47269	6738	109794	13488	151451	17672	165385	18688	2.64	2.15
United Kingdom	347850	6907	675941	12023	944610	16411	1108568	18714	2.44	2.10
Japan	160966	1926	1242932	11334	2321153	18795	2581576	20413	5.95	5.04
France	220492	5270	683965	13123	1026491	18092	1150080	19558	3.50	2.77
Germany	265354	3881	944755	11965	1264438	15925	1460069	17799	3.62	3.22
Australia	61274	7491	172314	12764	291180	17028	382335	20337	3.89	2.10
Canada	102164	7436	312176	13838	524475	18934	622880	20559	3.84	2.14
United States	1455916	9561	3536622	16689	5803200	23214	7394598	27331	3.44	2.21

Source: Maddison, 2003. NOTE: pcy* refers to GDP per capita.

As for the performance of Indian economy is concerned, over the years, it has been growing steadily. The real GDP of India in 2003/04 was Rs. 1567399 crores which is more than 10 times its 1950 level, and the real GDP per person in 2003/04 was Rs. 14607 which is more than 3.5 times what it was in 1950[i] (RBI, 2004[ii]). Compared to the pre-Independence period, it has been impressive performance but as we saw above it is far from satisfactory and well below the best performing economies in our close neighbourhood.

1.5 WHY STUDY THE PROCESS OF ECONOMIC GROWTH?

What is it about the economic growth that we need to spend so much time in studying the economic growth process in details? There could be various reasons for doing so. Some of the important ones are as follows:

1) It enables us to gain a better understanding of an important historical process. For instance we may want to understand

   a) Why Britain was the first country to industrialise? Or

   b) Why even after having the head start Britain has fallen behind the United States, Germany and Japan and, more recently, to many other west European countries?

   c) Why economic growth has been concentrated in the relatively small part of the world economy of Western Europe, North America and parts of Asia?

   d) What were the reasons for rapid economic growth of the East and South East Asian economies for almost three decades and what about China in last two decades – that seems to have outshined all previous growth experiences and showing no signs of slow down?

   Economic theory of growth is essential for answering all these questions though it may not be sufficient. This is because the growth theory has not developed adequately to explain some important phenomenon like technical progress or the welfare consequences of growth.

2) It may also be because the historical experience of each of the economy has some unique characteristics which involve forces some of which may not be possible to duplicate in another economy. Economic theory, in these circumstances, can suggest some hypotheses while rejecting the others, as to

why growth occurs at different rates at different times across countries. In the process it can also identify some strategic variables in the process, such as increases in agricultural productivity, or rate of capital accumulation etc. More on these and related issues will be discussed in the later Units in this course.

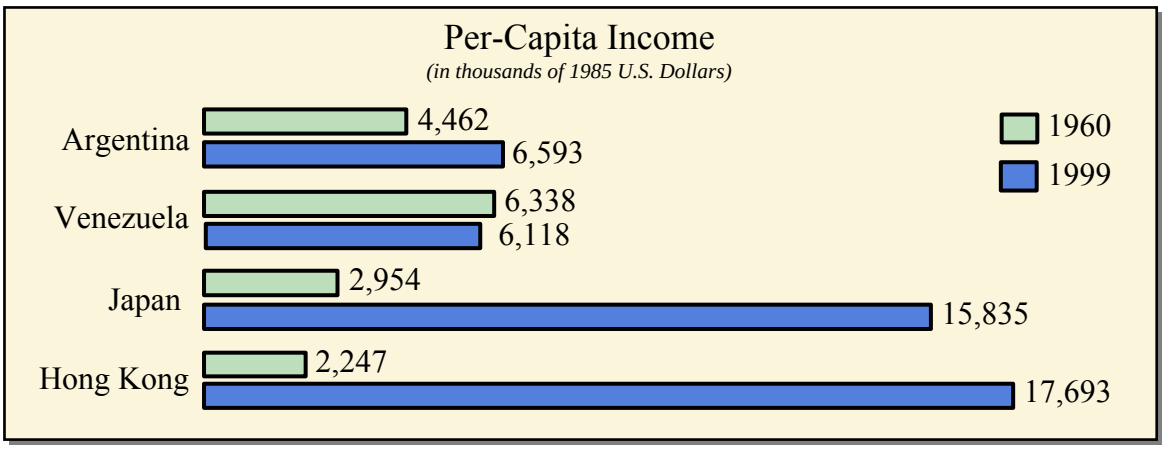
3) It may also be because the historical experience of each of the economy has some unique characteristics which involve forces some of which may not be possible to duplicate in another economy. Economic theory, in these circumstances, can suggest some hypotheses while rejecting the others, as to why growth occurs at different rates at different times across countries. In the process it can also identify some strategic variables in the process, such as increases in agricultural productivity, or rate of capital accumulation etc. More on these and related issues will be discussed in the later Units in this course.

4) Understanding of economic growth process may help *in formation of economic policy*. In the sphere of policy it is not always possible to make a distinction between short and the long run. For instances short run policies to stabilise and economy may have quite different long term ramifications, whether it is exchange rate or monetary or fiscal policies as they have differential impact on the consumption and investment in the economy. One of the reasons why Keynesian policies[iii]: were so popular across the world was that it identified rate of investment as a key policy variable but it proved to be inadequate because it was not able to offer any potential relationships between productivity and real wages.

1.6 THE IMPORTANCE OF ECONOMIC GROWTH

The relationship between wealth resulting from rapid growth and happiness is difficult to establish. As there is no unambiguous evidence that rich are happier than the poor, or that individual grow happier as their incomes increase. In so far as economic growth results from alertness in seeking out and seizing economic opportunities, it is to be expected that it should be associated with less happiness. There is some evidence to suggest that a far higher level of psychological dissatisfaction in the U.S. and Japan – country with one of the highest level of per capita income–than there is in most of the low income economies of Asia and Africa.

Cross country differences in growth rates over a few decades substantially alters relative income. From 1960-1999, per capita income growth in Argentina and Venezuela was 1% and - 0.1% respectively. In the same period, the growth rates of Japan and Hong Kong were at much higher level of 4.4% and 5.4% respectively. Note how the rapid growth rates of the two Asian economies dramatically altered their relative incomes compared to the other two economies.



