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POSSIBLE CONTRIBUTIONS OF TIMBER PRODUCTION FORESTRY TO ECONOMIC DEVELOPMENT

ABSTRACT

Economic growth or development, the process by which a nation gains wealth, is analysed in Part I. Probably, development is possible only if many economic and non-economic variables have values within certain relative ranges, which should be the subject of further study.

A dynamic consumption function has been used to construct a simulation model to help guide an economy's approach to "take-off". It seems that early and large imports of foreign capital (a minimum of about 10 per cent of GNP annually), or a camparable reduction in personal consumption, are needed to initiate economic development.

In Part II, analyses indicate that a limited role can be played by forests in the poorly understood but urgently sought process of economic growth. Usually, forests can help the economy take-off, and also meet the requirements created as development proceeds.

Foresters have often looked only at the benefits from forestry. It is essential to consider also the costs involved in using forests. Such costs are in the form of missed opportunities to use forests fully or to replace them with a substitute for forest products.

Forestry is suitable for being given priority in a national or regional development plan because it can (1) efficiently utilize under-employed rural resources, (2) produce important raw material for making paper which is necessary for human investments, (3) substitute for imports and earn foreign exchange, (4) provide fuel and release cow dung for use in agriculture in some parts of the world, (5) serve as a basis for regional development where forests are plentiful and (6) produce a very versatile product - wood.

Forest products needed to initiate and sustain development can be supplied best by managing forests in such a way that the present profits from forest property

are maximized without detriment to the present worth of future profits. Surplus funds then should be used for investments in the most economically desirable fields. It is shown that revised user cost concepts can be applied in forestry. These determine the optimum rate of forest harvesting and investment so that the present worth is maximized. Further refinements of decision theory are needed to solve the complex problems involved.

Finally, policy implications for under-developed countries in general, and India in particular, are discussed. It is concluded that the policy of rigid sustained yield forest management should be rejected and replaced by maximization of present worth of net benefits from forest land in each management unit. Then, forestry can play its maximum possible role in economic development.

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ABSTRACT

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Economic growth or development, the process by which a nation gains wealth, is analysed in Part I. So far there is no theory which fully explains the phenomenon of sustained increases in the per capita income of a country. Probably, development is possible only if many economic and non-economic variables have values within certain relative ranges, which should be the subject of further study.

In this thesis a dynamic consumption function has been postulated and used to construct a simulation model to help guide an economy's approach to sustained economic growth. Computer analyses with the model show the changes in per capita income as an economy approach es the "take-off" stage. They also suggest that, due to different existing values of the relevant variables, each country may find its optimum method of development to be different from others. It seems that early and large imports of foreign capital (a minimum of about 10 per cent of GNP annually), or a comparable reduction in personal consumption, are needed to initiate economic development.

In Part II analyses indicate that a limited role can be played by forests in the poorly understood but urgently sought process of economic growth. Under usual circumstances, forests

can help the economy move towards the take-off stage and meet the requirements created as development proceeds.

Forests, like any other resource, are important for development and human welfare. But, society must forego something when it uses any one resource. Foresters have often looked only at the benefits from forestry. It is essential to consider also the costs involved in using forests. The costs are in the form of missed opportunities to use forests fully or to replace them with a substitute for forest products. This thesis helps evaluate the role that forestry can play in economic development. The widely accepted principle of sustained yield forest management has been criticized. The principle of maximization of the present worth of net benefits from forest land is suggested as a desirable alternative.

Forestry is different from other sectors in that (1) wood is its product as well as the major part of capital, (2) the period of production is long and (3) the product is very versatile. Forestry is suitable for being given priority in a national or regional development plan because it can (1) efficiently utilize under-employed rural resources, (2) produce important raw material for making paper which is necessary for human investments, (3) substitute for imports and earn foreign exchange in today's underdeveloped countries, (4) provide fuel and release cow dung for use in agricultural fields in some parts of the world and (5) serve as the basis for regional development where forests are plentiful. Commonly, if plans change, wood grown for one purpose can be used easily for another.

Most of these characteristics have been recognized by forestry economists but their studies have usually been based on historical evidence rather than analysis of possible future development. The future importance of forestry depends on its technological progress in relation to other sectors which are potential rivals of forestry.

Forests can facilitate development and also help maintain economic growth. As per capita incomes rise, demands for forest products increase. Forest products needed to initiate and sustain development can be supplied best by managing forests in such a way that the present profits from forest property are maximized without detriment to the present worth of future profits. Profits then should be used for investment in the most economically desirable fields. It is shown that revised user cost concepts can be applied in forestry. These determine the optimum rate of forest harvesting and the amount of investments to be made in the present so that the present worth of the forests is maximized. Further refinements of decision theory are needed to solve the complex problems involved.

Because there are many substitutes for them, only the most economical forest products will remain important in the long run. Forestry's role can be enhanced most effectively if foresters improve the technology employed in growing and utilizing forests.

Finally, policy implications for underdeveloped

countries in general, and India in particular, have been discussed. It is concluded that the policy of rigid sustained yield forest management should be rejected. It should be replaced by maximization of present worth of net benefits from forest land in each management unit. Then, forestry can play its maximum possible role in economic development.

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TABLE OF CONTENTS

TABLES

ILLUSTRATIONS

APPENDICES

INTRODUCTION

Never before in the history of mankind have the differences in the levels of living among ordinary persons in different countries been as great as they are today. It may not be possible to prove this statement with the backing of statistical information, but all accounts of various civilizations until about two centuries ago show that everywhere the masses lived in poverty and only a lucky few enjoyed the fruits of prosperity. The exception has been the last few generations (Keenleyside 1966) in the small corner of the world mostly populated by people of European extraction (Galbraith 1964a). Especially in North America there has been great and unprecedented affluence.

Vast disparities exist between the inhabitants of these countries and the remaining two-thirds of the world's population that lives elsewhere (Leibenstein 1963). A glance at the per capita income figures for the mid-1950's (Bhagwati 1966) makes this difference obvious. The United States of America (U.S.A.) had a per capita income of \$2,343 and Nepal of \$40. The average computed by Bhagwati for 96 countries of the world was \$200. In 1949 some 54 per cent of the world population lived in countries with less than \$100 per capita annual income while only 7 per cent lived in a country with over \$1,000 per capita income (United Nations 1950).

No doubt, per capita income is not a wholly satisfactory yardstick for comparing the relative standards of living of various communities and it tends to exaggerate the differences (Patel 1966). Yet, it is one of the best available and certainly indicates that the average Nepalese citizen is very much poorer than an average citizen of the U.S.A., although the American may not be 58 times better off than the Nepalese as suggested by the per capita income figures.

It was only after World War II that the existence of such disparities was fully realized by a significant number of ordinary people in both the affluent and poor countries. It is only since then too, that modern economists have started giving serious thought to this question (FAO 1966) and a large volume of literature has been written on this subject. Because of the knowledge of the much higher standards of living of the prosperous nations, and because of the aspirations created by political emancipation of most of the poor countries, their people want a better life for themselves and their children almost at once. They want to compress the two centuries of growth of Europe and North America into a few decades, but no one seems to know exactly how such a feat might be accomplished. In fact, the only example of a country "forced marching" into relative prosperity is the Soviet Union. This "regimentation" approach is presently being followed by the Communist Chinese. Even those who do not prefer the communist way, now agree that the government of a country must take an active role in leading or pushing the country into the road to prosperity. This is so, because the problem at this stage is not simply an economic one, but also involves politics, sociology, social anthropology and especially psychology.

The political systems in the Soviet Union and the People's Republic of China are opposed to those in North America and Western Europe. The Communists seek to convert the major part of humanity to their way of thinking by showing them the carrot of economic development and so the West has been forced to take an increasing interest in the development of the poverty stricken people of the world. The hope of maintaining

"Western" prosperity lies only in avoiding a major war with its political antagonists, and this the West can do only by not allowing large sections of the world's poor to fall into the communist sphere of influence. This in turn is possible only if those of the underdeveloped nations who do not desire the communistic political philosophy are helped to move on to the road to prosperity at a reasonably fast pace.

The largest and most obvious group of such people who have rejected the political philosophy of the communists and any totalitarian form of government are the 500 million Indians. The most important group of people who have chosen - or have been forced to choose - communism and a totalitarian government since World War II are the 700 million Chinese. Both are determined to find the road to development and prosperity - one through "democratic socialism" and the other through "dictatorship of the proletariat". To a very large extent the rest of the poor countries of the world will decide which to follow, after observing the concrete progress of these two giants. In their modus operandi the Chinese have a successful precedent - the Soviet Union. The Indians have no precedent to look to. The dictatorship of the Chinese has shown that it can revolutionize society with astounding rapidity. The Indians on the other hand are attempting to bring about "revolution with consent" and this means moving slowly. It may be true that what the Indians lose in speed they gain in soundness (Zinkin 1964), but political stability becomes difficult to maintain when progress is too slow.

A totalitarian form of government can reduce the level of consumption of its people or put considerable checks on its increase. Thus it can force savings comparatively easily. The democratic government can not easily persuade its people to refrain from increasing their consumption to the extent they desire. Even when it can persuade them, the result is not anywhere near what a totalitarian government can do in increasing savings. Therefore, the democratic efforts at initiating development can hope to succeed only if there is a possibility of getting some foreign aid which can be used for development purposes (Galbraith 1964b). Foreign aid (Keenleyside 1966) is the most crucial single factor that can decide the success or failure of an attempt to reach the take-off stage (Rostow 1960) in economic development.

The aim here is not to analyze whether a totalitarian government that can bully its people into ways that facilitate development is essential, or whether it is possible for a democratic government to persuade its people, by creating suitable incentives and by establishing necessary checks, to achieve self-sustained growth. No one knows the answers to these questions. For the purposes of this thesis it will be assumed that a democratic government can initiate development. Given that, it will discuss how such an initiation can be made and what role the forest resources of a country can play in reaching the take-off stage in its economic development. Also, it will analyze the ways in which forest investment and utilization can be used most effectively and efficiently, for meeting the requirements that will have been created if development gets underway. Such analyses have been attempted mainly by Westoby (1962) and followed up by Beazley (1965) and Zivnuska (1966a) but the problem, generally, does not seem to have received much attention from foresters and economists. This thesis is an attempt by a forester to see the entire question objectively and to try to evaluate his standing in an economy which wants to develop.

Although the discussions will be general and applicable to any underdeveloped economy in a broad sense, they will be aimed at India which is making a critical, and the largest, experiment in world history in transforming a stagnant economy into a modern developed country by a democratic process (Taylor et al. 1965).

In the first three chapters comprising Part I the thesis is concerned with pure economics and tries to define and explain the phenomenon of economic development without any particular reference to forestry. In Part II it deals specifically with the role of timber production forestry in economic development and studies the problems of allocation of resources for investment (in forestry) and the rate of utilization of forests in this context.

PART I

THE PROCESS OF DEVELOPMENT

CHAPTER ONE

WHAT IS ECONOMIC DEVELOPMENT?

GENERAL

An easy and adequate definition of economic development is not possible. So vast are the disparities in natural endowments, economic structure, cultural heritage, and social and political institutions among the countries of the world today that any attempt to devise a single criterion for distinguishing "developed" from "underdeveloped" regions is futile. Even definitional approaches that combine a number of indicators of economic underdevelopment have so far proved intellectually unsatisfactory as they include so many variables that they become descriptive rather than analytical in character.

Even as early as 1776 Adam Smith (1784a) was concerned with the

<u>growth</u> of national output over the long-run in his "Wealth of Nations". He observed that the greater the proportion of annual produce to its population the better off was the nation. The "proportion" which was an index of welfare of a people was, for a given endowment of natural resources, considered to be dependent on:

1. the skill, dexterity and judgement with which labour was generally applied, and
2. the proportion between the number of those who were employed in useful labour and that of those who were not so employed. Useful or "productive" labour was thought of as that which the modern economists would treat as employed in production of "goods" only and not "services" (Adam Smith 1784b).

He considered the former of these circumstances as more important and reasoned that specialization of labour brought improvements in it. The welfare of a nation over time would thus be expected to show improvement if the skills of labour and the employment rate increased. It was this increase in the produce of an economy that was called economic growth or economic development.

Schumpeter (1962) defined "development" differently. The mere growth of an economy, as shown by the growth of population and wealth was not designated by him as a process of development. He argued that economic systems had a tendency towards an equilibrium position. This tendency gives the means of determining prices and quantities of goods and is an adaptation of the system to data existing at any time. The system brings about changes in incomes, quantities and prices in its attempt to reach the equilibrium, but these changes do not constitute development in the Schumpeterian sense. The changes that occur while striving for a changed equilibrium position due to changes in non-social data (natural conditions) or in non-economic social data (effects of war, changes in commercial, social or economic policy), or in consumers' tastes are also not classified as development by Schumpeter. Development meant such changes in economic life as were not forced upon it from without but rather those that come about by its changing of its own data, by fits and starts. When discontinuous changes in the traditional way of doing things brought about productive revolutions then development had taken place.

> "Should it turn out that there are no such changes arising in the economic sphere itself, and that the phenomenon that we call economic development is in practice simply founded upon the fact that the data change and that the economy continuously adapts itself to them, then we should say that there is no economic development. By this we should mean that economic development is not a phenomenon to be explained economically, but that the economy in itself without development, is dragged along by the changes in the surrounding world, that the causes and hence the explanation of the development must be sought outside the group of facts which are described by economic theory." (Schumpeter 1962)

Development defined in the narrow and formal sense used by Schumpeter is a "distinct phenomenon entirely foreign to what may be observed in the circular flow or in the tendency towards equilibrium. It is spontaneous and discontinuous change in the channels of the flow, disturbance of the equilibrium, which forever alters and displaces the equilibrium state previously existing."

This concept covers the following five cases:

(1) The introduction of a new good or a new quality of good with which consumers are not yet familiar.

(2) The introduction of a new method of production not yet tested by experience.

(3) The opening of a new market where a particular good has not yet entered.

(4) The conquest of a new source of supply of raw materials.

(5) The carrying out of the new organization of any industry, like creation of monopoly or breaking up of a monopoly position.

Modern authors usually distinguish two broad categories of growth (Ackley 1961). The first type is that involved in the shift from an "underdeveloped" to a "developed" economy, and the second kind is the growth of the already "developed" economy. Hirschman (1963) has used the term "economics of development" for application to the former and "economics of growth" for the latter.

Some characteristics of an underdeveloped economy have been described and discussed by Higgins (1959), Leibenstein (1963) Viner (1963), Samuelson (1964) and Bhagwati (1966) amongst many others. But, as already recorded, no analytical definition of developed or underdeveloped is forthcoming. One of the easiest, though a very arbitrary definition (or rather description), is that a country with per capita gross national product (GNP) below about $500 is underdeveloped (Higgins 1959). This "definition" is not of much value except for the purposes of a very wide distinction between the two categories.

Not only are the income levels in the underdeveloped countries low due to lack of capital and natural resources but also these countries are plagued by over-population; illiteracy; low levels of technology; lack of stable advanced forms of national government; very strong regional, tribal, religious and other parochial feelings; and worse: considerable resistance to change. For a number of years output per person has been almost stagnant in such economies. Except for North America, Western Europe, the Soviet Union, Japan, Australia, New Zealand and South Africa, almost the whole of the world can be put in this category.

The developed economies on the other hand, are those where economic growth can be taken for granted (Reynolds 1963). Some of these economies have been expanding continuously for two centuries or more and have high levels of per capita income. Capital accumulation, population growth and technological advance are the earmarks of further growth of such economies, and it is plausible to assume that they can be analyzed by purely economic tools.

The study of the growth of an underdeveloped economy involves a transformation of the total culture and requires the help of disciplines other than economics, e.g., sociology, political science, anthropology, psychology, pedagogy and engineering of various kinds. The underdeveloped economy has first to be pushed into the category of "developed economy" before the problem of its growth becomes amenable to rigorous economic analyses. Till then, analyses, drawing from other sciences, may be required as the discussions of Tweeten (1966) point out.

If it is recognized that all countries which have not developed to the degree of the most economically advanced are in this sense "less developed", we may picture a continuum of economic development from the least to the most, each country occupying a position in the series. The "less developed" or "underdeveloped" countries would be found near the end of this continuum (Beazley 1965). Viewed thus, "developed" and "underdeveloped" appear to be only comparative terms (Keenleyside 1966).

Till the early thirties the main cause of the development of some countries and the lack of development in others was supposed to be the abundance or scarcity of natural resources (Hirschman 1963). Later on, capital came to be considered the principal agent of development, and now the supply of entrepreneurial and managerial abilities is also treated as being at least as important as capital. The contribution of investment in human beings as productive agents has also been increasingly stressed (Schultz 1956). Other requirements for development are considered to be efficient law enforcement, public administration, public order and various cultural and psychological factors.

Experience seems to have demonstrated fairly conclusively (Hirschman 1963, Keenleyside 1966) that under appropriate conditions any people can learn industrial skills and that countries poorly endowed with natural resources can achieve high levels of per capita output and income. As regards savings, even people living at the subsistence level, by Western standards, collect enough (Lewis 1964) to go through marriage ceremonies or other traditional types of expenditures which may appear extravagant to Westerners. The capacity to save is thus existent in most people. Also lack of capital seldom prevents a profitable project from being carried out. It seems as if all the usually discussed requirements for growth are present in most underdeveloped countries but growth itself is missing. If, somehow, growth takes place the natural resources begin to get used; if they do not exist they are created. Savings are then mobilized and put in the right channels of investments and capital accumulation begins. But how does the growth begin?

This problem appears, on the surface at least, very similar to the problem of cyclical unemployment in the developed economies. There, unutilized capital and unemployed labour exist side by side. It is like scarcity of drinking water in the middle of the ocean. Water is available but not in the form required. If only it could be made available or if the unutilized labour made "available" to the unutilized capital the problem would be solved.

There may really be no great difference between the two problems. The solution to the cyclical unemployment of developed economies can be had through deficit spending or similar Keynesian remedies which recombine the unutilized labour and unutilized machines. In the underdeveloped economies one has to combine the various ingredients. The task, though far more difficult to accomplish than in a developed economy, is nevertheless similar.

For the purposes of this thesis growth of both a developed and an underdeveloped economy shall be defined as a sustained increase in per capita output while the population is static or increasing. This is not only to fit the needs of poor nations into the definition but also because the rich nations also seek exactly the same (e.g., see Phelps 1962 and Gutmann 1964). Such growth will take place only in those economies where the percentage increase in net national product (NNP) every year is greater than the corresponding percentage increase in population.

Growth as defined here does not distinguish between the genuine Schumpeterian growth and the growth due to change in data as described by him. It is the total of the two. Conceivably the proportion of income-increases in developed economies due to Schumpeterian growth will be higher than that in underdeveloped economies. The latter will be adapting themselves mainly to the change in data that will be caused by innovations in the developed economies. It is only if, and when, the underdeveloped countries catch up with the developed ones that substantial proportions of their income-increases can come from growth as defined by Schumpeter. This is not to say that there can not and will not be any such growth in the underdeveloped countries. There may be such growth but, by and large, the underdeveloped economies will take most of their innovations from the developed countries for a considerable period.

Growth, in the sense described, does not concern itself with distribution and assumes that income distribution is perfectly equitable and growing output per capita means that the masses are sharing the increased prosperity. In actual life this assumption is far from being realistic. A more equitable distribution of income may be better than a less equitable one for any particular point in time; but it is quite likely that existence of disparities may be more conducive to future income increases than perfect equitability. The rich usually have a higher propensity to save and therefore large proportions of national income accruing to them may mean larger savings and investments. The neo-classical model of modern theorists, discussed in Chapter Two, shows that an increase in the saving ratio does not affect the rate of growth of the aggregate economy in the long-run, but it does push the rate up in the short-run. Continuing income distributions in favour of the rich may, as a result, mean increasing growth rates in the future. The case for unequal income distribution may thus have some economic justification. But, on social grounds, large inequalities can not be tolerated as permanent features of the society. At their best they can be allowed only as necessary evils so that the future may be better than the present for most people. A policy that permits inequalities in early stages of development but aims to remove them, in the not too distant future, may be the appropriate one for developing countries. With such a policy which presumably would have reconciled the inter-generation inequalities, the assumption made above may be reasonable.

The progress of an economy in this thesis will not be measured by the per capita consumption but by per capita output alone. Output may sometimes grow while consumption declines, either because saving is increasing or because the government is using up more output for its own purposes. But, a reduced consumption can be forced on the population only by a totalitarian regime and, in our case of a democratic government, consumption will normally increase as output increases.

DEVELOPED AND UNDERDEVELOPED

An attempt will now be made to define the developed and underdeveloped economies in an analytical way in the context of Keynes (1964).

The Keynesian consumption function is usually given as a relationship between aggregate income and aggregate consumption in an economy. Yet it is doubtful if Keynes' "fundamental psychological law" could operate in the way visualized by him if the aggregate income increased but per capita income dropped due to a proportionately higher increase in population. The "law" works well only if interpreted in relation to per capita income. Many students of consumption function have made this correction, according to Ackley (1961), but development economists do not seem to have paid much attention to it. This is surprising, as the main concern of economics in the field of development is not just the growth of aggregate income over time but the per capita income. For this thesis, the relationship between income, consumption, saving and investment will be considered on the per capita basis as this appears to be a more reasonable formulation of Keynes' ideas.

Secondly, the income that can be created in any economy depends not only on the number of labourers employed but also on the quantity of capital, natural resources and entrepreneurial capacity available in it. The term "capital" should be meant to include educational capital that makes workers suitable for the jobs that go with the existing level of technology. Only one of these productive factors - capital - will be considered at present, and discussion regarding natural resources and entrepreneurial capacity is postponed.

The already existing quantity of capital determines to a large extent the maximum output that the economy can produce (in the short-run) if all of it is utilized. If a smaller quantity than available is used then, obviously, the output will be smaller. The proportion between the capital equipment used and the current output produced by it ($1/\beta$) will be assumed to be constant in the absence of technological change. That is, marginal capital-output ratio is assumed equal to average capital-output ratio.

In every economy there must be continuous replacements of the used up parts of capital. For our hypothetical economy let us assume a fixed proportion (d) of the per capita capital (k) to be worn out and depreciated every income period. Thus, a per capita investment of kd must be made regularly to keep the stock of capital, and so the per capita income, from falling. This means investing (d/β) of Y every income period per head, where Y denotes the per capita income. Also, let it be assumed that no lags of any kind exist.

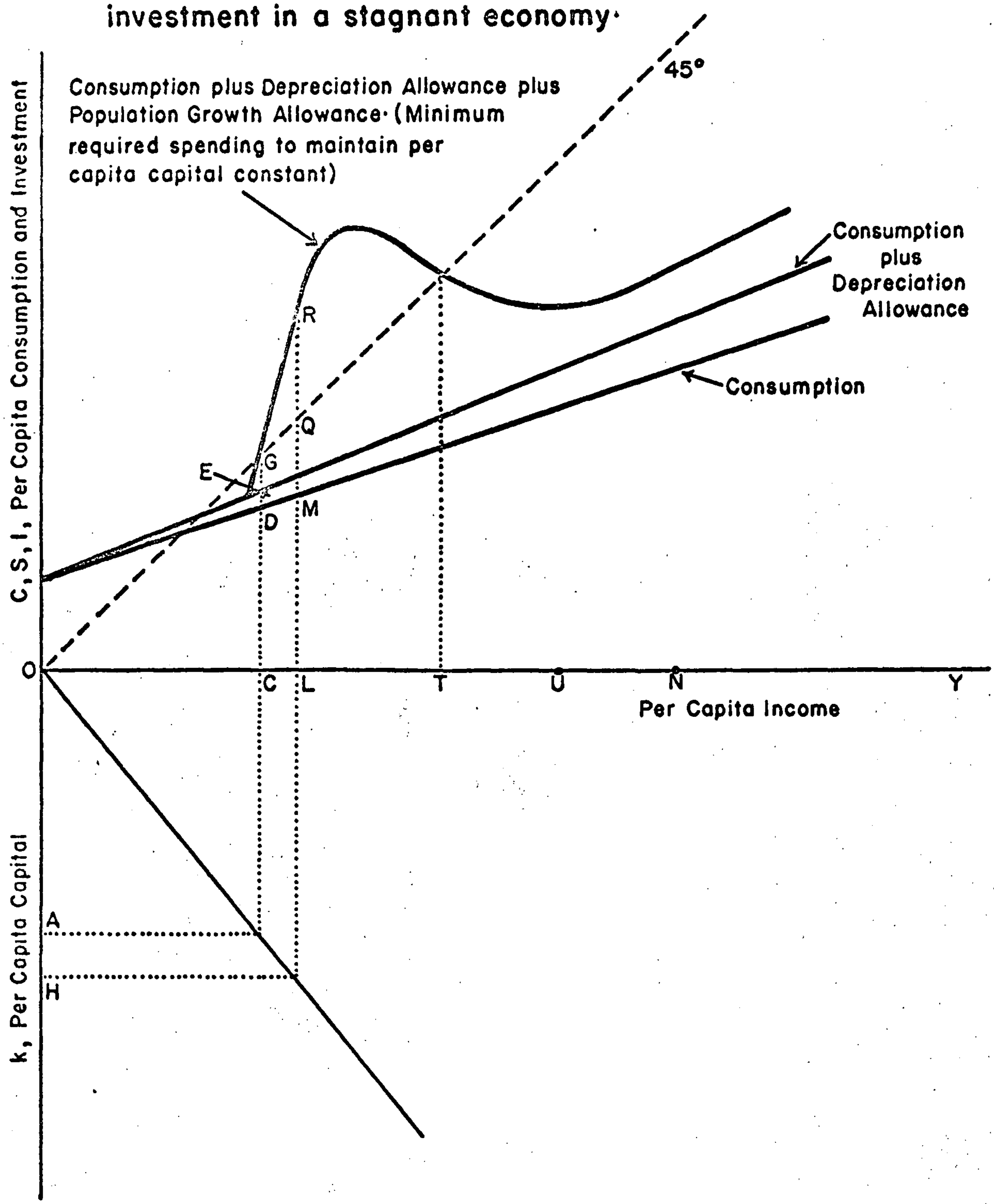
Fig. 1 shows the per capita income, per capita capital and per capita consumption in this economy. It also shows the total demand (sum of consumption plus requirements to meet depreciation) that will keep a per capita income level stable if there is no population growth. This figure as well as all others in this thesis do not have any particular scale on their axes but only show the general shapes of the functions involved.

If population is also growing at a rate of π (expressed as a fraction of the population base) per income period, then an investment of $(\pi/\beta)Y$ in addition to depreciation allowance must be made in each income period to keep the income level from declining.

The value of π can not be expected to remain independent of the level of income, at least not in the underdeveloped economies of the modern world. One of the first investments made in such economies is in improvement of health. Also, the smallest rises in per capita income mean more and better food and generally better medical facilities. Therefore mortality rate is reduced sharply in the early stages of income growth (Lewis 1955).

The birth rate in a community is affected by a large number of variables like age composition of the population, minimum and maximum age at which children can be borne (Dublin et al. 1949), and economic conditions.

Fig. I. Per capita capital, income, consumption, depreciation and investment in a stagnant economy.



It is difficult to say how economic development and birth rate are interconnected (Spengler 1964); yet, it is generally believed that fertility rate - at least in the beginning - is not much affected by rising incomes. As a result, the net effect of development on rate of population increase is initially, to cause a sharp rise in it. Such has actually been the case in India (Coale and Hoover 1958, Mauldin 1964). This may be expected to very gradually fall to a constant level as incomes continue to increase and reducedmortality rates ensure survival of the desired number of children from fewer births. Adelman (1964) has also assumed a sharp rise in growth rate of population with increase in wage rate at low levels and a gradual decrease in it as wages continue to rise. Afterwards, the population growth rate has a tendency to come to a constant level in her assumption. As wage rate and per capita income are directly related, we can assume that population growth rate increases sharply as per capita income rises from low levels, but gradually comes to a maximum and then very slowly falls to a stable rate.

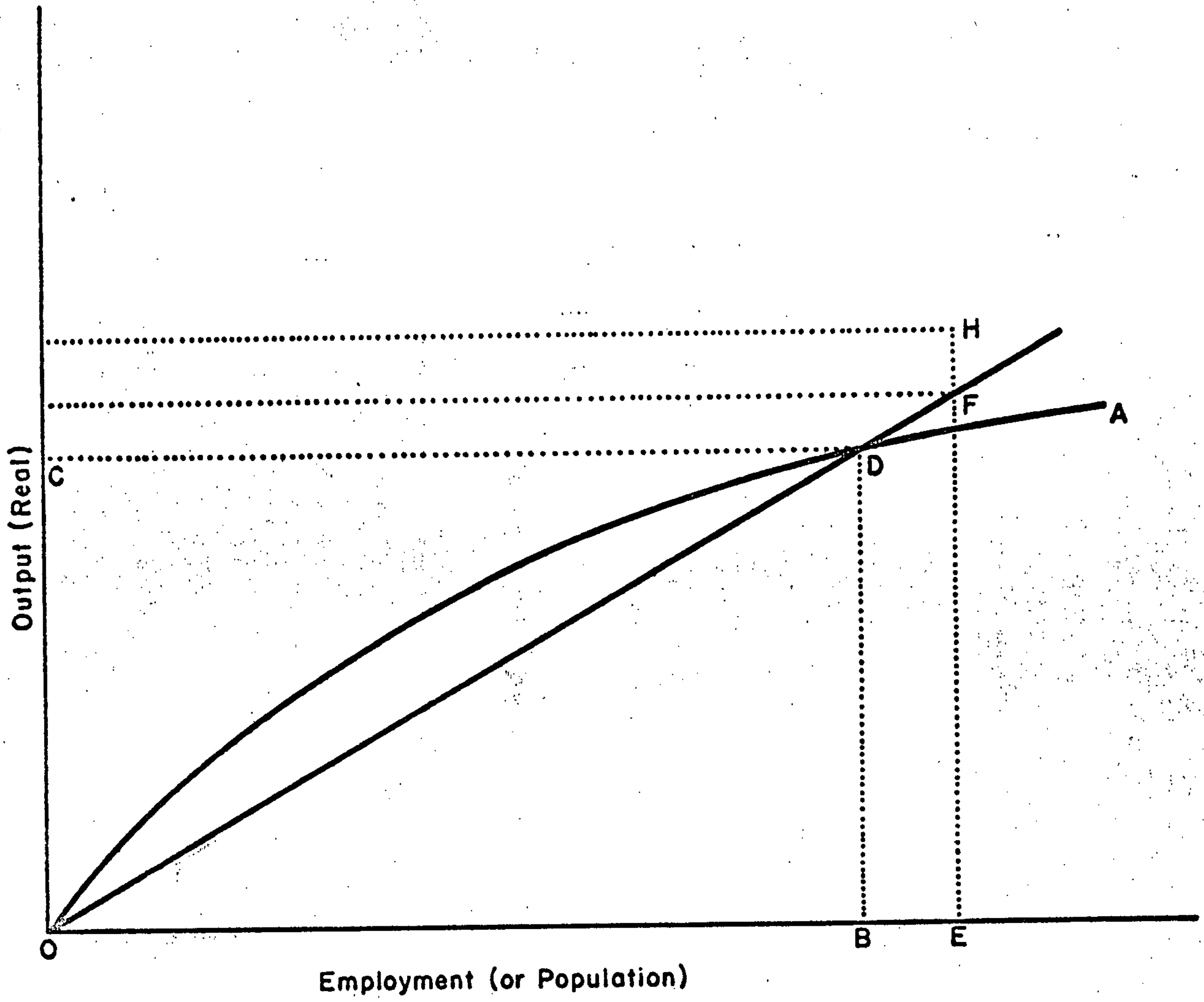
In Fig. 1 the requirements of investment for maintaining the per capita income level in the face of such population growth are shown by drawing a total demand curve for consumption, investment for meeting depreciation needs, and investment for meeting increased population needs. Only if an investment demand equal to that shown by this curve is maintained, can a corresponding income level be maintained.

An economy that has a per capita income of OC, per capita capital equipment of OA, and per capita consumption of CD, will save GD per capita. If the investment is also GD, so that ED goes to replacements and GE to creation of new capital, then the per capita capital will be maintained in the subsequent income periods and the system will be in a sort of equilibrium. Let us define that the "net" investment now is zero. This is a stagnant economy.

Before describing a developed economy let us investigate the relationship between output and employment in an economy with technological change. Keynes (1964) very clearly demonstrated that the employment level is a function of the output level and that full employment is not a natural state of affairs (Hansen 1953). For a fixed quantity of capital in an economy the relationship between output and employment would be expected to be like OA in Fig. 2, because of the diminishing marginal returns.

If an employment level of OB represents full employment of labour then the output level corresponding to it will be OC. Let us assume that the labour force bears a fixed proportion to the total population in the community for the entire period of analysis. Then OB is a measure of the population level and per capita income of DB/OB corresponds to the full labour employment situation. Let this situation be represented by point N in Fig. 1. If population now increases as time goes by, and neither technology improves nor more capital is accumulated, then the per capita income level for full employment will decrease. If, however, the per capita capital in an economy is maintained at its initial level, as is the case with the stagnant economy of Fig. 1, then the curve OA of Fig. 2 is not applicable for determining the per capita income level for full employment. Labour has increased and capital equipment has increased in the same proportion. The per capita income corresponding to full employment may now be greater than, equal to, or smaller than, DB/OB (Fig. 2) depending on whether we assume increasing, constant, or decreasing returns to scale for the aggregate economy. Ackley (1961) suggested that aggregate employment

Fig. 2. Output and employment in any economy.



may show diminishing returns at very high level but, before that stage is reached, output may expand proportionately or even more than proportionately to labour input. The "very high" level mentioned is from the U.S. standards and, therefore, for the purposes of countries less developed than the United States in the present day world, an assumption of constant returns to scale may not be unreasonable.

With such an assumption and still with no technological improvements, as time moves on, the per capita income corresponding to full employment with an increased population will be FE/OE which is the same as DB/OB. This means that the per capita income corresponding to full employment of labour in an economy where population is changing and per capita capital equipment is maintained constant will remain constant.

This, however, does not happen in real life. Technological changes do take place. At least for the purposes of underdeveloped countries better technologies, which they can always copy, are already in use in other parts of the world. All the modern methods of advanced countries may not be suitable for them but some certainly are better than they have.

High yielding maize hybrids, Japanese method of rice paddy cultivation, improved fertilizer use and the Linz-Donawitz oxygen-blowing process of steel production are some of the improvements of technology that can be used by any country (Galbraith 1964b). They economize all resources and are as appropriate for underdeveloped countries as for developed ones. But the labour-saving capital-intensive techniques may not be very useful to the less developed countries. In any case, technological improvement does take place and can be used by both underdeveloped and developed countries, and especially the underdeveloped ones.