Source: *Robert Summers and Alan Heston, Penn World Tables*

Besides there are many more advantages of the process of growth. Some of these are listed below:

1) The advantage of economic growth is not that it increases happiness but it creates potential for wider range for human choice (tangible as well as intangible). In other words economic growth gives us freedom to enjoy greater leisure or more material wealth (in form of goods and services) or some combination of the both. In poor countries around 50–70 per cent of population works in agriculture to feed everyone whereas in rich countries less than 10 per cent are enough to do the job. So, in the latter countries there are much larger number of people who are available for other activities (such as medical science, education, scientific research, entertainment etc.). So, economic growth makes it possible to release people from basic task of growing food to more complex and interesting economic activities.

2) Rapid economic growth is one of the important instruments to resolve social tensions which tend to result from different segments of populations trying to extract more and more than already have, e.g. workers asking for higher wages, better housing, education, health and other amenities. If the level of income in the economy is stagnant then desires of one group could be met only at the cost of the other groups which tend to cause social conflicts. Through rapid economic growth this conflict to a very large extent could be avoided. Due to this reason, policymakers and political leaders should need no convincing for the urgency of stimulating growth (Lewis, 1955).

3) What distinguishes humans from the other creatures is that we have greater control over our environment but not that we are happier. So, from this perspective economic growth is desired greatly. There is no doubt that economic growth increases control of humans over their environment and thereby expanding their freedom and horizon. Higher levels of income resulting from rapid economic growth free life from nature' menaces of death and diseases.

4) In the process of economic growth women are likely to benefit far more than the men. In most low income economies, most of the household tasks are done by women and many of these are done by the mechanical devises in the advanced societies – such as grinding grains, washing clothes and dishes, cooking among others. economic growth transfers many of these and many other tasks like spinning and weaving, teaching children, minding the sick to external establishments which are specialized at doing these with the scale advantages. In the process women gains freedom from drudgery and emancipated from seclusion of the household, gains at last the chance for being complete human being exercising her mind and her talents in the same way as men (Lewis,1955).

5) Economic growth also permits mankind to indulge in the luxury of greater humanitarianism as at higher level of income they can afford to forgo part of their income to uplift others who have not been so fortunate (Lewis,1955).

6) Economic growth process has been found to by far the most effective tool to alleviate poverty. There is lot of evidence to suggest that income inequalities tends to worsen at the initial stages as the economy grows but there is very little evidence of worsening of poverty. The best example of this is this is the experience of China, India[iv] and countries of East and South East Asian economies in the past two to three decades characterized by rapid economic growth. In the literature, this effect of growth on poverty is known as the *trickle down effect*. So rising inequalities and lower poverty tend to go hand in hand in the process of economic growth.

This is not exhaustive list but give us some idea about how process of economic growth could benefit a society and correspondingly its citizens.

Check Your Progress 2

1) Describe the broad contours of the growth of nations in the second half of the twentieth century.

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2) What in your opinion would be the main reasons for studying the growth of nations? What useful knowledge can we obtain?

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3) Discuss any three advantages of economic growth.

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1.7 SOURCES OF ECONOMIC GROWTH

Economic growth is a complex process that generally involves several interrelated factors. Economists stress the importance of three major sources of economic progress:

a) investment in physical and human capital,

b) technological advances, and,

c) institutional and policy changes that improve the efficiency of economic organisation.

   i) competitive markets,

   ii) stable prices,

   iii) free trade,

   iv) flexible capital markets,

v) avoidance of high marginal tax rates

vi) secure property rights, and

vii) political stability,

However, here we must remember that in a country's growth process the role of economic factors is crucial and decisive. The *stock of capital* and the *rate of capital accumulation* in most cases settle the question whether at a given point of time a country will grow at what pace. There are few other economic factors which also have some bearing on development but their importance is hardly comparable to that of capital formation.

Capital Formation: More capital generally means more production, and more production means more growth. To get capital, countries have to invest and so the level of investment may be a big determinant of *future* growth. So, Capital formation is of crucial importance in the *process of economic growth*. It is quite necessary to step up the rate of capital formation so that a large capital stock of machines, tools and equipment could be accumulated which can be geared into faster growth in the level of production of goods and services. Not only that, capital formation requires the creation of skill formation so that the physical appearance requires the creation of skill formation so that the physical apparatus or equipment created can be utilised to raise the level of productivity. In the words of Indian Planning Commission "The level of production and the material well-being a community can attain depends, in the main, on the stock of capital at its disposal, i.e. on the amount of land per capita and of productive equipment in the shape of machinery, buildings, tools and implements, factories, locomotives, engines, irrigation facilities, power installations and communications. The larger the stock of capital, the greater tends to be the productivity of labour and, therefore, the volume of commodities and services that can be turned out with same effort" (First Five Year Plan p 13).

Experiences of other countries in other countries suggest that a high rate of capital formation was achieved to trigger rapid economic growth. In Japan, investment rate between 1913 and 1939 averaged 16 to 20 per cent. The First Five Year Plan of the Soviet Union had a target of net investment amounting "between a quarter and a third of national income" though in the subsequent plans the rate of investment was lowered and stabilised at about 20 per cent of national income. In some of the East European countries like Czechoslovakia and Poland, gross investment rates ranged between 20 and 25 per cent.

Capital-Output Ratio: Another determinant of economic growth is the capital-output ratio. The term 'capital-output ratio' refers to the number of units of capital that are required in order to produce one unit of output. In other words, capital-output ratio reflects the productivity of capital in the various sectors of the economy at a point of time. The capital-output ratio for the economy as a whole is only a shorthand description of the *productivity of capital*.

The capital-output ratio is different for different industries and different economies and it varies over a period of time. According to Indian *First Five Year Plan* "There is no unique capital-output ratio applicable to all countries at all times. Much depends on the stage of economic development reached but also on the precise form of further expansion." For instance in the early phase of growth process, when a country is making heavy investment in economic infrastructure, i.e. on building irrigation works, hydro-electric projects, roads, railways, etc. the corresponding additions to output will be small. But with passage of time as the power potential and transport equipment are utilised to the full, there shall be a favourable shift in the capital-output ratio. Similarly, basic industries like iron and steel, machine tools, engineering and metallurgy are more capital-intensive than consumer goods industries. Consequently in the initial years of development when the economic foundations are being laid, capital-output ratio tends to be unfavourable. But as development gathers momentum, and the emphasis is shifted to the production of

consumer goods, relatively smaller increases in investment bring about large increments to output. In other words, the stage of growth and the mix of various types of investment determine the capital-output ratio.