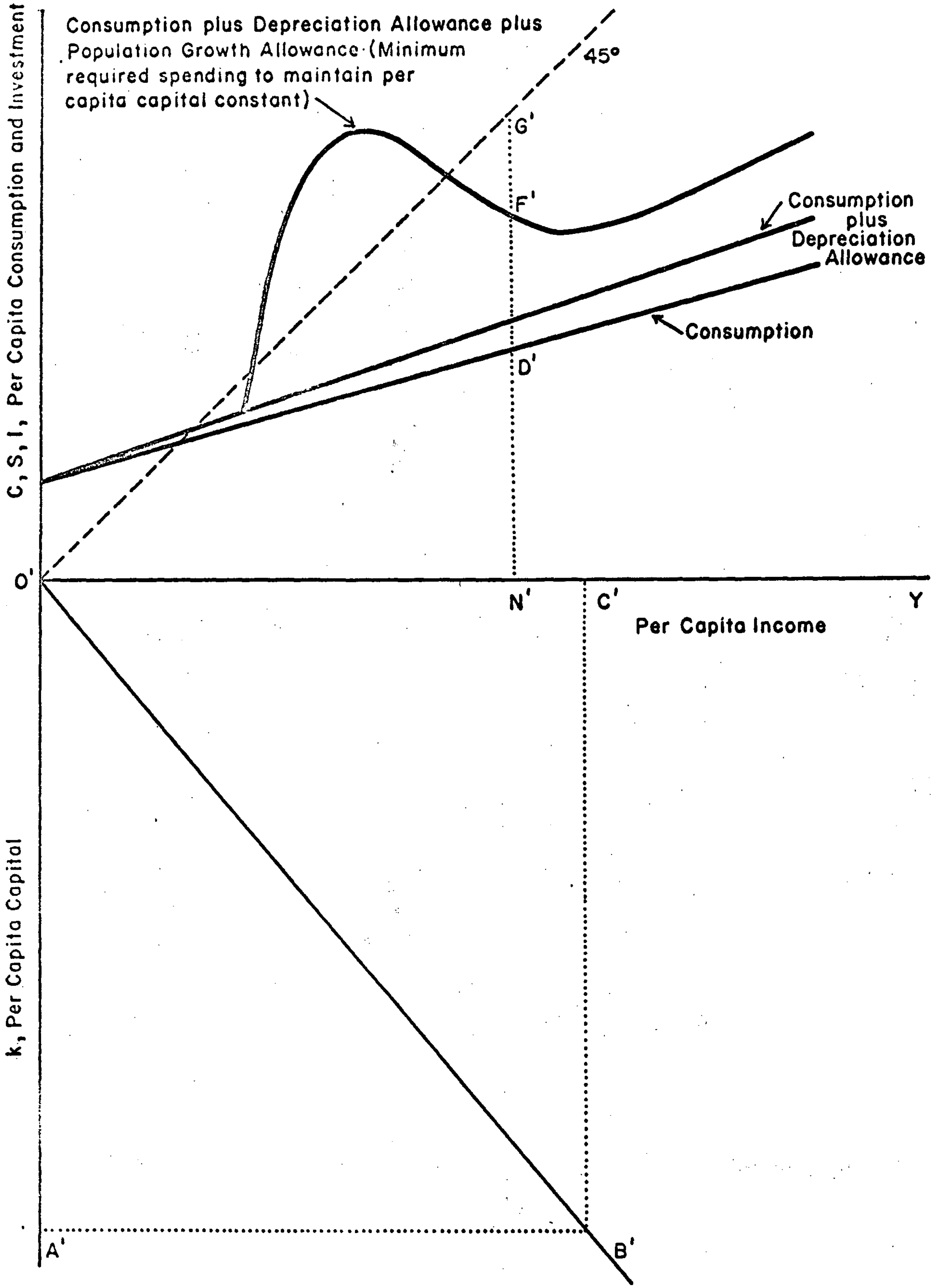
If such improvement has taken place between the time when the population of a country was at levels corresponding to OB and OE (Fig. 2), then we can safely assume that the output level corresponding to OE will not be EF but EH, which is greater than EF.

The per capita income level corresponding to full employment will thus be increasing over time as population increases, capital equipment is increased at least in proportion with population, and as technological improvements are adopted. If capital accumulation is at a rate greater than the population increase (as is bound to happen at one stage or the other) then the per capita income corresponding to full labour employment level (ON) will be moving to the right in Fig. 1 at an even faster rate.

It has been demonstrated here that, in a dynamic formulation of the Keynesian concepts, the per capita income corresponding to full employment of labour continuously goes on moving farther and farther from the origin in Fig. 1.

A developed modern economy can now be described as in Fig. 3. The capital stock in it is more than sufficient to produce the income level that employs all the labour force. The per capita capital equipment available in this economy is O' A' which, if all used, can produce an income level of O'C'. But under the existing technology all of the labour force is fully employed at an income level of O'N' and there is bound to be over capacity. For maintaining the full labour employment level of O'N' a gross investment of G'D' is required. This will result in a net investment of G'F' inspite of the fact that there is already over capacity. With each of these net investments the capital equipment increases and so C'

Fig. 3. Per capita capital, income, consumption, depreciation and investment in a developed economy.



moves further and further to right as time goes by. If at any time there is cyclical unemployment and income level is to the left of N', an increase in investment can improve the situation and the Keynesian prescription works perfectly.

Prescription of increased spending by deficit financing does not have the same effect in a stagnant economy (Rao 1963). An increased investment by itself will not raise the income level until the capital equipment to support it is available. Deficit financing of investments will only cause inflation and the per capita income level will remain stationary at best.

In modern economies the higher the level of income corresponding to full labour employment level, and the greater the efforts of their governments to achieve this level, the higher will be the net investment, unless the "consumption plus depreciation plus population allowance" curve in Fig. 3 remains above the 45^{0} line at all times and at all incomes. Since this possibility is not considered here, one can say that the higher the per capita income in an economy the greater is the amount of per capita net saving and investment. The rate of accumulation of capital will thus go on increasing.

With already existing surplus capacity and the political pressure to make higher and higher investments for the sake of maintaining full labour employment, the excess capital in the economy will grow. Under such circumstances it is very likely that new innovations or technological advances will be in the direction of greater capital-intensity. This will increase the output and so income per head, and therefore, the full labour employment level will shift to the right. The economy will thus go on growing larger and larger if governments try to keep always striving for the full employment stage.

The stagnant economy can move forward only if its capital equipment increases. This can happen either by getting such equipment from a developed economy or by forcing a reduction in consumption below the CD level in Fig. 1.

If somehow the stagnant economy increases its capital equipment to the level OH (Fig. 1) then it can generate per capita income of OL and can maintain it there only if all the equipment is used, all the domestic savings of QM are invested, and in addition a foreign investment equal to RQ is made. If the foreign investment is not forthcoming and consumption can not be pushed below LM, by a quantity equal to RQ, then the per capita capital can not be maintained at level OH and so the per capita income will fall to OC again. If foreign aid equivalent to RQ is available, income levels can be just maintained at OL. For any improvements in this, more foreign aid than RQ is essential. With the type of consumption function assumed here foreign aid will be necessary not only to push the income levels up, to OT but also to hold them where they are at levels below OT. At the stage when OT is reached no foreign aid will be needed to maintain that income as, at this level also (like at OC), the gross domestic savings are just equal to the investment needed to adequately care for depreciation and population growth and thus maintain the per capita capital constant. A small push to the left from here will make the economy go to OC again if foreign investment is not available. But a push to the right will enable it to be independent of foreign aid in future. From here onwards, if only all the domestic savings are invested in each income period, a continuous growth in the per capita capital is assured.

Rostow's (1960) stages of economic growth have been criticized on the grounds that there is no statistical way of identifying them (Kuznets 1964). In this analysis, although we are still far from being able to identify a "stage" in a statistical sense, we certainly can define the per capita income level of OT (Fig. 1) as the take-off stage. Once beyond OT, economic development will occur without our consciously trying to achieve it provided we try to achieve full, efficient employment of capital. At income levels below OT the system can not develop on its own. There, either methods designed to reduce normal consumption must be used or foreign aid must be sought. The level OT will be different for different economies. This will be so because the consumption function, rate of depreciation and population growth patterns will undoubtedly be very different in countries with diverse cultural and economic backgrounds.

Just because it has an income (per capita) above OT (Fig. 1), does not mean that the country can be called a developed one. With the given level of technology all the capital equipment may be fully used up at an income level of OU. But all the labour force can be fully employed only at ON and so the country is still underdeveloped. It will be called a developed country only when per capita capital equipment is enough to produce an income level higher than ON. While trying to reach this stage it must be realized that the point N itself is continously moving to the right as improvements in technology take place. Reaching take-off may signify much progress but the goal of overcoming underdevelopment is still far off.

Natural resources and entrepreneurial capacity can now be introduced into our model. Both can be put on the axis where per capita capital equipment has been shown so far, and these can set a maximum limit to the per capita income that can be generated. An economy will be underdeveloped until these limits by natural resources and entrepreneurial capacity are equal to or greater than the level of income corresponding to full employment of labour.

So far it was assumed that the line, showing total of consumption, depreciation allowance and population growth allowance for maintaining per capita incomes stationary, is above the 45^0 line in Fig. 1, between the income levels that are identified with stagnation and take-off. In the light of our knowledge of the underdeveloped countries of the contemporary world this seems to be a reasonable assumption. If, however, in any country it is not so, and the required total to keep per capita capital levels from falling is less than the income level itself, then the country is not likely to have any problem in reaching the take-off stage.

The consumption function used in this discussion has been the Keynesian short-run relationship. The difference between the two kinds of economies described is therefore relevant only in the short-run. In the long-run the argument remains the same as already discussed, but the consumption function changes. As long as this consumption function remains upward sloping the basic difference between a "developed" and "underdeveloped" economy will continue to be what has been shown in this section. The long-run consumption function is discussed in greater detail in Chapter Three.

Apart from describing the difference between an underdeveloped and a developed economy, the discussions of this chapter point out that there seems to be nothing automatic about development as such. There is nothing built into the system which will spur it to achieve higher and higher per capita income levels. It is only the social and political forces in developed countries which induce their governments to seek the full employment of labour and this inadvertently causes the productive capacity of the economy to grow. In underdeveloped countries, also, it is the social and political forces that compel their governments to desperately seek higher standards of living and thus initiate action leading to growth in one way or the other. Unless a large number of conditions are fulfilled simultaneously, it is evident that only the lucky countries can achieve growth. This may probably explain why conscious attempts at development are often frustrating.

CHAPTER TWO

THEORIES OF DEVELOPMENT

CLASSICAL THEORIES

For this thesis development has been defined as a "sustained increase in per capita output". This can also be expressed as sustained increase in productivity of labour because per capita output and average productivity of (all kinds of) labour are almost the same thing. The theories of development deal with this increase in productivity of labour in the aggregate but not with any increase in any particular enterprise. Economic productivity of an enterprise may increase simply due to increase in profits but this does not necessarily increase the aggregate income (unless it is assumed that everything else remains the same) and, therefore, productivity-increases at micro-economic level by themselves, do not constitute the theories of development. The increased physical productivity at the enterprise level has much influence on the process of development but it is only the increased productivity at the aggregate level that is the subject of these theories.

The classical theories of development that are discussed here are those of Adam Smith (1723–1790), Thomas Robert Malthus (1776–1834), David Ricardo (1772–1823) and Karl Marx (1818–1883).

Adam Smith recognized the existence of three factors of production: labour, capital and land (Adelman 1964). In mathematical terms he said that:

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

where Y is the output, K is the amount of the services of the economy's capital stock employed, L is the amount of labour employed and N is the rate of use of land or natural resources. Labour was considered to be the sole standard of value.

He did not postulate any diminishing marginal returns but said that the production function was subject to increasing returns to scale as a result of internal and external economies arising from increases in market size. Economies of scale were realized in production and in marketing owing to a greater degree of division of labour and to general improvements in machinery. Once set in motion this development process of increase in output would thus appear to be self re-inforcing. But what caused the market to increase in size? The answer was greater productivity due to division of labour, which in turn occurred due to an increase in the size of the market.

Amount of capital in existence and the institutional restrictions that are placed upon trade were the factors that offered a way of breaking into the interdependence of market size and greater productivity. In Adam Smith's opinion the fundamental determinant of growth was the rate of capital formation, and the rate of progress of the economy was proportional to its rate of investment. However, the rate of capital formation depended crucially upon the relationship between the market rate of net profits (r) and the minimum consistent with compensation for risk bearing ($\bar{r}$). Both of these depended on the institutional organisation. Freedom of international trade, regulation of competition, security of life and property, and political institutions all played a role in establishing the relationship between r and $\bar{r}$. If the legal and political systems were favourable then the difference between r and $\bar{r}$ could be maintained or even increased. This could contribute significantly toward increasing the flow of investment. An unfavourable system would close the gap between the r's and choke off all capital formation. Adam Smith considered free trade as one of the most favourable institutions for progress. He also considered government interference in economic affairs as very unfavourable.

The major contribution of Malthus to economics is the bringing of the problems of population growth into economic questions. He saw in the process of capital accumulation not the key to a theory of growth but the proof that the development then on record was a fleeting phenomenon. Increase in capital stock would permit the capitalists to take advantage of improved techniques and would also raise the wages fund. This would mean a higher wage rate only if the number of workers did not rise in proportion. A higher standard of living of labour would cause an increase in population that would increase the labour force and so reduce the wage rate again. Population could not rise without a proportionate or nearly proportionate increase of wealth (Higgins 1959), but a natural tendency toward population growth was not seen by Malthus as a guarantee that either population or income would grow.

He showed more appreciation than most of his contemporaries of the importance of a distinct and systematic theory of growth. He recognized that mere increases in numbers do not provide a stimulus to economic expansion, and that population growth encouraged development only if it brought an increase in demand. He flatly repudiated "Say's law" and did not believe that savings were demand for capital goods. Savings for him meant non-consumption and so reduction in demand.

He also believed that abstinence on the part of capitalists, far from accelerating economic growth, would, in itself, retard it. He recognized the need for saving and investment for economic growth but suggested a concept of "optimum propensity to save". Up to a certain point saving was needed to finance (without inflation) the investment for which profitable opportunities existed. Beyond that point saving would reduce consumer spending to such an extent that investment too would be discouraged.

One of the most important anticipations of Malthus was the theory of "dualism" as applied to underdeveloped countries (Higgins 1959). He envisaged the economy as consisting of two major sectors: one industrial, one agricultural. Technological progress was regarded as a phenomenon confined to the industrial sector - at least in the advanced countries. This sector showed increasing returns, and the agricultural sector had diminishing returns, as its primary characteristic. This picture was a good approximation to reality in Nineteenth century England.

The Malthusian picture of economic development seems to have been one in which capital was invested in agriculture until all the arable land was brought into cultivation, stocked and improved. After that there were no more opportunities for profitable investment in that sector, and investment opportunities existed only in the industrial sector. Diminishing returns to increased employment on the land could be avoided only if technological progress in the industrial sector was rapid enough, and if enough investment took place, to absorb most of the population growth in the industrial sector and to reduce the cost of living of workers on the land, permitting reductions in their corn (goods) wage rates.

Because of no opportunities for investment in the agricultural sector, and increase in population due to a higher wage level, the economy would move towards the stationary state (stagnation). He proposed late marriage and abstinence as means to check population growth.

The other great classical economist, David Ricardo, postulated a production function like that of Adam Smith where output depended on land, labour and capital. But unlike Smith he subjected it to diminishing marginal productivity. The marginal productivity of all three factors was assumed to decline as a greater proportion of each was employed. At the same time technological progress shifted the production function upwards, according to him, and thus the rapidity of the decline of marginal productivity was counterbalanced by improvements in technology. The technological progres in manufacturing was believed by him to be so rapid that historically this sector would be seen to be displaying increasing returns. In the agricultural sector, however, technological changes were assumed to be insufficient to affect the tendency for diminishing returns and would only temporarily check costs of production. These assumptions may not be correct for the developed countries of today but they certainly seem to be relevant for countries like India where agricultural techniques have long remained stagnant (Adelman 1964).

As technological progress determines the point where diminishing returns begin, the production function is in effect:

$$Y = f\ (K,L,N,S) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where S denotes level of technology employed by the economy.

Ricardo defined profit as the return to capital and labour above the subsistence wage at the margin. At the margin there is no rent and so a higher subsistence wage would mean a lower profit. Hence, the tendency of profit would be to fall as more and more labour is used to procure additional quantities of food. Periodically, this tendency would be checked due to technological progress and so profits would increase and therefore capital accumulation would become faster. He erroneously believed technological progress itself as subject to diminishing returns and so the long-run trend of profits as downwards.

At first, the rate at which profits would fall due to diminishing returns would be sufficiently slow to permit the share of profits in total output to increase. At the beginning stages of growth, as a result, capital accumulation would proceed at an accelerated pace. The downward pressure upon capital accumulation exerted by the falling rate of profits would be outweighed by the upward pull of a larger net surplus above subsistence. However, as society expanded, the share of profits in total output would begin to drop. The rate of capital accumulation would slow down. Ultimately, as the pressure of an increasingly larger population required the cultivation of poorer and poorer land, the portion of the product at the margin swallowed up by the subsistence wage would become so great that profits would approach $\bar{r}$. When this happened capital accumulation would stop, population would remain constant, and the economy would enter the stationary state. Normal progress of this economy toward the stationary state would be punctuated by periods of temporary equilibrium, during which wages would be at the subsistence level and size of population stationary. Since, during these periods the rate of return on investment would be above $\bar{r}$, these temporary equilibria could not persist.

The role of Karl Marx's thoughts in modern attacks on the problem of economic development is very different from that of other classicists. Even though he was the only classical economist who made development as the central theme in his general scheme of thought (Schumpeter 1954), so far as pure economics is concerned, his system is less directly applicable to problems of underdeveloped countries than that of Malthus. He did not think of underdevelopment as an enduring condition, but as a pre-capitalist one. The underdeveloped countries would, unfortunately, have to go through the capitalist phase before they reached the bliss of communism (Higgins 1959). He did not discuss population pressure and so his ideas can not be applied easily to today's underdeveloped countries.

The Marxist sociological and political theory does provide some clues to the economic history of underdeveloped countries. It focusses attention on power relationship between classes and compels one to see whether the existing relations are a barrier to growth. In the countries of Western Europe about which Marx wrote, such relationships are irrelevant today, but may still be important in some underdeveloped countries. Marx's theory suggests that causes of underdevelopment may be in the economic conditions of the colonialist country rather than in those of the colonized. Conditions in many of the underdeveloped countries today are not very different from those predicted by Marx for the presently advanced ones: exploitation of labour, wages close to subsistence, large armies of unemployed, sharp class structure and a very small or non-existent middle class and sometimes even increasing misery. Under such circumstances revolution of one sort or the other should not be a surprise.

The greatest contribution of Marx to development of underdeveloped countries is in the fact that nations like the Soviet Union exist today. For political reasons communist nations have either themselves taken a hand in development of backward economies or have, inadvertently, pushed the Western countries into doing so. It is doubtful if the world would be as seriously concerned with the problem of underdevelopment as it is today if there were no communist block in it.

NEO-CLASSICAL THEORIES

The theories of economists of the last quarter of the Nineteenth and the beginning of the Twentieth century are included under this heading. The neo-classical economists, most important among whom were Alfred Marshall (1842-1924), Leon Walras (1834-1910), W. Stanley Jevons (1835-1882), Carl Menger (1840-1921), and Knut Wicksell (1851-1926) did not pay much attention to the theory underlying considerations of economic development. Their interest was more in the theory of the individual or of the firm than in development. Their major contribution to the understanding of economic development was in the marginal analysis and the theory of general equilibrium. Though their viewpoints have more of an indirect than a direct influence on modern theories of economic development, nevertheless the influence is great.

The neo-classical system can be studied by first looking at a static system of Walrasian type (Watson 1963). In this competitive system there are neither savings nor investments. All the land and capital is always used regardless of the price levels. The amounts of labour offered by households and the amounts of other goods and services bought by them depend on relative prices of various consumer goods, capital goods, land and labour. The demand for consumer goods depends on prices of other goods and productive factors. The supply of factors depends on the prices of consumption goods and production factors. Amounts of each factor used per unit of output of a commodity depend on relative prices. The price of each consumers' good equals its cost which is equal to the sum of the values of the productive services required to produce it. In this system no economic development of any sort occurred even after Wicksell replaced Walras' fixed "technical co-efficients" by productivity functions.

The implied theory of economic development of the neo-classicists can be seen if capital formation is introduced into this model. If each type of capital good can be produced in the economy in addition to consumers' goods then the factors of production will be distributed amongst capital goods and consumer goods according to their relative prices, and prices of production factors. Also, the price of each capital good must be equal to its cost. An interest rate also develops because the neo-classicists postulated that consumers choose between consumer goods and savings. What is not spent on consumption goods is spent in one way or the other on capital goods.

In this theory, capital goods, like any other goods, must be produced in such quantity that their prices are equal to their production costs. And, as capital goods are factors of production, their demand curves must intersect the supply curves at precisely these prices. With a given amount of labour and no technical innovation, the demand for capital will decline as accumulation goes on and so savings will be discouraged as interest rates will fall. The system will gradually move to no savings and thus stagnation. As a matter of fact, the notions of profit, capital accumulation, and development fit into the neo-classical model only as consequences of a shift away from the position of equilibrium or stagnation. In this position, the remuneration of capital has to be the same in all its applications and corresponds to the rate of interest. To the extent that the profit or remuneration to capital is in a particular sector higher than average, it is to be deduced that optimum distribution of productive resources has not been achieved, for it is possible to increase the productivity of a factor by shifting it to another sector. As accumulation, i.e., net investment, takes place only when profit is anticipated, Furtado (1964) claimed that in the neo-classical theory, optimum utilization of resources was incompatible with an economy in a state of growth. Hence, although in the classical model stagnation represented a limit towards which an economy in development tended, in the model of the neo-classical economists, it was a "must" for the optimal operation of the economy. Furtado's claim can not be justified if it is admitted that technological progress could be taking place in all sectors in such a way that profits increase equally in them.

In this theory growth occurs because of geographic expansion, technical innovation and continuous investment. In the small world of the neo-classicists, which comprised Great Britain, Western Europe and North America, there was little evidence that they were wrong. Long-term-equilibrium underdevelopment was considered impossible by them.

Wicksell probably contributed more to the modern thoughts on economic development than his contemporaries. He not only paved the way for dynamic theory and mathematical economics and developed the theory of distribution and marginal productivity; but also made such contributions to capital theory as the Wicksell Effect which Robinson (1956) considered as the key to the whole theory of capital accumulation. The Wicksell Effect may not really be the "key" to capital accumulation (Blaug 1962) but the contributions of Knut Wicksell to the methodology of modern theories of development are considerable. He does not seem to have received due recognition in this field.

MODERN THEORIES

Economists seem to have lost interest in development theory from the time of Marx until the Nineteen Thirties when the problems of the great depression led many of them to the subject. The sole exception, in this period of neglect for half a century, was Joseph A. Schumpeter (1883-1950) who as early as 1912 published his "Theorie der wirtschaftlichen Entwicklung" (Haberler 1964) and suggested that economic development rested on technological innovations. The most complete statement of his analysis of capitalist development came in his "Business Cycles"

(Schumpeter 1964). Though his system was in the neo-classical tradition (Duesenberry 1950) it has three important differences:

1. His theory of saving.
2. His theory of interest rate.
3. His idea of the process of capital formation.

Voluntary savings according to Schumpeter are made only by entrepreneurs. Saving is done out of their profits to repay bank credit. He defined savings not as the difference between income and consumption but as that part of the difference which is intended as a permanent addition to assets. Thus, residential housing, educational investments and accumulation for future purchases or retirement are not savings in his sense.

He said that all investment is financed out of bank loans and so interest rate is what the banking system makes it. There is no need for the rate to be such that it will equate savings and investment. He also postulated that investments are not made in response to favourable conditions but as a result of the vision and imagination of an innovator or entrepreneur.

An economy always has the tendency to settle down to an equilibrium but is moved away from it by innovations which appear all of a sudden. Innovations first cause an increase in prosperity then a recession, succeeded by the appearance of a new equilibrium. His viewpoint has been described as optimistic by Gittinger (1955) and pessimistic by Higgins (1959) but he himself denied that it was "deafeatist". In any case he had a large element of tautology in his theory of economic growth. Economic growth, according to him, occurred when the social climate was conducive to the appearance of a sufficient flow of innovators, but the only real way to test whether the social climate was appropriate was to see whether the innovators were in fact appearing; that is, whether there was economic growth. If vigorous economic growth appeared, the social climate was appropriate; when there was no vigorous economic growth, the social climate was by definition inimical to it.

Even though the theory may be non-testable, it certainly has some relevance to the problems of underdeveloped areas. The lack of adequate entrepreneurship is one of the most frequently cited obstacles to "take-off" in such countries. Also the social climate, e.g., the attitude towards businessmen in some places, may be inimical to the growth of entrepreneurship.

Modern interest in economic development was revived in 1936 with Keynes (1964). He was, however, concerned mainly with the problems of unemployment caused due to lack of enough demand in an economy where productive capacity was not in doubt. His theory does not have direct application to the problems of underdeveloped countries, but provides new analytical tools and intellectual stimulation that are of great importance to underdeveloped areas.

Keynes' proposal differs from the classical view that savings and investment are brought to equality by changes in the rate of interest. He suggested that the two are brought to equality by changes in national income. He also pointed out that new investment in capital assets is more or less autonomous and unstable. It need not necessarily rise when income rises, or fall when income falls. He also viewed savings as a function of national income rather than of the rate of interest. If savings exceed investment the income would fall and if investment was greater than savings income would rise till the two are equal.

The mechanism of determining the rate of interest, which determines the level of investment is the main contribution of Keynes to the formal theory of economic development (Gittinger 1955). He suggested that liquidity preference prevents the interest rate from falling beyond a certain point (about 2 per cent) and can be the cause of an insufficient amount of investment to maintain a given level of income. Income would have to fall until a low level of employment and output was reached which would result in a level of income at which the equation between investment and what people wished to save was achieved. An unemployment equilibrium was thus shown to be possible; the economists of earlier days did not admit this.

Many of the concepts of Keynesian analysis are not applicable to underdeveloped economies. Rao (1963) pointed out that the secondary, tertiary and other increases of income, output, and employment as a result of investment do not operate despite the high marginal propensity to consume. Also, because of the rigidities of economic organization, primary producers cannot increase their output in proportion to their income. This is suggested to mean that in effect the income multiplier is higher than in real terms. Another argument of Rao is that a large proportion of any increase in income will be directed toward food and will reduce the marketable surplus of food grains with serious effects on non-agricultural prices. Thus the forces operating in underdeveloped countries tend to lead neither to higher income nor to higher employment. Rao conceived of economic development as taking place on two levels: development within a given structure and development by moving from a lower to a higher stage of economic development. The Keynesian analysis is held to be valid only for the development within a given structure, while the aim of underdeveloped nations is to move from one structure to a higher one.

Singh (1954) also pointed out that the Keynesian analysis is a special case not applicable to the actual economic conditions which exist in underdeveloped areas. He suggested that industrialization was essentially a matter of economic organization and not centered around the Keynesian "spiral of saving and investment". It seems that what Singh was concerned with is the means of encouraging economic development by utilizing underemployed resources.

At this point it may be helpful to refer to the distinction between the "growth theories" and "development theories" that have appeared after Keynes. The "growth theories" deal with the way economies actually grow over time and have nothing to do with underdeveloped countries in particular. The "development theories" on the other hand try to explain how the backward countries of contemporary world can be moved from their low income levels to higher levels of prosperity. In spite of the difference seeming to be fairly obvious, both may in fact be investigating the same problem. England's growth from the pre-Industrial-Revolution era to the present day is a subject of "growth economics" but is also exactly what "development economists" would like to understand and want to see happen to the underdeveloped countries. If growth economists can explain how underdeveloped England transformed itself into a developed nation, then the development economist might be able to suggest a way of doing the same to the less developed economies of today. One main difference between the two situations is that England was not in such a great hurry as the underdeveloped countries are today. This is because England did not have, at that time, any society in sight which was very much better off than herself. Today poor countries know that there exist nations, where not just a few but a very large majority of the people are living a far better material life than their own. As a result they no longer accept poverty as an inevitable way of life (Black, E.R. 1963, Hoffman 1966). But for this difference which lends urgency to the problems of underdeveloped countries, the two kinds of studies may actually be investigating the same problem. It may be that to a large extent it is because of this urgency or lack of patience that disciplines other than economics have also to be drawn on for formulating policies of development. Recognizing that "growth" and "development" may not be so very different as is sometimes implied the post-Keynesian work in the field is reviewed below under separate sub-headings.

Growth:

The post-Keynesian theories of economic growth have been very neatly surveyed by Hahn and Matthews (1964). Their central concern has been with the theoretical models of economic growth. Problems of optimum saving and the development of backward countries have not been considered by them. The survey takes the Harrod-Domar model (Harrod 1939, 1952; Domar 1947, 1957), which will be briefly outlined here, as the starting point.

The approach of this model differs from that of the classicists. The classical theories treated economic development as a race between technological progress and capital accumulation on the one hand, and diminishing returns to a growing population applied to a fixed supply of land on the other. Population growth was a dependent variable, mutually determined with profits, investment, income and so forth. The Harrod-Domar model, like Marx, discarded diminishing returns from land as a "primary determinant", and considered both the rate of population growth and the rate of technological progress as independent variables in advanced countries (Higgins 1959). In it, the three "fundamental elements" are (1) manpower, (2) output per head, (3) quantity of capital available.

The major assumptions of the Harrod-Domar model are:

(1) A constant proportion (s) of income (Y) is devoted to savings, i.e., average and marginal propensities to save are equal.

(2) The amounts of capital and labour needed to produce a unit of output are both uniquely given. This can also be expressed by stating that the capital-labour ratio is fixed.

(3) The labour force grows over time at a constant rate, n, fixed by non-economic, demographic forces.

Other assumptions that are commonly made in this and many other models are:

(4) There is only one good which can be used either for consumption or else as an input in production. Thus output and capital can be measured in the same units.

(5) Labour is the only other input in production.

(6) There are constant returns to scale

(7) There is either no technical progress or if present it is neutral in the Harrodian sense.

(8) Prices are constant.

(9) There are no lags of any kind.

(10) Savings and investment refer to the income of the same period.

The requirements for steady-state growth in Y, i.e., changes in Y when the proportional rate of growth of all the relevant variables remains constant over time (Hahn and Matthews 1964), may be looked at from the side of two inputs, labour and capital, separately. As the two inputs are not on a par due to one (capital) being a produced means of production and the other not; the requirements will be different.

Since labour requirements per unit of output are given, it will not be possible for Y to permanently grow at a constant rate greater than n. If there is to be steady growth in Y we must have $g < n$, where g is the rate of growth of Y. If $g < n$ there will be increasing unemployment over time. If increasing unemployment is incompatible with equilibrium, the necessary condition for steady growth becomes $g = n$. In Harrod's terminology n is the natural rate of growth, i.e., the highest rate of growth that is permanently maintainable.

As regards capital, the amount people plan to save must equal the amount they plan to invest if equilibrium is to be had. Also, producers must at all times have just that amount of capital they require for current production. The stock of this capital grows at the rate I/K where I is planned investment, and K is the capital stock. Due to a fixed capital-labour ratio and no technological progress, the capital output ratio (v) is constant and therefore the rate of growth of output or income must equal the rate of growth of capital stock in the steady state. The rate of growth which will ensure that producers have just the right amount of capital was called the warranted rate of growth by Harrod and can be expressed as

$$g_w = \frac{I}{K}$$

$$= \frac{I}{Y} \cdot \frac{Y}{K}$$

$$= s/v$$

I is the ex ante investment and is proportional to the expected increase in output. When growth at rate g_w is taking place so that $g_w = s/v$ then it is steady state growth from the point of view of capital, one of the factors of production.

Considering both labour and capital, therefore, it is required that for steady state growth the rate of growth (g) be equal to n as well as s/v, i.e.

$$n = \frac{s}{v}$$

Since n, s and v are independently determined, this will be possible only in a special case. In a more normal situation the natural (n) and the warranted (g_w) rates of growth will diverge. If g_w is greater than n then most of the time the actual rate of growth (which will be smaller than n) will fall short of g_w. This means that investment ex post will run ahead of investment ex ante and excess capacity will appear. This is the case of secular stagnation. When g_w is smaller than n the actual rate of growth will mostly remain above g_w and ex post investment will continously fall short of ex ante investment. This is the case of secular exhilaration (Peterson 1962).

It is thus seen that in the Harrod-Domar model full-employment steady growth is possible only by coincidence and is not at all assured. If the possibility of steady growth is to be assured then one or more of n, s and v must be allowed to be adjustable. Hahn and Matthews (1964) have listed the following assumptions which give rise to models that assure steady state growth. These assumptions can be combined in various ways.

1. Labour-market Assumptions. If the labour market works in such a way that full employment is merely a ceiling, and equilibrium in the system is not incompatible with growing unemployment, the equation $n = s/v$ is replaced by the inequality

$$n > s/v$$

So long as this condition is satisfied, the warranted rate s/v is a steady state path of a sort.

2. Labour-supply Assumptions. The rate of growth of labour force, n, may be a variable that responds to economic pressures rather than a constant. The equality of n and s/v may then be achieved not by the result of a happy accident, but by the adjustment of n.

3. Technology Assumptions. Instead of there being fixed coefficients in production, there may exist a production function offering a continuum of alternative techniques, each involving differing capital-labour ratios; or else there may be not a continuum of alternatives but a finite

exhilaration (Peterson 1962).

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3. Technology Assumptions. Instead of there being fixed coefficients in production, there may exist a production function offering a continuum of alternative techniques, each involving differing capital-labour ratios; or else there may be not a continuum of alternatives but a finite

number of alternative techniques. The consequence is that the capital-output ratio v is adjustable. This provides a way in which n and s/v may be brought into equality.

This assumption is the crucial one for the "neo-classical" models of Meade (1961), Solow (1956), Swan (1956), Samuelson (1962) and Tobin (1965). It may be noted that these models are quite different from the "neo-classical theories" discussed earlier in this chapter.

4. Saving Assumptions. The equality of n and s/v can also be made possible by flexibility in s. The most common assumption that gives rise to flexibility in s is that of differences in the propensities to save of wage earners and profit earners.