Besides, in certain sectors of the economy output can be increased with comparatively small additions to output, while in other sectors, comparatively large additions to capital are called for. For instance, in Japan, between 1885 and 1915, labour productivity in agriculture was doubled by a comparatively small quantum of investment in the form of better seeds, improvements in water supply, control of crop diseases and use of fertilizers. In additions to this, capital-output ratio depends upon the efficiency with which the new types of capital equipments are handled and the quality of managerial and organisational skill becomes available. Co-ordination of the programme of investment so as to develop complementary economic activity simultaneously has a favourable effect on capital-output ratio. In other words, the capacity of the economy to more effectively use the investment at a particular time also affects the capital-output ratio.

The rate of growth of national income in an economy depends upon the rate of investment and the capital-output ratio:

$$\text{i.e.} \quad \text{Rate of Growth of GDP} = \frac{\text{Investment - Income Ratio}}{\text{Capital - Output Ratio}}$$

In other words, to achieve high rate of growth of national output, economy has to operate on two variables, viz

a) to step up the rate of investment; and

b) to generate forces which improve productivity;

Occupational Structure: Another factor which determines and is determined in due course by economic growth process is the occupational structure of the working population. Experience from all over the world suggests that in the process of growth, transfer of working force from primary to secondary and then secondary to tertiary sector of the economy has invariably taken place. For instance between 1870 and 1930, the proportion of work force engaged in agriculture declined from 54 to 23 per cent in U.S.A., from 43 to 25 per cent in France, and 80 to 48 per cent in Japan. It is, therefore essential that as growth proceeds there is an optimum distribution of the work force in different occupations. As this improves the efficient utilisation of labour which will further boost the overall level of productivity of the economy.

Technological Progress: This is perhaps the most widely accepted (and easiest to understand) source of economic growth. This is because technology makes it possible to produce more from the same quantity of resources (or *factors of production*). This boosts the potential level of out put of the economy. The pace of technological change will depend on:

a) the scientific skills of the country

b) the quality of education

c) the amount of GDP devoted to research and development

In the next section we will discuss the limitations of the economic growth in details for your clearer understanding of the underlying process of economic growth to enable you to critically evaluate it.

1.8 LIMITATION OF ECONOMIC GROWTH

The process of economic growth has certain limitations as well. Thus we should not lose sight of these in the blind race of growth as these could have serious social and

economic repercussions for the society (as happened in many of the Latin American countries).

1) **Inequality of income** –growth rarely delivers its benefits evenly. So the issue of distribution of the fruits of the growth process becomes first important limitation of process of economic growth. There is evidence to suggest that, al least in the initial stages of development; growth tends to worsen the distribution of income. Although the relationship between growth and distribution is far from settled. There is no doubt that rapid economic growth creates the potential means for alleviating the problem of poverty which affect almost all the developing countries. With adequate state intervention, this potential has been used to significantly reduce the poverty incidence in the economies of East and South East Asian economies as well as China. It is possible to have economic growth without the majority of population being any better off, as the expanded output enriches only a small section of powerful population. But such developments are immoral, and would result in more social conflicts and could undermine the economic policymaking which benefit only a few (Lewis, 1955).

2) **Pollution (and other *negative externalities*)** – the drive for increased output tends to put more and more pressure on the environment and the result will often be increased pollution – air, water, and noise. This may be water or air pollution, but growth also creates significantly increased noise pollution. Traffic growth and increased congestion are prime examples of this.

3) **Loss of non-renewable resources** – the more we want to produce, the more resources we need to do that. The faster we use these resources, the less time they will last. This invariably leads to loss of non-renewable resources like oil, and other minerals, forests etc. It is clear that economic growth, by either increasing the total availability of goods and services, or by increasing the capacity to do so, makes it possible for people to reach higher level of material welfare for some commodities and at present. However, economic growth process may reduces social welfare as sometimes increasing the level of output may lead to relative scarcity of some other resources or same factors for future generations and could make it more difficult for them to maintain the present level of welfare in the times to come.

Check Your Progress 3

1) Discuss the three main sources of economic growth.

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2) Discuss some limitations of economic growth.

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1.9 LET US SUM UP

The importance of economic growth cannot be overstated. Income growth is essential for achieving economic, social, and even political development. In recent years, an enormous amount of talent and effort has been invested in understanding the process of economic growth, making it one of the most dynamic fields in economic analysis.

In this unit the concept of economic growth was discussed in detail. We also understood the difference between the concept of economic growth and development. The unit also elaborated about why we need to study the process of economic and its importance. We also examined the performance of the countries over last five decades. We ended the unit with discussion of limitation of economic growth.

1.10 KEY WORDS

Gross Domestic Product: Measures level of economic activity in an economy's boundaries in a particular time period, normally a year or a quarter.

Income per capita: This is calculated by total *gross domestic product* of a country divided by total population. Per capita income is often used as an indicator of *level of living* and *development.* It, however, can be a biased index because it takes no account of *income distribution.*

Economic growth: A simple definition is that it is an increase in the level of output of goods and services that is sustained over a long period of time, measured in terms of value added.

Extensive growth: This refers to growth in total output level of an economy.

Intensive growth: This refers to growth in per capita output level in an economy.

Trickle-down effect: This effect refers to the negative link between incidence of poverty and the process of economic growth

1.11 SOME USEFUL BOOKS

Ahluwalia, M.S., (1977), "Agricultural Growth and Rural Poverty", *Journal of Development Studies.*

Barro, Robert & Xavier Sal-i-Martin, (2004) E*conomic Growth*, Second Edition.

M.I.T. Press, Cambridge, Massachusetts

Ghatak, S. (2003) *Introduction to Development Economics*, , Routledge, London,

Lewis, W. Arthur (1955) *Theory of Economic Growth*, George Allen & Unwin, London,

Lucas Robert E. Jr, (2002) *Lectures on Economic Growth*, Harvard University Press, Cambridge,Massachusetts

Maddison, Aungus (2003) *The World Economy: A Millennial Perspective*, Overseas Press (India) Limited, New Delhi.

1.12 ANSWERS / HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) See section 1.2 and answer.
2) See section 1.3 and answer.
3) See section 1.3 and answer.
4) See section 1.3 and answer.

Check Your Progress 2

1) See section 1.4 and answer.
2) See section 1.5 and answer.
3) See section 1.6 and answer.

Check Your Progress 2

1) See section 1.7 and answer.
2) See section 1.8 and answer.

UNIT 2 HARROD-DOMAR GROWTH MODEL

Structure

2.0 OBJECTIVES

After reading this unit you should be able to:

- Understand the 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;
- Appreciate the role of savings and investment in the growth process, as expounded by Harrod, and the implication of this relationship;
- Express the role of savings and investment in the growth process, as expounded by Harrod, and the implications of this relationship;
- Identity the similarities and dissimilarities between the Harrod Model and the Domar Model; and
- Develop an integrated view of the Harrod Model and the Domar Model, and get a clear idea of the usefulness and limitations of this integrated model.

2.1 INTRODUCTION

Economic growth, as you have been in Unit 1, 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.

2.2 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.

2.2.1 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.

2.2.2 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.

2.3 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.

2.3.1 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

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

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

or $I = S$

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

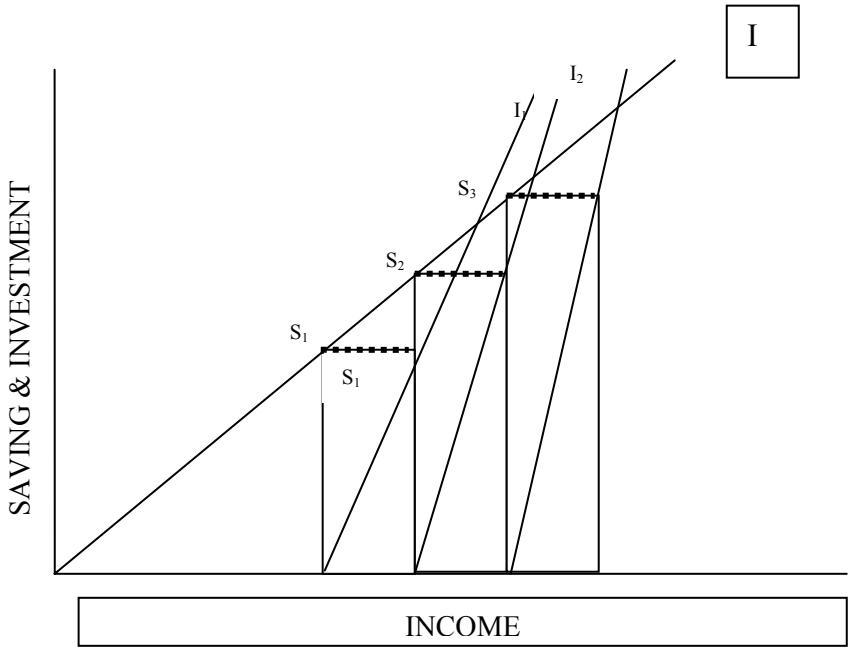

Fig. 2.1

In Fig.2.1, 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:

$G = G_w$, 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.

2.3.2 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.

2.3.3 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.

2.3.4 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.

2.3.5 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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2.4 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.

2.4.1 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.

Equilibrium: In equilibrium, the demand and supply should balance. Therefore,

$$Y_d = Y_s$$

or $I/d = \sigma K$

By cross multiplication,

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

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:

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

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:

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

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.

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

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

$$\Delta Yd = \Delta Y_s$$

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

cross-multiplying , we get,

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

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 ΔI/I greater than σ d the economy would experience boom. The economy would suffer from depression, it ΔI/I is less than σ d.

2.4.2 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.

2.4.3 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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2.5 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.

2.5.1 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.

2.5.2 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 capital output ratio	Assumed for inconvenience	Due to fixed interest rate, low substitutability, etc.
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.

2.6 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).

2.6.1 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.

2.6.2 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 growth. 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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2.7 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.

2.8 KEY WORDS

Capital-Output Ratio: The number of units of capital required to produce a unit of output.

Investment: That part of national income which is spent on the acquisition of capital goods.

Natural Growth Rate: Refers to the maximum growth rate which an economy can achieve with its available natural resources.

Savings: That part of national income which is not spent on the purchase of consumer goods.

Warranted Growth Rate: Refers to that growth-rate of the economy when it is working at full capacity and making optimum use of machine and manpower.

2.9 SOME USEFUL BOOKS

Meier, Gerald M. and Rauch, James E (eds.) (2000). *Leading Issues in Economic Development (7th edition*). Oxford University Press, Oxford.

Solow, Robert M. (2000), *Growth Theory: An Exposition (2nd edition).* Oxford University Press, Oxford and New York.

Surrey, M.J.C. (ed.) (1976). *Macroeconomic Themes*. Oxford University Press, Oxford.

2.10 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) See Section 2.2
2) See Sub-section 2.3.1
3) See Sub-section 2.3.4
4) See Section 2.2
5) See Sub-section 2.3.1
6) See Sub-section 2.3.4

Check Your Progress 2

1) See Sub-section 2.4.1
2) See Section 2.4.1
3) See Sub-section 2.4.1

Check Your Progress 3

1) See Sub-section 2.5.1
2) See Sub-section 2.5.2
3) See Sub-section 2.6.1 and 2.6.2

UNIT 3 THE NEO-CLASSICAL GROWTH MODEL

Structure

3.0 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.

3.1 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 base-line model that they critiqued and found limitations with. Empirical economists spent lots of time, effort and 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.

3.2 SOME BASIC CONCEPTS AND TOOLS TO STUDY GROWTH MODELS

In this section we first set out some basic concepts regarding the meaning and measurement of economic growth that you will find useful not only for this unit but for the entire course.

Growth and change

The concept of the growth rate is very important and you thoroughly need to understand it.

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 one has to be careful in expressing the change.

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

People sometimes erroneously express it as a 3% fall.

Calculation of growth rate assuming that the rate of growth is constant

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

Let Y_0 be income in the initial year.

Let n be the number of years. Let r be the constant compound annual rate of growth. Then income in the final year, Y_t, is given by:

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

=) $log\ Y_t = log\ Y_o + n\ log\ (1+r)$ where log stands for logarithm.

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

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

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

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

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

Calculation of growth when the rate of growth is not constant

When the rate of growth is *not* constant, it is say

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

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

This is the geometric mean.