Hahn and Matthews (1964) have discussed a number of growth models which can be linked in one way or another with the better known Harrod-Domar model by making one or more of the above assumptions. The "neo-classical" model with flexible capital-output ratio is one of these and will be discussed now.

This model has been put forward as a single sector model by its authors but can easily be extended into a two-sector and n-sector model. In its n-sector form it can be related to the Leontief (Leontief 1951) and Neumann (von Neumann 1938) models. The production function in the model is

$$Y = F(K,L) \qquad (3)$$

where Y is output, K the capital employed and L the labour employed. The model has constant returns to scale but shows diminishing marginal products with respect to proportions of capital and labour. Thus, if labour is held constant and capital is increased, then output-capital ratio (1/v) will decrease as capital-labour ratio (K/L) increases. At this stage it is assumed that no technical progress occurs.

The fixed saving ratio assumption of the Harrod-Domar model is still retained and planned savings are equal to planned investments. Therefore

$$\Delta K = sY$$

or, if continuous variables are considered,

$$\dot{K} = sY \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The assumption that there is no depreciation is retained at this stage but can be relaxed later if desired.

If the labour force grows at a constant proportional rate determined exogenously, and the same proportion of the force employed, then:

$$\dot{L} = nL$$

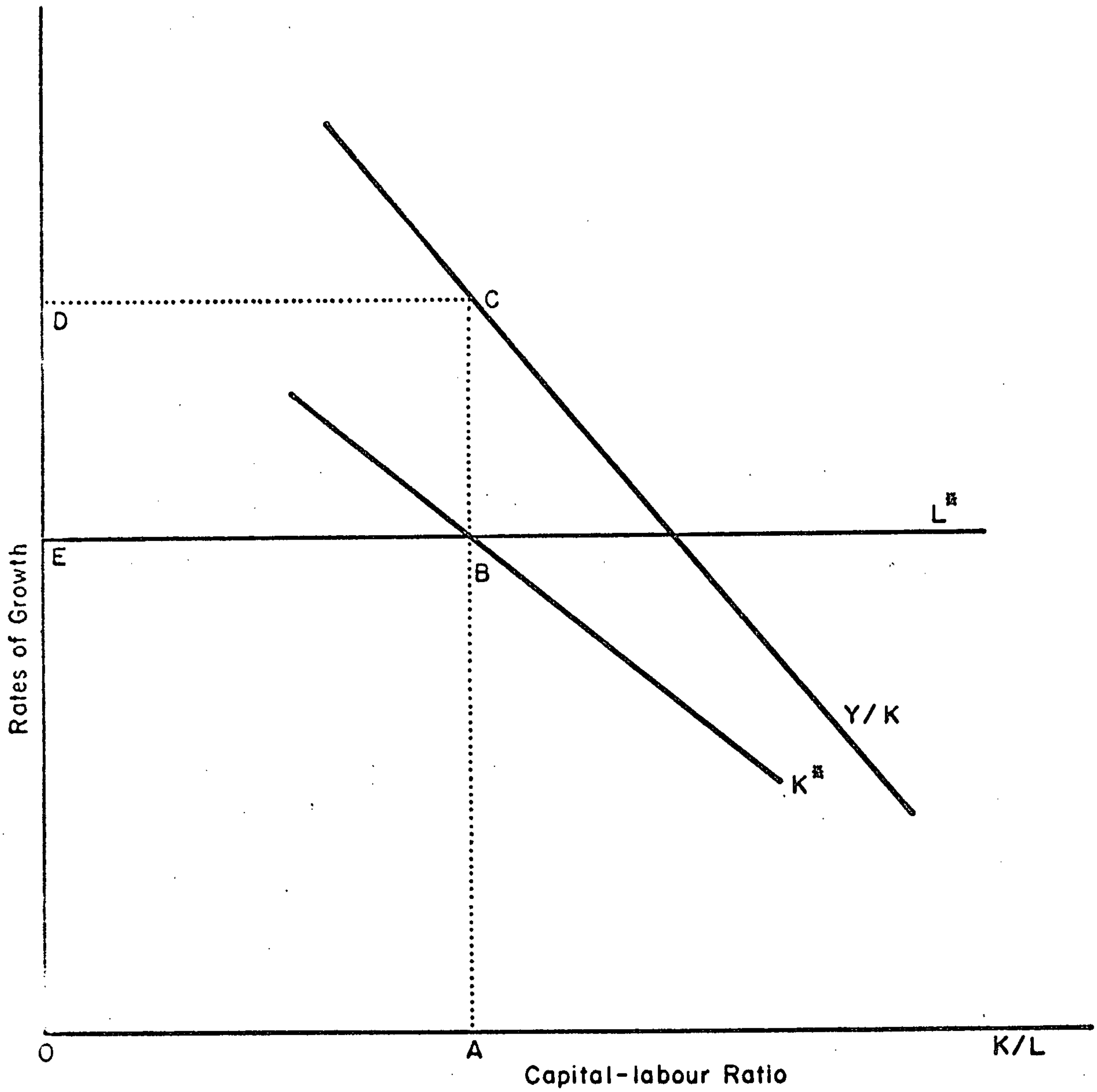
$$\text{or} \quad L = L_0 \, e^{nt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

This assumption that rate of growth of labour force is determined outside the economic system can be relaxed, and is in fact relaxed later in the formulation of the neo-classical model given here.

Fig. 4 shows the K/L ratio on the horizontal axis and rates of growth of capital and output as well as other pure numbers on the vertical axis. The rates of growth are denoted by an asterisk.

The rate of growth of labour force $L^* = n$ is independent of K/L and is therefore shown by a horizontal straight line. The output-capital ratio (Y/K) will be a decreasing function of K/L as already explained and

Fig. 4. Steady state growth in neo-classical model.



is represented accordingly. The rate of growth of capital [K*] can be determined from the Y/K function because

$$K^* = \frac{\dot{K}}{K} = \frac{sY}{K}$$

Now the capital-labour ratio of OA is an equilibrium value. This can be seen from the fact that any K/L value less than OA in the diagram will correspond to a situation where $K^* > L^*$ and therefore K/L will increase over time till it reaches the value of OA. Similarly, any point to the right of A will have $K^* < L^*$ so that K/L must decrease over time till it reaches OA. At A the K/L value is in stable equilibrium as any small variation from it has a tendency to get corrected.

In this model, therefore, a steady growth at rate n will take place and the capital-output ratio will stabilize at a value equal to s/n. Labour productivity which can be considered as a direct measure of per capita income is $\frac{Y}{L} = \frac{Y}{K} \cdot \frac{K}{L}$

In the steady state it will be OA.AC or the area of rectangle OACD.
The area of rectangle OABE is

$$\frac{K}{L} \cdot \frac{\mathring{K}}{K} = \frac{\dot{K}}{L} = \frac{sY}{L}$$

Therefore area of EBCD is $\frac{(1-s)Y}{L}$

In other words EBCD is the consumption component of labour productivity in the steady state and OABD is the savings component. With no technical progress the labour productivity (or per capita income if the two are assumed to be related) will remain constant and equal to the area of OACD. The per capita consumption will also remain constant.

The capital-labour ratio that maximizes consumption per man in perpetuity along a balanced growth path will be different from the stable ratio OA. Due to existence of constant returns to scale the production function (Equation 3) can be expressed as $\frac{Y}{L} = F\left(\frac{K}{L}, 1\right)$. If $F\left(\frac{K}{L}, 1\right)$ as a function of K/L is assumed to be passing through origin and convex upwards, i.e. no output is produced unless both inputs are positive, and capital has diminishing marginal productivity (Solow 1956); then Marty (1964) has shown that, unless it is by coincidence, a capital-labour ratio other than OA must be chosen for maximising consumption per capita.

> "To push capital deepending further is like purchasing an increment to output per man at the expense of a still greater increment to savings per man and a permanent reduction in consumption per man. This can unequivocably be ruled out as wasteful". (Marty 1964).

It may appear wasteful if it is assumed that the population is not increasing at an increasing rate, as in the neo-classical model. But, in the context of the underdeveloped countries of today, where this problem exists and in cases where one balanced path is disturbed by shocks before it adjusts to another equilibrium path, the capital deepending process, at least in initial stages of development, may not be too wasteful.

From Fig. 4 it can be seen that in the steady state the rate of growth of capital is equal to the rate of growth of labour force. As K/L is stabilized in this state Y/K will also be stabilized and so the rate of growth of Y must also be equal to the rate of growth of capital and labour force.

Thus in equilibrium

$$L^* = K^* = Y^* = n$$

The rate of growth of investment ($\mathring{K}^* = \ddot{K}/\dot{K}$) will also be equal to n as can be seen from the fact that in equilibrium

$$\dot{K} = nK$$

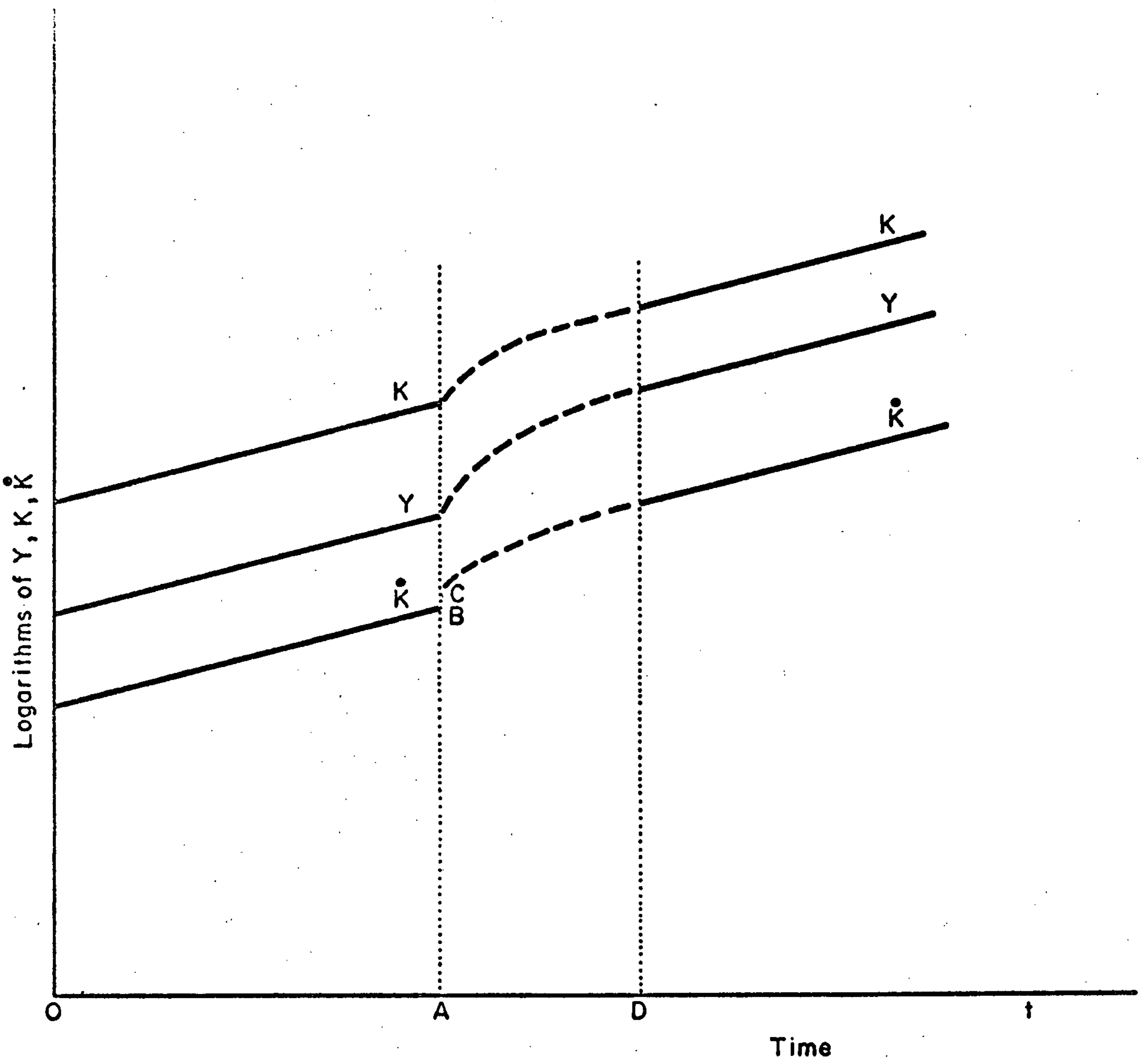
and so $$\ddot{K} = n\dot{K}$$

or $$\frac{\ddot{K}}{\dot{K}} = n ,$$

In Fig. 5 the rates of growth of capital, output and investment are therefore shown by three lines of equal slope to the left of A. The horizontal axis shows time and the vertical axis has logarithms of Y, K, and $\dot{K}$.

When the economy is growing on this steady path, i.e., when the capital stock, output, and investment are growing at a rate equal to the rate of growth of labour force let it receive a shock in the form of a sudden increase in saving ratio s. Let it be assumed that the shock comes at time corresponding to A on the horizontal axis. As $\dot{K} = sY$, this will bring about a sudden increase in the level of investments from AB to AC. This in turn will result in the capital stock suddenly growing at a faster rate than n. Such a situation can not be sustained. In terms of Fig. 4 it can be seen that the shock will shift the K* curve upward and to the right. The new equilibrium capital output ratio will be higher than before and the new Y/K will be less. The sudden increase in rate of investment will raise the rate of growth of capital above n and so K/L will be rising. As K/L rises, the rate of growth of K will come closer and closer to that of L. When they both are equal, K/L will not change any more. This new equilibrium K/L ratio will be greater than the former equilibrium ratio. At the new equilibrium, the Y, K and $\dot{K}$ will again be found to be growing at rate n. The result of the shock can thus be shown by the broken lines in Fig. 5. It is not possible to say how long the economy takes to adjust to the shock but after adjustment the rates of growth will be the same as

Fig. 5. Effects of shock on rates of growth in steady state.



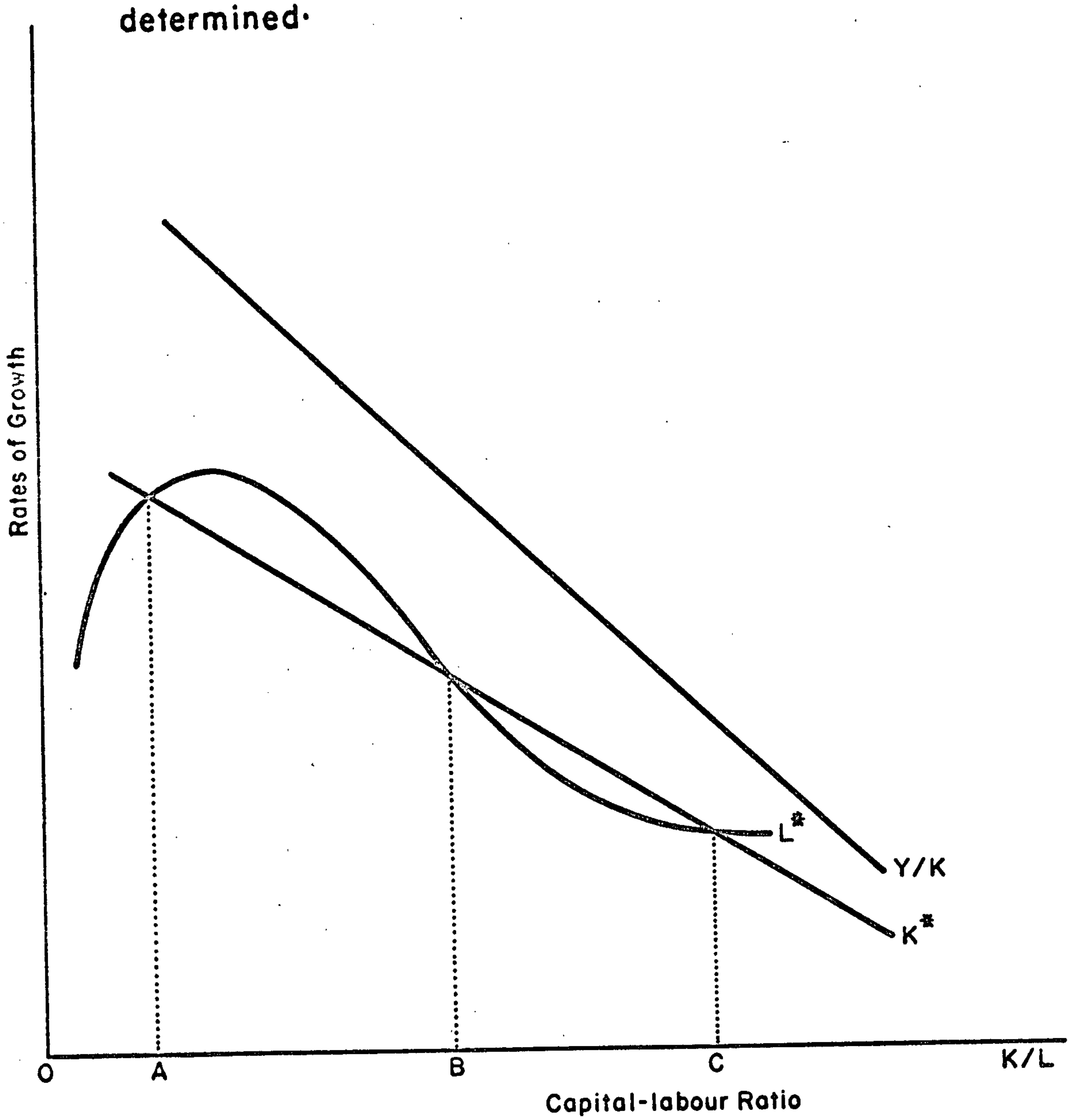
before. In the post shock period the absolute levels of K, Y and $\dot{K}$, however, will be higher than the levels that may have existed at any given time without the shock.