Exponential Growth

We know that growth can be written as

$\dfrac{\triangle x}{x}$. This is in general terms

Compound rates are the same as geometric growth. Continuous compound growth implies 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

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

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

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

We saw above that when the compound rate of growth is constant,

$Y_t = Y_o(1+r)^t$. This means Y_o grows at 100r % If compounding takes place m times a year (you may think of money in a bank earning compound interest), then in this case,

$$Y_t = Y_o\left(1+\frac{r}{m}\right)^{mt}.$$

As m gets larger and larger, and approaches infinity (theoretically, but this is conceptually very important), the term within the parenthesis acquires a definite value. We can show it as follows:

We can write the above expression as

$$Y_t = Y_o\left[\left(1+\frac{r}{m}\right)^{\frac{m}{r}}\right]^{rt}$$

Let m/r be denoted h then

$$Y_t = Y_o\left[\left(1+\frac{1}{h}\right)^{h}\right]^{rt}$$

As m tends to infinity, so does h. A result in calculus states that

Limit of $\left(1+\frac{1}{x}\right)^x$ as $x \to \infty$ is equal to e where e = 2.71828 approximately. This e is the inverse of natural logarithm. That is, for any number w, $e^{\ln w} = w$

Hence as h$\to \infty$, $\left(1+\frac{1}{h}\right) \to$ e

Thus theoretically, $Y_t = Y_o e^{rt}$. This is called exponential growth. Exponential growth is the same as compound growth, where compounding is done instantaneously and constantly.

Depicting Growth in infinitesimal terms

Let $y = f(t)$ where t is time

Take natural logarithms of both sides

$$\ln y = \ln\left(f(t)\right)$$

Differentiating both sides with respect to time, we get

$$\frac{d}{dt}(\ln y) = \frac{d}{dt}\ln\left(f(t)\right)$$

$$= \frac{1}{f(t)} \bullet \frac{df(t)}{dt}$$

Using the fact of logarithmic differentiation and the chain rule (see course on quantitative methods MEC003)

The right hand side above we can recognise as the instantaneous proportionate rate of growth

$$\frac{\triangle x}{x} with \triangle x \to 0 = \frac{1dx}{xdt}$$

Usually $\frac{dx}{dt}$, the time derivative of a variable x, is denoted $\dot{x}$.

Time as an independent explanatory variable

You have studied in the course on quantitative methods that if a variable y depends on x, and we postulate a linear relation between y and x, we can depict a statistical relationship under uncertainty as

$y_i = \alpha + \beta x_i + \varepsilon_i$, where i is the observation and α and β are coefficients to be estimated. When events takes place over time, we can show this in two ways. The first way is that we take the usual regression method, and use observations over time, what is called time –series data. Then the subscript will indicate time and is usually denoted by t. The second way is to say that time itself causes the change and can thus be considered like the variable x above, that is, time is considered as an independent variable in regression, as a regressor. This is how we get the concept of trend.

A linear trend relationship can be denoted as:

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

where T indicates time. One has to appropriately define the origin, that is, the starting year or time period.

Without disturbances, a constant growth series, as we have seen above, 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 longs of both sides of (2) given

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

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

If we think that a series has a constant growth rate, plotting the log of the series against time provides an easy measure of growth. 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.

The β coefficient of (1) represents the continuous rate of change $\partial \ln y_t / \partial t$, whereas g represents the discrete case.

Some Concepts Of Equilibrium Growth

An economy is said to be experiencing a **steady-state growth** if all variables are growing at a constant proportional rate or not at all. These rates may be different for different variables. An economy is said to be experiencing **balanced growth** if all variables are growing at the same constant proportional rate. Suppose in an economy, output per worker continues to grow at a constant 3%, savings rate continues to grow at 20%, capital per worker continues to grow at 8%, then this economy is showing steady state growth; if an economy is such where per-worker output, savings rate, capital per worker all grow at say 10 %, then this economy is experiencing balanced growth.

Kaldor's Stylised Facts about Economic Growth

Nicholas Kaldor, on the basis of his studies, presented in 1959 and 1961 works some "stylised facts" which he said could be observed with regularity, in the modern era, which we merely mention :

1) In the long run, per capita output grows at a positive rate which shows no signs of diminishing.

2) The capital-output ratio shows no perceptible upward or downward trend, that is, in the long run it remains roughly constant.

3) The return to physical capital, that is, the profit rate, shows no perceptible upward or downward trend, that is profit/capital remains largely constant.

4) There is a great variety of growth rates of per capita income income across the world, that is, the rates of per capita growth vary substantially across nations.

Facts 1 and 2 together imply that

5) In the long run the capital labour ratio grows at a positive rate which shows no signs of diminishing.

Facts 2 and 3 together imply that

6) The income shares of labour and physical capital remain constant in the long run, and this, in turn implies that wage rate shows a rising trend.

3.3 THE SOLOW MODEL

Let us begin our study with the basic neo-classical model. The model has certain assumptions which we state now and then set out the basic structure of the model.

3.3.1 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 $L_t = L_0 e^{nt}$.
6) People save a constant proportion of Income. If S denotes saving then
7) $S = sY$. 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.
8) There is no foreign trade
9) The government does not intervene in the economy; there are no taxes or government purchase

3.3.2 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.

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

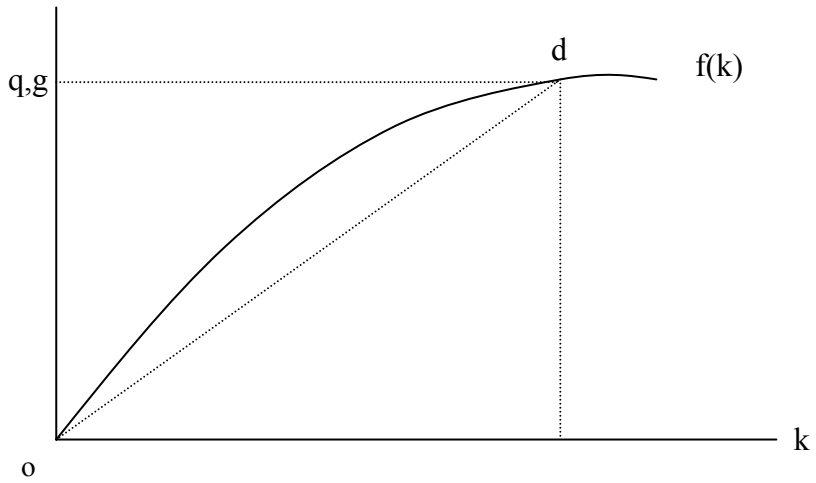
Or y=f (k)

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 in 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

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

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

or, $\ln k = \ln K - \ln L$

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.