It is quite possible that the time of adjustment as shown by broken lines may be considerable and the economy may receive another shock before it reaches the steady path shown by the solid lines to the right of D. For the study of growth problems, especially of underdeveloped countries, investigations into the transitional period between AD may be as important or even more important than the investigations of the equilibrium conditions in the new steady state.

The assumption that the rate of growth of labour force is constant and independent of economic variables may now be relaxed. As argued in Chapter One it can be assumed that the rate of growth of labour force increases sharply with increases in per capita income at low levels and then gradually drops down to a constant. Also it can be intuitively seen that per capita income would be an increasing function of the K/L ratio, at least in capital-poor economies. Therefore the diagram of Fig. 4 can be modified as that in Fig. 6.

The L* curve in this figure ceases to be a horizontal straight line but may have a hump as shown. The points of intersection of L* and K* corresponding to A, B and C are equilibrium points but only A and C are stable. Any movement away from A which falls short of B will lead the economy to come back to A. The move must push the economy beyond B before it can hope to reach an era of sustained growth in per capita income. It is such considerations which have probably lead Leibenstein (1963) to propose a critical minimum effort hypothesis.

Fig. 6. Neo-classical model with population growth endogenously determined.



At this stage it will be helpful to note that increases in per capita income in a poor economy that is near A (Fig. 6) may often have a "keep up with the Jones'" effect and the people in an effort to imitate the living standards of more affluent societies may actually bring their savings ratio s to a lower level. This will depress the K* curve in Fig. 6 and push the critical point B farther to the right.

Without technological progress the per capita incomes remain stationary in the neo-classical model. When steady state growth occurs, from the point of view of the definition in this thesis, the model leads to "stagnation". Continuing improvement in technology therefore is the most important factor needed for a sustained increase in per capita income.

Of the other models discussed by Hahn and Matthews (1964), the studies of Robinson (1956, 1960a, 1960b), von Neumann (1938), Kemeny et al. (1956), Leontief (1951) and Morishima (1958, 1959, 1960, 1961) are particularly interesting but are not being outlined here. Another recent analysis of economic growth but not concerned with the development of underdeveloped countries as such is by Hicks (1965).

Development

Apart from studies in "growth" considerable work has been published on "development" of underdeveloped countries in the recent years. Amongst these the more notable may be Lewis (1955), and Rostow (1962) in dealing with the general problem; Rosenstein-Rodan (1963) and Nurkse (1953) regarding balanced growth; Hirschman (1963) and Streeten (1961) regarding unbalanced growth; Sutcliffe (1964) for a synthesis of the two; Leibenstein (1963) for a critical minimum effort hypothesis; Horvat (1958), Sen (1961), Kahn (1951), Chenery (1953), Leibenstein and Galenson (1955) and Eckstein (1957) for optimum rate of investment and investment criteria; Pazos (1953) regarding inflation; Meier (1963), Ellis and Wallich (1961) and Prebisch (1959) regarding international trade; and Nicholls (1955, 1963), United Nations (1951) and Johnston and Mellor (1961) on the role of agriculture in development. Many important essays and articles on the subject have been put together by Agarwala and Singh (1963), Novack and Leckachman (1964) and Meier (1964). Higgins (1959) and Kindelberger (1965) are comprehensive studies of the basic issues involved in development.

Both Lewis and Rostow see the growth of output per head as a function of two complex variables, viz., resources and human behaviour. The term "resources" here should be meant to include natural resources, capital, land, and scientific, technical and organizational knowledge. Availability of each of these can be altered by the second variable - human behaviour - which itself, to a great extent, depends on the resources. Thus, study of growth of per capita income becomes the study of interaction of many very intricately interdependent variables. It is not surprising that a comprehensive all-inclusive theory of development is not forthcoming.

On the face of it, more resources per man should mean more income per head. But this is not necessarily so because other things may not be equal. Another important factor to consider is the will of the people to get most out of a given situation and the effort made to expend a minimum amount of resources for getting a fixed output. That society will have higher per capita income which makes greater efforts to economize, both given the same endowment of resources. One of the most important factors in human behaviour that will determine the level of income per man is his will to economize and the rational effort put into achieving this end.

Yet one can think of two cases where the resource endowment and will to economize may be equal but the knowledge available may be different. Obviously, the per capita income will be higher where greater knowledge is available and is applied in production.

The prime necessities of development may therefore be summarized as (1) Effort to economize, (2) Level of knowledge and (3) Availability of resources. It must be observed here that (3) depends on (1) and (2) as well as original endowment of nature and its increase can be well studied by economists. The study of (1) and (2) goes fairly outside the scope of economics. Except for discussing the "institutions" which may or may not favour the growth of (3) little work has been done on the "causes" and "causes of causes" of (1) and (2).

While attempting to increase resources per head, it is necessary not to waste skills and energy in increasing those items which are already in plentiful supply. Those items must be increased, which are in short supply as compared to those which are plentiful and with which they must be combined to form products that the population wants. It is the comparatively more scarce resources that must be economized in the short-run and the availability of which must be increased in the long-run.

This operation will assume different forms and policies in various countries. The differences in human and other resources between nations are so great that it may not be possible to have one general "theory of development" applicable to all the underdeveloped areas of the world (Galbraith 1964b). Instead, many prescriptions, each for a particular area, may be all that can be had. The stagnant economies can not be considered to be in an "equilibrium" state in the economic sense. They have some fundamental disequilibria (Tinbergan 1962) which must be recognized to see where to make largest or earliest investments so that the growth of output per head can be increased. This is the problem of determining the most critical resource which must be solved by the "theory" of development. As income increases the frontier of critical region will expand and other resources may become critical. Successful strategy of development planning lies in anticipating the critical frontier in time and providing for it.

A country may still have a primitive tribal society with each tribe isolated from the others, and all units self sufficient at subsistence level. There may be no communications and no banking system. Such a country probably has an efficient administration and effective government as the most important need. It would be folly to develop a steel mill or heavy machinery in this country. When the administration is settled probably a network of roads, then general education, improved agriculture, banking, railroads, higher and technical education and capital may be required to be developed. The most common mistake in a development programme is likely to be that of putting the cart before the horse and so a "theory" of development must enable the policy makers to decide which is the cart and which the horse.

For more output a country must have more capital, more labour, more natural resources and more skills. It can create all of these with its existing productive capacity. Even the stagnant economy of Fig. 1 which has a per capita income of OC does so. The theory must be able to say which, how, how much and when to produce. This would have been sufficient if each country is considered in isolation. But in the modern "shrinking" world it would be a gross misallocation of world resources if goods and services required for development, especially the capital goods and skills, could not easily flow from one place to the other. A theory of development must then also be able to say how much and when should a developing country borrow from a developed country.

Another question that a theory of development has to resolve is that between present consumption and present investment. Investment comes from non-consumption in the present so that more may be had in the future. What is the optimum amount that must be saved and invested in the present? Horvat (1958), Sen (1961) and Phelps (1966) have addressed themselves to this question. Too much of investment is not good because an economy can not absorb it. As it gets more investment and grows, it increases its absorptive capacity and so gradually increasing investments must be made. An economy may for this purpose be looked at as a balloon which can expand as it fills and so increase its capacity. The optimum rate of investment is that which keeps the balloon almost full all the time without spilling anything.

Two apparently conflicting doctrines - balanced and unbalanced growth - have come up in the literature of economic development since the interest in the subject was revived about two decades ago. The balanced growth doctrine asserts that significant "discontinuities" or lumps exist in production functions and demand, and a simultaneous expansion in a large number of industries is necessary before the product of each can be demanded by the workers of others. If only one or two industries expand, their outputs can not be consumed by their own workers and other industries would not have enough workers to consume them. Therefore a balanced growth of all sectors is necessary.

The unbalanced growth doctrine rejects this contention on the main ground that such a big expansion requires a large amount of decision making capacity which is the very thing that is most scarce in underdeveloped countries. It suggests that the technique of development is to create strategic unbalances which will induce easily made responses. Sutcliffe (1964) has attempted to show that the two doctrines are really not so divergent as they first seem. Balanced growth means not equal growth in all industries but more in some and less in others. It is in fact like balanced diet which does not mean all items in equal quantity but in proper quantity. This is very much the same as unbalanced growth if reviewed carefully. Both doctrines are an acceptance of the necessity for a "big push" in economic development which is also suggested by Leibenstein (1963) and the neo-classical growth model. In Sutcliffe's view the doctrines differ only in the type of external economies (Scitovsky 1963) that predominate in them. At the same time he has also admitted that the concept of external economies itself needs much more clarification.

The literature on investment criteria shows that fully acceptable criteria for development are yet to be developed. It is obvious that the investment must be profitable socially, and returns in future must be discounted to the present at an appropriate rate to determine the profitability of an investment.

Pazos (1953) felt that development programs can be pursued with price stability. But, it is not very simple to do this. Prices will remain stable only if the volume of real goods and services increases at the same rate as the investments. As investments very often take more than a year to mature, the increase in the volume of goods can not keep up with the increase in investments. In a developing country the investments are likely to grow at an increasing rate and so inflation seems to be inevitable unless money supply is reduced. At the same time, it is difficult to maintain that inflation, especially if it is severe and for long durations, can be helpful to economic development.

There seem to be quite conflicting views on the role that international trade can play in development. Almost everyone seems to agree that if underdeveloped countries could make exports of manufactured goods as profitable enterprises, then they would be benefited. The difference of opinion is in the role of primary products as major items of export by underdeveloped countries.

As regards the role of agriculture there is no difference of opinion. Agriculture happens to be the greatest contributor of national income in underdeveloped countries of the world and probably has large quantities of surplus and redundant labour. Not only is a sharp rise in agricultural productivity required to free this surplus labour which must be engaged in manufacturing (that should be expanded simultaneously); but a substantial proportion of the surplus needed for investment almost must come from agriculture. For most underdeveloped countries the agricultural sector may therefore be the key to development. Unless agriculture is improved and a surplus created, any hopes of development must run into serious difficulties.

The lesser developed country has many disadvantages for reaching the developed stage, but it also has <u>one</u> big advantage over the more developed countries. It has the greatest latitude of choice: choice as to governmental organization and politics; choice as to kinds of technology at all levels; choice as to where and how to develop spatial infrastructure in terms of communications such as roads and railways; and environment, such as cities, towns and intensive agriculture. The genuinely less-developed countries largely do not have to concern themselves with the current and future opportunity costs of changing past decisions. If maximum use of this advantage is made, they might catch up the developed countries quickly (Beazley 1965).

Recent literature on economic development has been not only on purely economic aspects of the problem in an academic fashion as reviewed above but also on many other economic and non-economic aspects written mainly for the lay public. This is an indication of the widening awareness of the problem in the contemporary world. Such publications include Cantril (1962), Soule (1962), von der Mehden (1964), Wanamaker (1964), Grew (1959), Snider (1965), Heilbroner (1962, 1963) and Heilbroner and Bernstein (1963).

CHAPTER THREE

A SIMULATION MODEL OF ECONOMIC DEVELOPMENT

INTRODUCTION

In this chapter a single sector model of a planned economy will be constructed. It will show how combinations of various factors can lead to a state of stagnation in which the per capita income is likely to remain constant or very gradually sliding down for long periods. Such a situation was estimated to have existed in India in the first half of the Twentieth century (Neale 1965, Patel 1966) before any development planning started in 1951. The savings of a very low income were just sufficient to create more income producing capacity so that after taking the depreciation in capital and increase in population into account, the per capita income remained just about the same. Apart from describing the state of stagnation, the main aim of the model is to provide a guide, howsoever rough, for making decisions regarding levels of investment that must be planned so that an underdeveloped country may reach the "take-off" stage. For this, it uses an IBM 7040 electronic computer to find the best set of investment schedules that will achieve the take-off in an economy for which various parameters can be estimated. The computer simulates the growth of an economy and then determines which schedule of investments is the best.

Simulation is not a new technique in forestry. Newnham (1964) described a detailed stand model for Douglas fir and provided a computer program which can be manipulated and modified to test many alternatives. Smith, Newnham and Hejjas (1965) noted that in an IBM 7040 a stand can be "grown" from age 10 to age 100 in 13 minutes. This technique can avoid costly social experiments in real life by giving a preview of the future and help one to make better decisions in the present. Gould and O'Regan (1965), while discussing the use of simulation in forestry, considered it as a step toward better forest planning which "holds great promise for pre-testing the impact that new policies are likely to have on a woodland over many years". O'Regan _et al_. (1965?) reported some results on a simulation approach to forest management. Valg and Smith (1966), while discussing simulation of forest stand growth, said:

> "By growing and harvesting our trees in the computer we are learning what the forest manager really needs to know and what he can do. We now have a flexible, and powerful, new tool that provides an excellent way to determine effects of risk from biological pests and even gives some ideas about the consequences of economic uncertainty by studying a wide range of alternatives."

Simulation has been used in economics much more than in forestry.

Its application in economic development is particularly fruitful. Orcutt (1960) and Greenberger (1961) discussed the general problems in simulation of economic systems. Holland _et al_. (1960) constructed a model for simulating dynamic problems of economic development. Mantesh (1964) and Chappelle (1966a) showed how computers can be used in forestry-economics. Chappelle (1966b) also gave a computer program for calculating allowable cut by area-volume method.

The model in this chapter does not have anything to do with forestry in particular. It only shows a way of determining the most desirable doses of foreign and total investments that an underdeveloped country needs to reach the take-off stage. Once the gross investment to be made year after year is thus known the forestry problem is to determine how much investment in forestry should be made out of the given total. The solution of this problem, as will be observed later, depends on the future course of the economy as a whole. Such a future course can be visualized by a simulation model.

THE MODEL

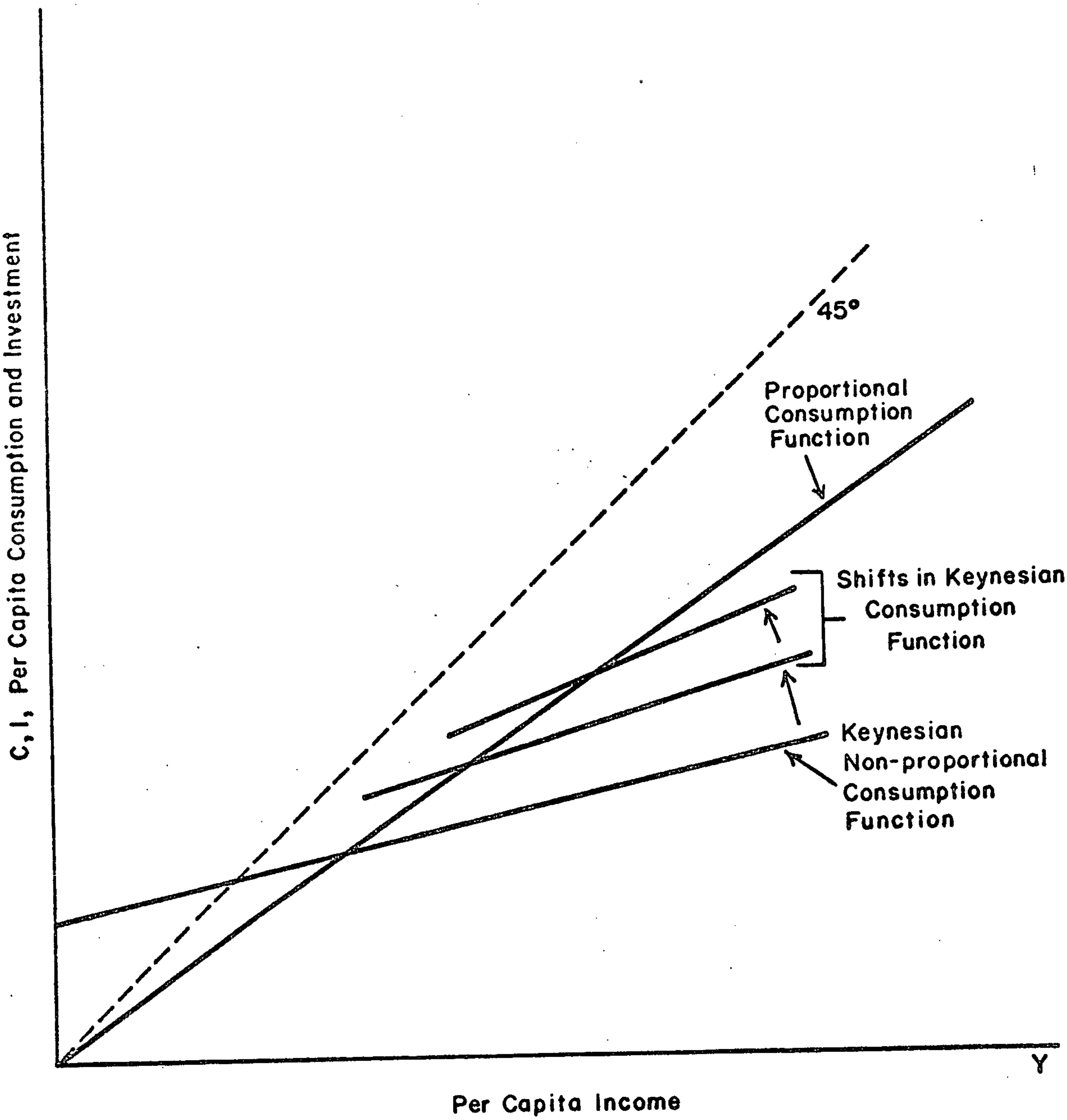
In its simplified form the model is like that of Chapter One and is built around the central concept that the consumption level of the people can not be kept below what economic circumstances would demand. In other words, consumption is a completely endogenous variable. Higher the per capita income the higher will be the level of consumption. As already observed, in such a model, foreign aid is a 'must' if development is to be achieved. The extent and implications of foreign aid both to the donor and the recipient were discussed by Mason (1964), Brannen and Hodgson (1965), Little and Clifford (1965) and Keenleyside (1966). Amount of aid received by India from 1951 to 1963 was summarized by Newman (1965). The model has nothing to do with the political implications of aid but only tries to find out the optimum level that should be sought by a recipient country.

In the following pages it is shown how each relevant item changes with time and other economic variables. The first item taken is consumption per capita. It will be noticed that, according to the formulation of the consumption function given below, development becomes easier and more probable if large and quick increases in per capita income are created as early as possible. This will be so because such a happening will leave large savings in early stages of development.

Consumption

On the basis of discussions in Chapter One, the relationship between income on the one hand and consumption or investment on the other will be considered in this model on the per capita basis. The Keynesian short-run consumption function when shown with per capita income (Y) on the horizontal axis and per capita consumption or investment on the vertical axis is usually represented as a line with an intercept on the vertical axis (Fig. 7). This is also called the non-proportional consumption function, as consumption does not bear the same proportion to income at all income levels. Empirical studies suggest that this consumption function shifts with time as incomes of people change. There is a tendency for it to move up and become steeper (Peterson 1962) as income levels rise through time. It is thus certain that to assume the Keynesian consumption

Fig. 7. Proportional and non-proportional consumption functions.



function stable for any length of time would be a mistake. In fact, studies for the United States (Kuznets 1946) for a period of about 70 years (from 1869 to 1938) show that the consumption function may actually be proportional to income in the long-run and would be expected to be represented as a straight line passing through the origin in Fig. 7.

Friedman's Permanent Income Hypothesis (Friedman 1957) and Duesenberry's Relative Income Hypothesis (Duesenberry 1949) try to explain the nature of the consumption function as something different from the simple Keynesian formulation. Modigliani and Brumberg (1954) also discussed consumption function in the light of utility analysis and Houthakker (1958) pointed out the shortcomings of Friedman's hypothesis. Farrell (1959) divided the "New Theories" of Friedman and Modigliani and Brumberg into three independent hypotheses.

1. Proportionality Hypothesis: For any individual, the relationship between his consumption and his normal income is one of proportionality.
2. Rate-of-growth Hypothesis: In long-run equilibrium, aggregate saving is determined by changes in population structure and in real income per head. If these factors change steadily, the fractions of aggregate income saved is proportional to the rate of growth of aggregate real income.
3. Normal Income Hypothesis: In any given period an individual's current income y affects his consumption C only through its effect on his normal income Y. We may write $C = \beta(Y)$, where β is independent of current income and assets.

Farrell rejected the Proportionality Hypothesis and found the Rate-of-growth Hypothesis as substantially valid. He also found the Normal Income Hypothesis well substantiated for farmers and business men in the United States. It might, however, not be suitable for countries and occupations where incomes are stable.

Regarding the Rate-of-growth Hypothesis he said:

> "It is thus an over-simplification to assert that in the long-run, the proportion of aggregate income saved is proportional to the rate of growth of aggregate income; but it is much nearer the truth than the linear consumption function so often postulated. It would be interesting to see the effect on the many "theories of economic growth" of substituting in them the Rate-of-growth Hypothesis for their present (usually linear) consumption functions."

Duesenberry (1949) and Modigliani (1949) suggested a hypothesis in which consumption was expressed as a function of current income and the highest previous peak income (or consumption). Ando and Modigliani (1963) suggested a similar model where the role of the highest previous income was played by net worth of future incomes. They considered their formulation convenient as a building block in models of economic growth and fluctuations".

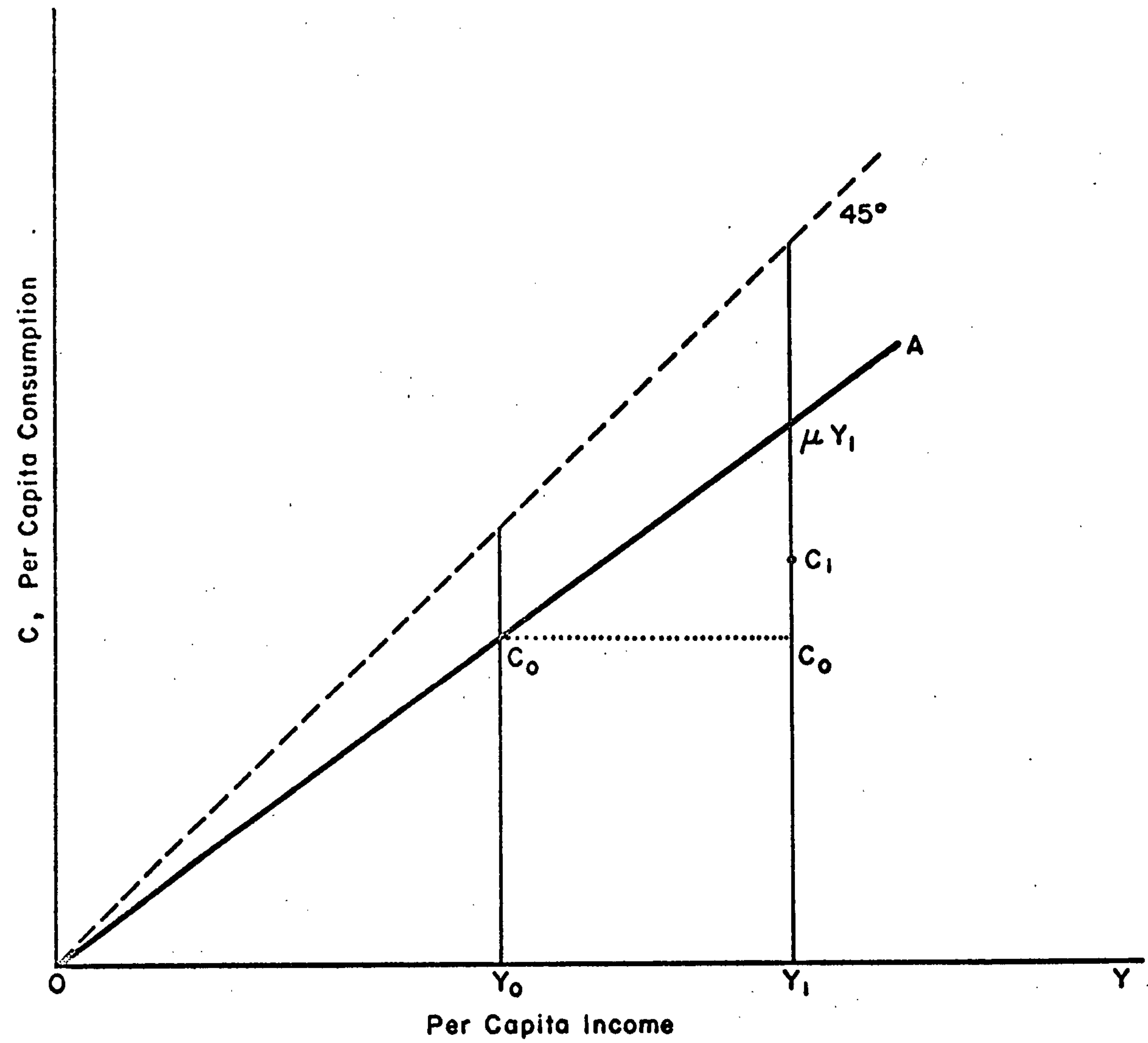
Taubman (1965) showed that the Permanent Income Hypothesis of Friedman in its original strong form can not be supported by empirical data. However, it was indicated that on the whole consumers saved a small proportion of their permanent income and a large proportion of transitory income. Liviatan (1965) showed that the Permanent Income Hypothesis was almost the Current Income Hypothesis.

From the review of this literature it seems reasonable to assume that the current per capita consumption is a function of the current per capita income as well as the per capita consumption in the previous income period. If the per capita income remains constant for a long enough period the per capita consumption may be a fixed proportion of the income. The ratio of consumption to income may be determined by cultural factors in a society which usually are such that the ratio does not change appreciably for such periods of time as 30 or 40 years or more. The per capita consumption (C) after it has had sufficient time to adjust to a new income level will thus be μY if Y is the per capita income and μ the said ratio. This μY is therefore the "fully adjusted" consumption corresponding to an income level of Y. If Kuznets' (1946) figures are assumed to be such "fully adjusted" figures then the value of μ would be about 0.85 for the United States. When consumers are "fully adjusted" to an income level then the "fully adjusted" average and marginal propensity to consume is equal to 0.85.

For every economy the value of μ would be different and the "fully adjusted" or long-run consumption could be represented as a straight line OA passing through the origin in Fig. 8.

If income has remained stationary at Y_0 for sufficient length of time then the per capita consumption will be equal to the vertical interval between C_0 and the horizontal axis. Now let it be assumed that income level has moved in the next income period to Y_1. What will be the corresponding consumption? If allowed to remain at Y_1 for a long enough period the income Y_1 would finally induce a consumption of μY_1 which would be represented by a point on OA vertically above Y_1. But the consumption would be less than μY_1 if sufficient time for adjustment were not allowed. The following analysis determines how much exactly the consumption would be.

Fig. 8. Consumption function for the simulation model.



If the change in income were instantaneous it may be assumed that the consumer has not yet been used to the changed income level and would continue to consume at level C_o to begin with. As time passed on and the income level remained at Y_1 his consumption would move up from C_o towards μY_1 on the vertical line above Y_1. If it is assumed that the farther the actual consumption is from μY_1, the greater would be the aspiration of the consumer to reach it then the "speed" with which the consumption level will start moving from C_o to μY_1 will be high at first and gradually diminish to zero when it reaches μY_1.

Here, there are at least two possibilities for describing how consumption level C_o can move towards μY_1.

A. The movement starts with a high speed which decreases at a constant rate and becomes zero when μY, is reached.

B. The movement starts with a high speed which is proportional to the "distance" yet to be covered to reach μY_1.

Possibility (A) is identical with the case of a particle that is thrown against the force of earth's gravity at a certain speed so that it just touches a given ceiling before it starts falling down again. The movement of the consumption level from C_o to μY_1 will be the same as the movement of this particle from the moment of its launching to its reaching the ceiling.

Let the "distance" measured along the vertical axis in Fig. 8 be denoted by s, time by t, and the constant rate of decrease of speed of adjustment as f.

Then $$\frac{d^2s}{dt^2} = f \quad \text{.......................... (6)}$$

and so $$\frac{ds}{dt} = u + ft \quad \text{...................... (7)}$$

where μ is the initial speed with which C starts moving towards μY_1.

The aim is to find the 'distance' moved in one time period (one year) when u was such that the C would come to rest at μY_1, i.e.,

$$\text{when } \frac{ds}{dt} = 0 \text{ and } t = -\frac{u}{f}$$

This means the time taken for getting fully adjusted to a new income level is

$$T = -\frac{u}{f} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

The time taken for adjustment can also be determined from integration of (7).

The distance moved from C_o to μY_1 is $(\mu Y_1 - C_o)$. The time taken for this movement is given by T where:

$$\int_0^{(\mu Y_1 - C_o)} ds = \int_0^T (u + ft)dt$$

$$\text{or} \qquad (\mu Y_1 - C_o) = uT + \tfrac{1}{2}fT^2$$

From (8) it is known that $T = \frac{-u}{f}$, therefore

$$\mu Y_1 - C_o = \frac{-1}{2} \cdot \frac{u^2}{f}$$

$$\text{or} \qquad u = \sqrt{-2f(\mu Y_1 - C_o)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

The "distance" moved in one income period is given by

$$C_1 - C_o = \int_0^1 (u + ft)dt$$

$$= u + \tfrac{1}{2}f$$

$$= \sqrt{-2f(\mu Y_1 - C_o)} + \tfrac{1}{2}f \qquad \text{when the value}$$

of u from (9) is substituted.

The parameter f has a negative value in this formulation as it is a deceleration and not an acceleration. If it is given a positive value then:

$$C_1 - C_o = \sqrt{2f(\mu Y_1 - C_o)} - \tfrac{1}{2}f$$

Similarly, $$C_n - C_{n-1} = \sqrt{2f(\mu Y_n - C_{n-1})} - \tfrac{1}{2}f \quad \ldots\ldots\ldots\ldots \quad (10)$$

This formula gives the consumption level corresponding to each per capita income level if the consumption level in the previous period and the parameters f and μ are known. The formula is applicable only when consumption levels are increasing.

If income level falls, and the new "fully adjusted" consumption level is below the old consumption level, the formula will become

$$C_{n-1} - C_n = \sqrt{2f(C_{n-1} - \mu Y_n)} + \tfrac{1}{2}f$$

Possibility (B) can be expressed by

$$\frac{ds}{dt} = g(A-s)$$

where A is $(\mu Y_1 - C_o)$ and g is a constant. This means that

$$-\log (A-s) = gt + k$$

The value of constant k is determined from the observation that at $t = o$; $s = o$.

Putting these values in the above function yields

$$k = -\log A$$

so that the function becomes

$$gt = \log A - \log (A-s)$$

or $$\frac{A}{A-s} = e^{gt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

The change in consumption in one unit of time (one year) can be found as the solution of s in (11) if t is put equal to one.

Thus $\frac{A}{A-s} = e^{g}$

or $s = \frac{A(e^{g}-1)}{e^{g}}$

i.e. $C_1 - C_o = \frac{A(e^{g}-1)}{e^{g}}$

Therefore

$$C_1 = \frac{\mu Y_1(e^{g}-1) + C_o}{e^{g}}$$

In general terms

$$C_n = \frac{\mu Y_n(e^{g}-1) + C_{n-1}}{e^{g}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

This formula will be applicable even when the income level is falling and the new "fully adjusted" consumption level is below the old consumption level.

Of the two possibilities either (10) or (12) could be used in the model for determining the per capita consumption level corresponding to a given income level if the consumption in previous year is known. Both are dynamic formulations of a simple static Keynesian consumption function.

Investment:

In the model it is assumed that some mechanism exists in the economy which ensures that all ex-ante savings are planned to be invested. The total investment, however, can be greater than savings if foreign capital is imported. The aggregate per capita investment made at any time will be the sum of per capita domestic savings (S_n) and per capita foreign investment (F_n).

Thus $I_n = S_n + F_n$

and $S_n = Y_n - C_n$

where I_n is the aggregate investment per head.

Let α and β denote the marginal and average output-capital ratio, respectively, in the economy as a whole. Subscripts indicate the period to which they refer.

Also, let an investment mature in m years on an average in this economy. Then a sum of I_{n-m}, invested in the year (n-m), will mature and get added to the capital stock in the year n. The additional income that this capital can produce will be

$$a \cdot I_{n-m} \cdot \alpha_{n-m}$$

Where α_{n-m} is the marginal (not average) output-capital ratio of this investment and a is the conversion factor for an investment into capital.

Depreciation

As in Chapter One, it is assumed here that every year a fixed proportion d of the per capita capital stock k is worn out. Thus, if at the end of year (n-1) the per capita capital was k_{n-1}, and population was P_{n-1}, then at the end of year n only $(1-d) \cdot k_{n-1} \cdot P_{n-1}$ in all, or $\frac{(1-d) \cdot k_n-1 \cdot P_{n-1}}{P_n}$ per capita, will be left. To this will be added the new capital that would come as a result of investments made in year (n-m).

The depreciation discussed is the "real" one as distinguished from the "allowed" or "book" depreciation of industry. It does not take into account the depreciation due to technical obsolescence.