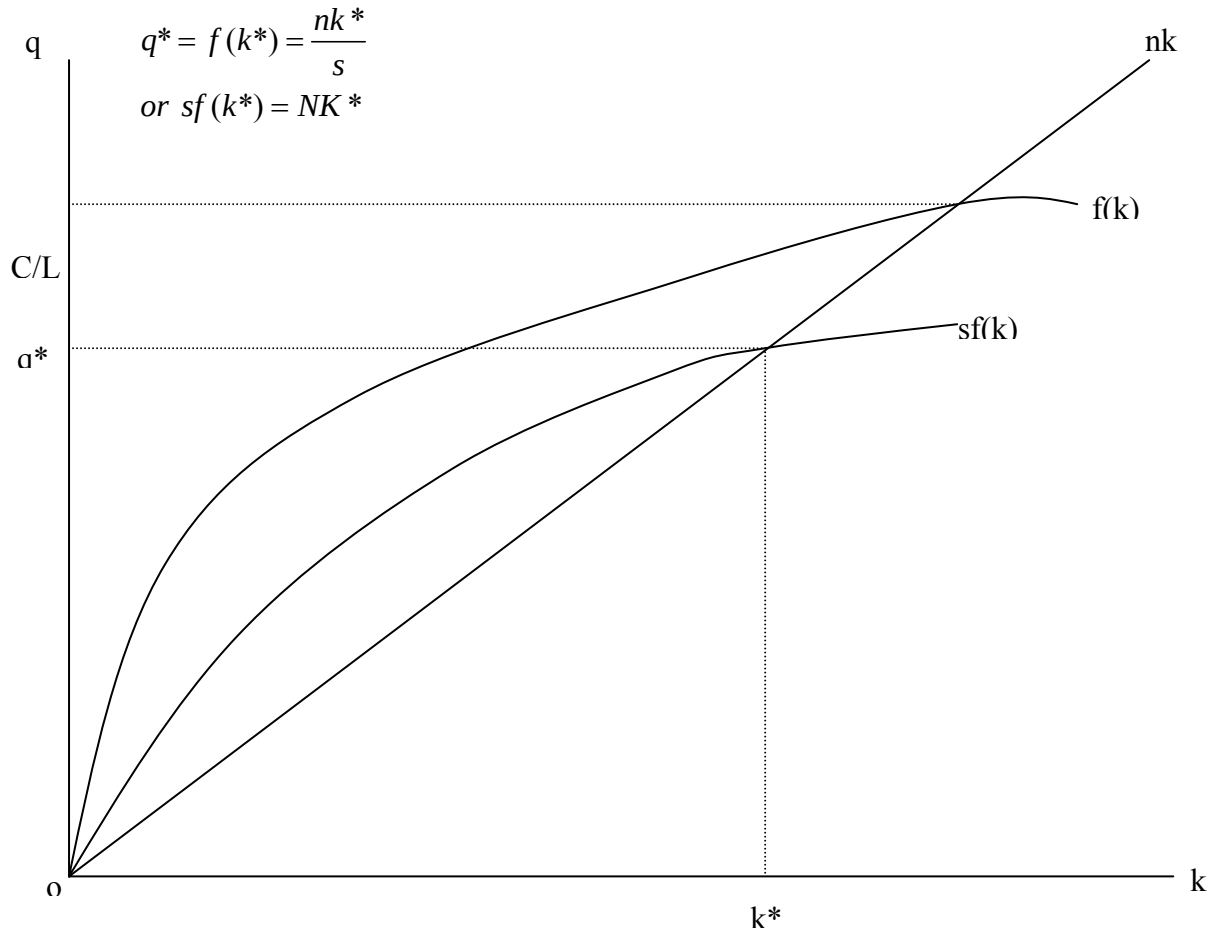
The equilibrium value of k is the one for which $\frac{dk}{dt}.\frac{1}{k}is-0,\ i.e.\ \ \frac{dk}{dt}=0$ or where k, once it reaches that value, does not change. Setting $\hat{k}=0$ in the equation above, we get

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

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

where an * above k denotes its equilibrium value.

The equilibrium q value is obtained as



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

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

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 $n = \frac{S}{V^*},$ 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;

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

$f(k) = \frac{C}{L} + \dot{k} + nK$ ……..(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 reverts to the steady 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 variables grow at the same rate) is the constant exogenous grow the of labour force, which is *n*.

3.3.3 A Comparison with the Harrod-Domar Model

The first basic difference that the Solow model has with the Harrod Domar model is that in the Solow model the capital output ratio is not exogenously fixed. It is endogenously determined. the second difference the process of adjustment in the variables is different in the two models. In the HD model, there are two knife-edges: the balance between the actual and warranted rates of growth, and between the warranted and natural rates of growth. Solow's model does not address this question, and instead assumes that planned investment equals planned savings at all times. This is, of course, again because s, v, n were all fixed in the HD model, whereas in the Solow model, there is a spectrum of values that that v, that is, the capital output ratio can take, and adjust to that value at which the warranted rate of growth equals the natural rate of growth.

Check You Progress 1

1) State and discuss the assumptions of the Solow model.

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2) Describe the structure of the Solow model.

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3) Compare the Solow model with the Harrod-Domar model.

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3.4 SOME APPLICATIONS OF THE NEO-CLASSICAL MODEL

3.4.1 Depreciation of Capital Stock

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 basic analysis that we studied, carrier over for the case of depreciating capital; we merely need to replace n by (n+δ).

3.4.2 Variable Savings Rate

We can use the Solow model to look at the situation where the saving rate is variable. Suppose the saving rate increases from s_1 to s_2. this means that the *sf(k)* curve shifts upwards. This means the sf(k) curve will cut the nk curve at a new point which is higher and to the right of the earlier point of intersection. This means equilibrium k and y will both rise. So an increase in the rate of savings does push up the output per man in the Solow model. But it is also important to note that in the Solow model, the savings rate is a key determinant of the level of capital per person . if the saving rate is high the economy will have a large capital stock and output. But saving has only a temporary effect on the *growth* in output per person. The economy will grow only till the economy reaches a new equilibrium capital per person level.

The above observation that a *permanent* change in the savings rate has only a *temporary* effect on the economy's *growth rate* is called the Solowian paradox of thrift. This point is important to note since it is often suggested that developing nations should raise their savings rate as far as possible. this is supposed to push up the growth rates of per capita income. This proposition is present in the theories of development economists like Nurkse, Rostow and Lewis. You will study these theories in block 5. Here you should keep in mind that increasing the saving rate would push up growth rates only temporarily. The basic lesson of the Solow model is that permanent increase in the growth rate of per capita income comes about only through a change or improvement in technology.

3.4.3 Population Growth

We can now examine in the Solow model the effect of a growth in population. We have seen that capital accumulation by itself cannot explain long-term growth. This can come about through technical progress. The other source is a growth in population.

Let us suppose that the population increase at a rate n. what effect does this have on the steady state growth? Once the number of workers rises, this will cause capital per worker k to fall.

We know that $\triangle k = sf(k) - nk$. So increase in population (not the rate, but the *level*) reduces k. of course, we had seen this while studying the basic model in section 3.2. the steady state level of k is determined from the pint where the curve sf(k) cuts the line nk. Dropping a perpendicular from this point to the horizontal axis (which measures k) gives us the steady state value k^*. of course, you have come across this diagram in section 3.3.

Let us now see what happens when the rate of population itself changes, that is, n itself undergoes a change. Let the rate of population growth increase from n_1 to n_2. This means that the nk line will tilt upwards. If the sf(k) curve remains the same the new nk line will cut the sf(k) curve to the left of the earlier intersection point. This results in the steady state capital per worker k^* to fall. Since y = f(k), a reduction in k^* results in y falling. Thus in the Solow model, if the *rate of growth* of population rises, output per worker will fall. This has lessons for developing nations. These nations should not allow the rate of population to increase as this may have detrimental effect on the per-worker output.

3.5 MONEY IN THE NEO-CLASSICAL GROWTH MODEL

James Tobin, in a paper published in 1965, presented a simple model of monetary growth which follows the Solowian model. Tobin had of course, earlier, independently developed a growth model in l955 which was similar to the Solow model but had the existence of government debt (net "outside" wealth). For our analysis, we assume that there is only one such type of outside wealth: money. Let money yield a certain rate of return, which we shall denote as R (we are concerned with a broad aggregate for money).

In the original Solow model, physical capital was the only form of wealth that existed. However, money is an important alternative store of wealth. Tobin extended this to bring in outside government wealth in the form of money. How does this change the Solow model?

Tobin used the simple quantity theory of money MV = PY. Assuming the velocity of money is constant, the growth in money equals the difference between the inflation rate and growth in nominal income.

$$\hat{M} = \hat{P} - \hat{Y}$$

where ^ represents the proportional growth rate of a variable x. Rewriting this, we see that the rate of inflation is merely the difference between the rate of money growth and the rate of output growth. The greater the difference, the higher will be the inflation rate. Note the important implication that if money stock is constant ($\hat{M} = 0$), then prices will fall at the rate of growth of output $\hat{Y}$ and real money balances, M/P, will grow at that same rate.

Let real wealth (A) be held in two assets, real money (M/P) and physical capital (K), in a proportion such that:

$$A = \alpha(M/P) + (1-\alpha)K$$

where α lies between 0 and 1. The value of α is determined through portfolio selection by households. The important thing Tobin did was to consider the real rate of return froom money as the difference between the nominal rate of interest and inflation rate. He suggested that people make a comparison between R and the marginal product of K. People do this comparing and in the economy it is determined how much wealth will be held and how much physical capital. This has implications thrugh the function f(k) on output growth. Thus in situations of inflation, people may hold less M/P because real value of money falls, people might hold more K. this leads to a fall inmarginal productivity of capital

D. Levhari and Don Patinkin (1968) and Harry. Johnson (1967) pointed out that a limitation of Tobin's model is the fact that it treats money solely as a store of value and, in effect, does not consider its use in overcoming transactions costs, etc. they suggested extensions to the Tobin model where money directly enters the utility function.

We have discussed the Tobin model. An extension of the Tobin model was provided by Sidrauski. However, we do not present the Sidrauski model here as it beyond the scope of our discussion at this point. It uses concepts and tools that you will learn only in block 3 in the unit on optimal growth. You will meet Sidrauski’s model when you come to that unit.

Check Your Progress 2

1) Discuss the effect of a change in the savings rate using the Solow model.

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2) Discuss the effect of a change in (a) the level of population and (b) the rate of growth ogf population using the Solow model.

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3) Briefly state how Tobin brings in money in a growth model.

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3.6 CONVERGENCE AND POVERTY TRAPS

In this section we look at two more important applications of the neoclassical model. These have some bearing on development economics, which means studying the development of the poorer nations. So you can read these, and when you come to block 4, and unit 18 in block 5

3.6.1 Convergence

If you look at the Solow model carefully, it might seem to you that the model suggests that the growth rates of different nations would tend to converge over time, that is, towards the same rate of growth. We can think of three reasons why the Solow model suggests this behaviour. First, the Solow model suggests the rate of return on capital is higher in countries with less capital per worker. Hence capital ought to flow from the rich nations to the poorer nations. Secondly, the Solow model predicts that countries eventually would converge to their **balanced growth** path. Finally, while there may be initial differences in incomes among countries because some countries have better stock of knowledge, eventually, as the poorer countries gain access to the latest technologies, such differences in incomes will shrink.

There are two types of convergence that is usually studied, absolute or unconditional convergence and conditional convergence. Absolute convergence states the following: suppose there is a group of countries. Suppose all these countries have access to the same technology *f(.)*, and have the same population growth rate n, have the same propensity to save, that is, the same saving rate s, but differ, and this is the *only* point of difference, in their initial capital-output ratio. Then the Solow model suggests that all countries would converge to the same equilibrium steady state capital labour ratio, output per capita and consumption per capita (k^*, y^*, c^*) and the same growth rate n.

To understand this further, suppose that there are two countries, one rich and one poor. Supoose the poor country has capital labour ratio k_1 and the rich country has k_2.. Since $k_1$is $< k_2$ the absolute convergence predicts that both countries will ultimately converge to a level k^*, between k_1 and k_2. This means the poor country will grow much faster as its capital and output grow faster than n, while in the rich nation the capital and output will grow slower than n. in other words, since $k_1 < k_2$, marginal product of k, that is, capital relative to labour is higher in the poor country than in the rich one, and thus the poor country will accumulate more capital and grow at a faster rate than the rich one.

Conditional convergence is invoked in light of the fact that in the real world, rich and poor nations do not seem to be converging to a steady state growth rate, as implied by the Solow model. Conditional convergence states that if nations are endowed with the same technological possibilities and population growth rates but differ in savings propensities that is, savings rate and the initial capital-labour ratio, then there will still be convergence to the same growth rate but not necessarily at the same equilibrium capital-labour ratio. This is due to the Solowian paradox of savings that we had outlined in sub-section 3.4.2. thus the conditional convergence hypothesis suggests that nations can differ in their capital-labour ratios and thus differ in their consumption per capita, but as long as they have the same population rate n, then all their *level* variables (as opposed to per capita) capital, output, consumption – will eventually grow at the same rate. Of course, we usually see the absence of even conditional convergence, but that may be because nations differ in their population growth rates.

Let us discuss the concept of convergence in some detail. If we consider unconditional convergence, it might appear that nothing much of great importance is being talked about. After all if we assume that parameters like savings rate, population growth, capital depreciation are similar. It might seem common sense to argue that this is only to be expected. But note that the hypothesis of unconditional convergence does not assume that the initial level of per capita income or the capital stock is the same. If the parameters governing the evolution of the economies are similar the initial levels do not matter.

A well-known study to examine the empirical validity of the unconditional convergence hypothesis was conducted by William Baumol and published in a 1986 paper. Baumol used data compiled by noted economic historian Angus Maddison. Baumol studied a set of 16 countries that are among the richest today. Baumol plotted the 1870 per capita incomes for these countries on the horizontal axis and plotted the growth rate of per capita incomes of these countries over the period 1870-1979 on the vertical axis. If the unconditional hypothesis were true, we would get an inverse relationship between initial per capita income *level* and *rate of growth* of per capita income. Baumol indeed found a downward sloping scatter plot, which showed a negative relationship. Baumol also ran a regression where the dependent variable was the difference of the natural logarithms of the per-capita incomes of 1979 and 1870 and the dependent variable was the natural logarithm of the per capita income of 1870. the regression can be represented as

$$\ln\left[\left(\frac{Y}{N}\right)\right] \ln\left[\left(\frac{Y}{N}\right)_{i,1979}\right] - \ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right] = a + b\ln\left[\left(\frac{Y}{N}\right)_{I,1870}\right] + \varepsilon_i \quad \text{where} \quad \ln$$

(Y/N) is log of income per person and ε is an error term. The estimated values of a and b were 8.457 and (minus)0.995 respectively. Since b is almost equal to –1, it shows almost perfect convergence.

Baumol's findings were challenged by Bradford De Long on two grounds. First, De Long pointed out that there were *sample selection bias* or, bias in the selection of the sample itself. When Baumol carried out the study, the countries chosen in his sample were already rich. In 1870, there was no way of knowing which countries were going to grow fast later. Ex-post knowledge cannot be a basis of ex-ante prediction. Historical data is constructed retrospectively. Those countries for which data is available over a long period are likely to be those that *have* grown rapidly in the past 100 years or so, and are industrialized today. On the other hand, countries that were already rich hundred years ago are likely to be included even if there subsequent growth has not been so fast.

The second point on which De Long challenged Baumol's findings is measurement error. Estimates of data for 1870 may not be precise. Those countries whose 1870 per capita income was overstated actually had grown faster than had been estimated. Those countries for which 1870 per capita income was understated had grown slower than had been measured. Either way, there was a bias towards showing convergence.

3.6.2 Poverty Traps

Empirically, the convergence hypothesis has not held up very well. The neo-classical model has not been very successful in 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 showing stagnant growth, while others were progressing very fact. This idea that the poorer nations were actually caught is a trap has come to be called poverty trap. It is a trap because in spite of efforts, these nations stay at 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 grows at a level lower than k*, the economy will slump back towards a very low income and output level because the level k* may show a unstable equilibrium.

The idea behind technological trap is that had 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 too, you will read in block 4.

b) **Population Trap**

The second way in which poverty traps can arise is induced 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. Robert Malthus 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 in 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 again become <0. Historically, in olden time in societies where k was below k_1, population was lost through 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 farther away rather than bringing it back into equilibrium. We have considered the interval (or range of values between) $[k_2, K_1]$. Supposing we have two equilibrium points k_a and k_b. Let k_a lie between k_1 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 given 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 on y and *k/l*. But in the last century, due to advances is health care and medicine, 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.

Check Your Progress 3

1) Explain the meaning of absolute and conditional convergence and distinguish between the two.

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2) Explain the concept of poverty trap. Discuss how it can come about.

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3.7 LET US SUM UP

The neo-classical growth model is the central, 'base-line' model which has saved on the spring board for almost all most researches into growth theory. The neo-classical model, associated with the name of Robert Solow, presented the first major extension to the Harrod-Domar model, by endogenising 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 then proceeded to apply the Solow model to look at some applications, like convergence and poverty traps. We also looked at some implications of the Solow model namely that 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.

3.8 KEY WORDS

Closed Economy: An economy which does not engage in any foreign trade.

Convergence: The basic idea that the natures or region with low level of per capita income will display higher rates of growth and later the levels of income of the different nations or regions will 'converge'.

Depreciation: Wear and tear in the use of capital goods (machinery, plant, equipment).

Exogenous: Something, the value of which is given from outside. In modelling, a variable the values of which are not determined by solving the model, but is taken as given.

Poverty trap: The idea that low savings rate and low capital, labour ratio lead to an equilibrium situation where poor nations are trapped in poverty, under a 'Big push' raises capital. Labour ratio sufficiently.

Rate: Change in the values of a variable with respect to another variable, usually time.

Returns to scale: The proportion by which output changes, when all inputs are increased by a certain equal proportion.

Steady State: A condition in which the key variables are not changing.

3.9 SOME USEFUL BOOKS

Barro, Robert, and Sala- I-Martin. (2004), *Economic Growth* (2nd edition) McGraw-Hill Singapore

Jones, Charles I. (2002), *Introduction to Economic Growth* (2nd edition). W.W.Norton, New York.

Lucas, Robert E. (2002), *Lectures on Economic Growth*. Harvard University Press, Cambridge, Massachusetts.

Romer, David. (2001), *Advanced Macroeconomics* (2nd edition). McGraw-Hill, Singapore.

Solow, Robert M. (2000), *Growth Theory: An Exposition* (2nd edition). Oxford University Press, Oxford and New York.

3.10 ANSWERS/ HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) See Sub-section 3.3.1 and answer.
2) See Sub-section 3.3.2 and answer.
3) See Sub-section 3.3.3 and answer.

Check Your Progress 2

1) See Sub-section 3.4.2 and answer.
2) See Sub-section 3.4.3 and answer.
3) See Section 3.5 and answer.

Check Your Progress 3

1) See Sub-section 3.6.1 and answer.
2) See Sub-section 3.6.2 and answer.