Income

The Income that can be produced in any one year will depend on the capital stock available. It will be noted that some of the capital would be new and some old. When α_{n-m} is the marginal output-capital ratio of the new capital and β_{n-1} is the average output-capital ratio of the old, the total income that can be produced in year n will be

$$(1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1} + a \cdot I_{n-m} \cdot \alpha_{n-m}$$

The per capita income in year n will be

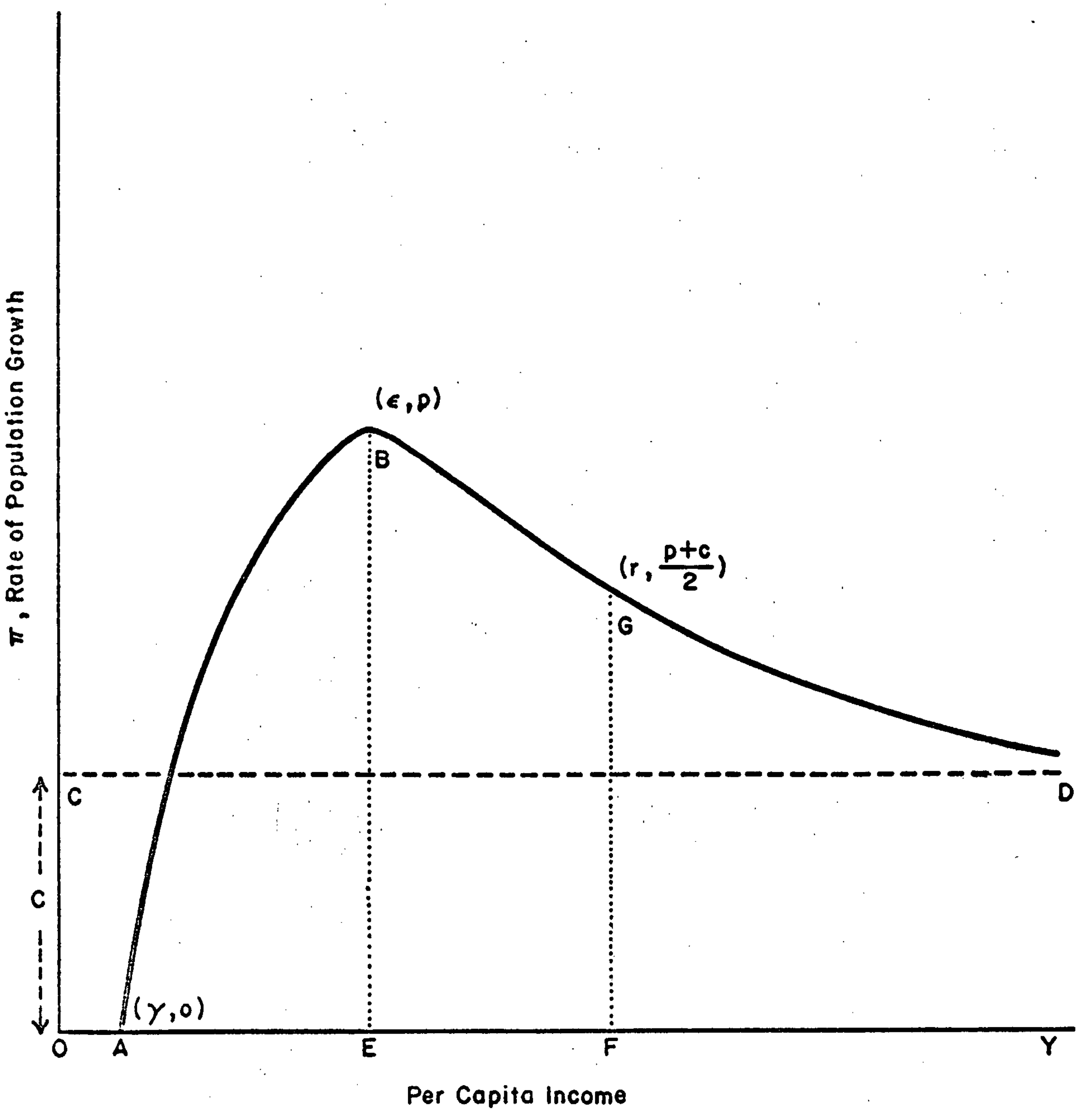
$$\frac{(1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1} + a \cdot I_{n-m} \cdot \alpha_{n-m}}{P_n}$$

Population

On the basis of discussions in Chapter One it is assumed that the rate of growth of population depends on the per capita income. It rises sharply with increases in income at low levels, but reaches a culmination point and then gradually drops to a relatively constant value as income level continues to increase (Fig. 9).

With per capita income of OA (Fig. 9) the economy shows no increase or decrease in population. With an income of OE the maximum possible rate of population growth (EB) is achieved. As incomes continue to increase the rate of population growth decreases and tends to approach the level of asymptote CD. The steady rate of population growth when incomes continue to grow is OC. When per capita income is OF the rate of population

Fig. 9. Rate of population growth as a function of per capita income.



growth is FG which is the mean of EB and OC.

The portion of this curve to the left of E resembles a parabola with its vertex at B. The portion to the right of E resembles the extension of this parabola from B so that it becomes parallel to line CD at infinity. If per capita income levels and the rates of growth of population for points A, B and G are known, along with the height of line CD above the horizontal axis, the rough equation to the curve can be written as follows (Thomas 1966):

$$\pi = \begin{bmatrix} p - \dfrac{p(Y-\epsilon)^2}{(\gamma-\epsilon)^2} & \text{for} \quad 0 \leqq Y \leqq \epsilon \\ c + \dfrac{(p-c)\,(r-\epsilon)^2}{(r-\epsilon)^2 - (Y-\epsilon)^2} & \text{for} \quad \epsilon \leqq Y \end{bmatrix} \quad \ldots\ldots\ldots \quad (13)$$

Where Y is the independent variable per capita income; π is the dependent variable rate of population growth; γ is the per capita income at which population stays constant; ϵ is the per capita income at which the maximum possible rate of population growth p is obtained; c is the level to which rate of population growth tends to settle down at high per capita income levels; and r is the per capita income at which rate of population growth falls to $\frac{p + c}{2}$ with increasing incomes.

If such an equation for the rate of population growth can be estimated for a country, and the total population in a base year is known, then the population in subsequent years can be determined.

For this model, it is assumed that the values of γ, ϵ, p, c and r are \$47, \$150, 3.30%, 1.00% and \$250, respectively. The equation therefore becomes:

$$\pi = \begin{bmatrix} 3.30 - \dfrac{(Y - 150)^2}{3214.85} & \text{for} \quad 0 \leqq Y \leqq 150 \\ \\ 1.00 - \dfrac{23000}{(Y-150)^2 - 10000} & \text{for} \quad 150 \leqq Y \end{bmatrix} \quad ..(14)$$

There is little doubt that such an estimate can not be very precise. But decisions can and should be made on the basis of available data even if they are rough. Subsequent additional information can always be used to improve the estimate and improve the decision making technique in the futmre. It is probable that, an assumption of a horizontal stretch of the curve to the right of B in Fig. 9, before it falls down to asymptote CD, may be more realistic.

Maintenance

In Chapter One it was shown that a certain minimum investment is necessary at each stage so that the per capita income would not fall below the existing level. In the model, where a time lag is admitted between investment and its maturity, a certain minimum investment is necessary in the year (n-m) so that per capita income in the year n does not fall below the (n-1) level. This minimum requirement is called maintenance herein. If the intention is not to let the per capita income in year (n+1) and onwards to fall below the level of year (n-1), then certain minimum investments must be made not only in year (n-m) but also in year (n-m+1) and subsequently. The investment is made up of domestic savings and foreign aid. As it is assumed that all domestic saving is necessarily invested, the foreign aid component of the "maintenance" can be found by simple substraction if the total investment required for maintaining income at a certain level is known. The following exercise shows how the calculations for total and foreign investment requirements for maintaining the per capita income at a level of Y_{n-1} would have to be made.

In year (n-1) total income is $P_{n-1} \cdot Y_{n-1}$

The total income in year n must be at least $P_n \cdot Y_{n-1}$ if the level of year (n-1) is to be maintained.

The left over capital of year (n-1) will create an income of $(1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1}$. The remaining income of

$$P_n \cdot Y_{n-1} - (1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1}$$

must be produced from the new capital that must come from the investments in year (n-m).

The minimum investment required in year (n-m) is therefore

$$\frac{P_n \cdot Y_{n-1} - (1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1}}{a \cdot \alpha_{n-m}}$$

or

$$\frac{P_n \cdot Y_{n-1} - (1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1}}{a \cdot P_{n-m} \cdot \alpha_{n-m}} \quad \text{per capita.}$$

This is the per capita maintenance requirement in year (n-m).

If the per capita domestic saving in year (n-m) is equal to or greater than this maintenance, it is ensured that the per capita income level of year n will not be below that of (n-1). If it is less, a minimum foreign investment of

$$\frac{P_n \cdot Y_{n-1} - (1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1}}{a \cdot P_{n-m} \cdot \alpha_{n-m}} - S_{n-m}$$

per capita is required.

If it is assumed that actually just this amount of foreign investment is made in year (n-m), per capita income Y_n in year n will be equal to Y_{n-1}. One can now calculate the requirement for the year (n-m+1). Assuming that this requirement is fulfilled Y_{n+1} will be equal to Y_n and Y_{n-1} and the maintenance requirements for year (n-m+2) can be determined. If the requirement at any stage is less than the domestic savings, income in years later will increase. This increase will not be due to foreign investments but only due to domestic investments.

In this manner a schedule of foreign investments needed to hold the per capita income of a country from falling below a certain level can be determined. The entire schedule is the "maintenance" requirement for the given income level. For each income level there will be a separate schedule.

After making a certain pre-determined schedule of foreign investments in the economy its growth can be simulated. For the per capita incomes in each of the years a "maintenance" requirement schedule can now be determined.

Average output-capital ratio

As has been shown the total income in the year n will be

$$(1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1} + a \cdot I_{n-m} \cdot \alpha_{n-m}$$

The total quantity of capital in the same year will be

$$(1-d) \cdot k_{n-1} \cdot P_{n-1} + a \cdot I_{n-m}$$

Therefore, the average output-capital ratio will be

$$\frac{(1-d) \cdot k_{n-1} \cdot P_{n-1} \cdot \beta_{n-1} + a \cdot I_{n-m} \cdot \alpha_{n-m}}{(1-d) \cdot k_{n-1} \cdot P_{n-1} + a \cdot I_{n-m}}$$

In Chapter One, where no lags of any kind were assumed and the consumption function was of a fairly simple kind, the take-off stage was defined to be at the per capita income level of OT in Fig. 1. A similar definition of the take-off stage, depending on the maintenance, is developed later in this chapter. This definition takes into account the lag of m years between making an investment and its fruition. It also takes into account the more complicated consumption function developed here.

Once the take-off stage is recognized the object will be to find the most desirable schedule of <u>equal</u> foreign investments which will move the economy from stagnation to take-off. For this, first of all, the growth of the economy from year to year for a sufficiently long period must be traced. This is done by an IBM 7040 computer with the help of a programme described below. Initial <u>equal</u> foreign investments are discussed in the model for the sake of convenience and for reducing computing time. There is no reason why in the absence of such a restriction, the most desirable schedule must be equal.

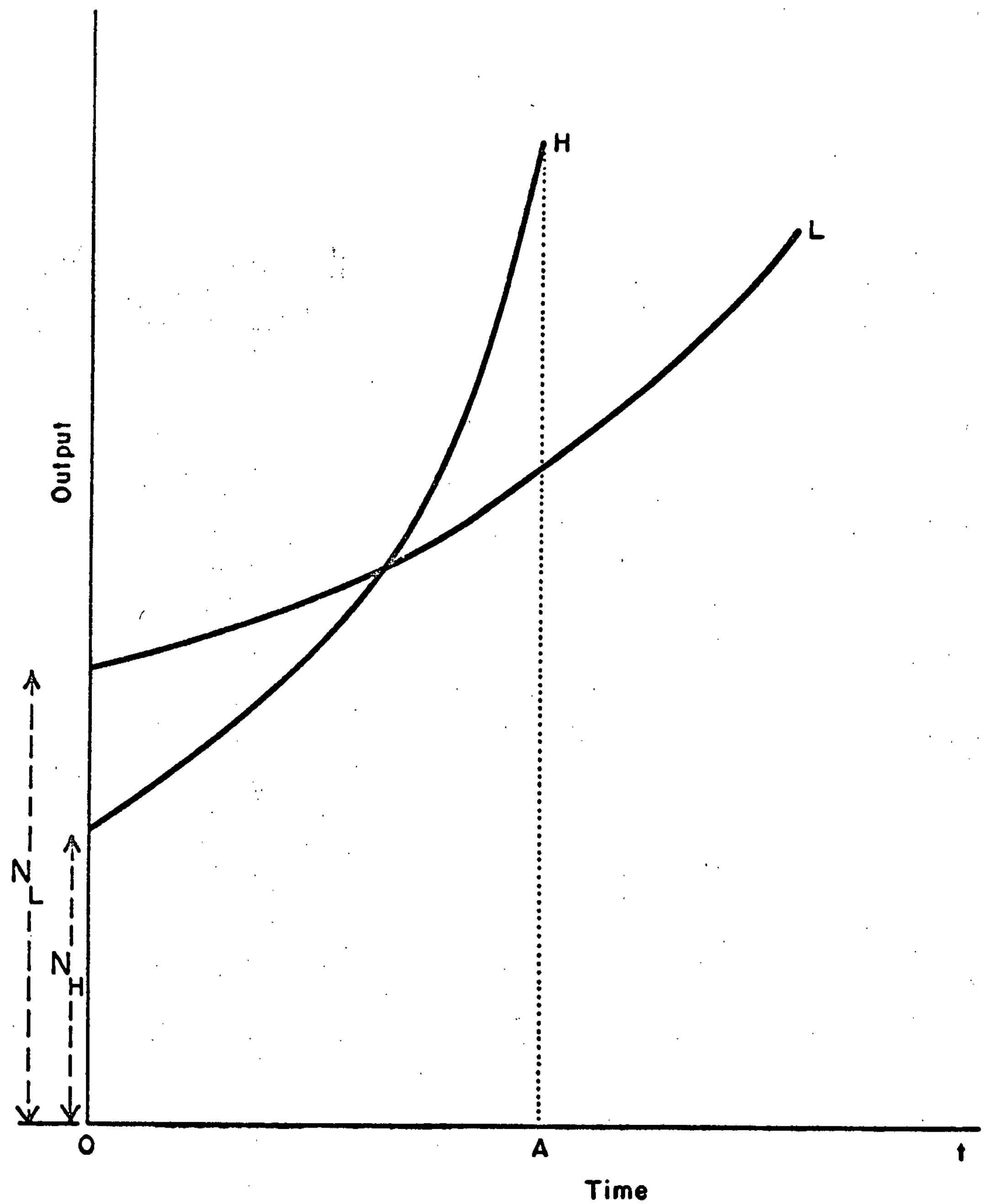
CHOICE OF MARGINAL OUTPUT-CAPITAL RATIO

In earlier paragraphs the marginal output-capital ratio (α) has not been assumed to be constant. Each year it could have a different value. This value will be determined by the planners or investors in the country. In this section the theory behind the planners choice will be discussed. Dobb (1960) and Sen (1960) analysed this problem in considerable detail and have many similar views.

In his simplest model, Sen (1960) concluded that, the choice of capital-intensity depends on the length of time horizon of the planners. A more capital intensive technique means relatively smaller current output but larger surplus and hence higher rate of growth in the future. A less capital-intensive technique, on the other hand, gives a larger current output but relatively lower future rate of growth. Given enough time, the technique with higher capital-intensity will certainly overtake the production that would correspond to the technique with lower capital intensity. In Fig. 10, exponential curves H and L show the growth of output with the higher capital-intensity and lower capital-intensity techniques respectively. Current output N_H corresponding to H is lower than current output N_L corresponding to L. At the end of time OA the average output per unit of time with either technique is the same. Beyond OA the higher capital-intensity technique (H) has a higher average output per unit of time. If the time horizon of the planners is longer than OA, technique H should be chosen over L. If it is shorter than OA technique L is better. This is one of the main conclusions drawn by Sen (1960).

Introduction of the concept of time horizon in the way presented, implicitly assumes that as seen from poin O, the worth of all future values occuring at any time beyond OA is nil, and of values within OA is not affected at all. This can not be considered a realistic assumption. The only assumption that may fit into real life experience seems to be the one which gradually decreases the worth of values (when seen from O) as they occur farther and farther away from O in time. If the rate at which

Fig. 10. Growth of output with time.



the future must be discounted is assumed to appear constant[1] through time from 0, then the discounted values of H or L are obtained by dividing the undiscounted values by e^{it}, where i is the rate of discount.

If rate of growth of H and L are assumed to be g_H and g_L then their growth paths in time are represented by

$$y = N_H \cdot e^{g_H t}$$

and $y = N_L \cdot e^{g_L t}$ respectively, where t represents time and y the value of output.

The growth paths of the discounted values will accordingly be

$$y' = N_H \cdot e^{(g_H - i)t} \quad \text{..........} \quad (15)$$

and $$y' = N_L \cdot e^{(g_L - i)t} \quad \text{..........} \quad (16)$$

Admission of a line, horizon like OA implies that the values of y' from (15) and (16) are extremely small for values of t larger than OA. This can be conceived of only when y' in (15) and (16) is a decreasing function of t. This in turn is possible only when both g_H and g_L are smaller than i. One can therefore reason that when Sen (1960) introduced

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1. It may be reasonable to think of the rate of discount as gradually increasing with the passage of time. With such an assumption the integrations discussed on next few pages become difficult to deal with and therefore only the simpler case, where the rate of discount is throughout the same, is given here.

a time horizon in his analysis he implicitly admitted that the rate of time preference is higher than any possible rate of growth of the aggregate economy. What he did not admit was that the discounting process should reduce the present worth of future values progressively and gradually with time. In his formulation there is no reduction within the time horizon; but, just beyond the time horizon, an excessively high reduction, amounting to complete "evaporation" of the future values takes place. Sen was aware of this awkwardness but did not attempt to redress it.

If instead of explicitly bringing in the time horizon into this analysis a continuous and uniform rate of discounting the future is introduced then the choice of higher capital-intensity will always be better than lower capital-intensity so long as i is smaller than g_H and g_L. When i is greater than g_H and g_L, the growth paths (15) and (16) of discounted values of output will be downward sloping as shown in Fig. 11. That technique should be chosen, the area under the growth path of which is greater.

The area under H curve is

$$\int_0^\infty y \, dt$$

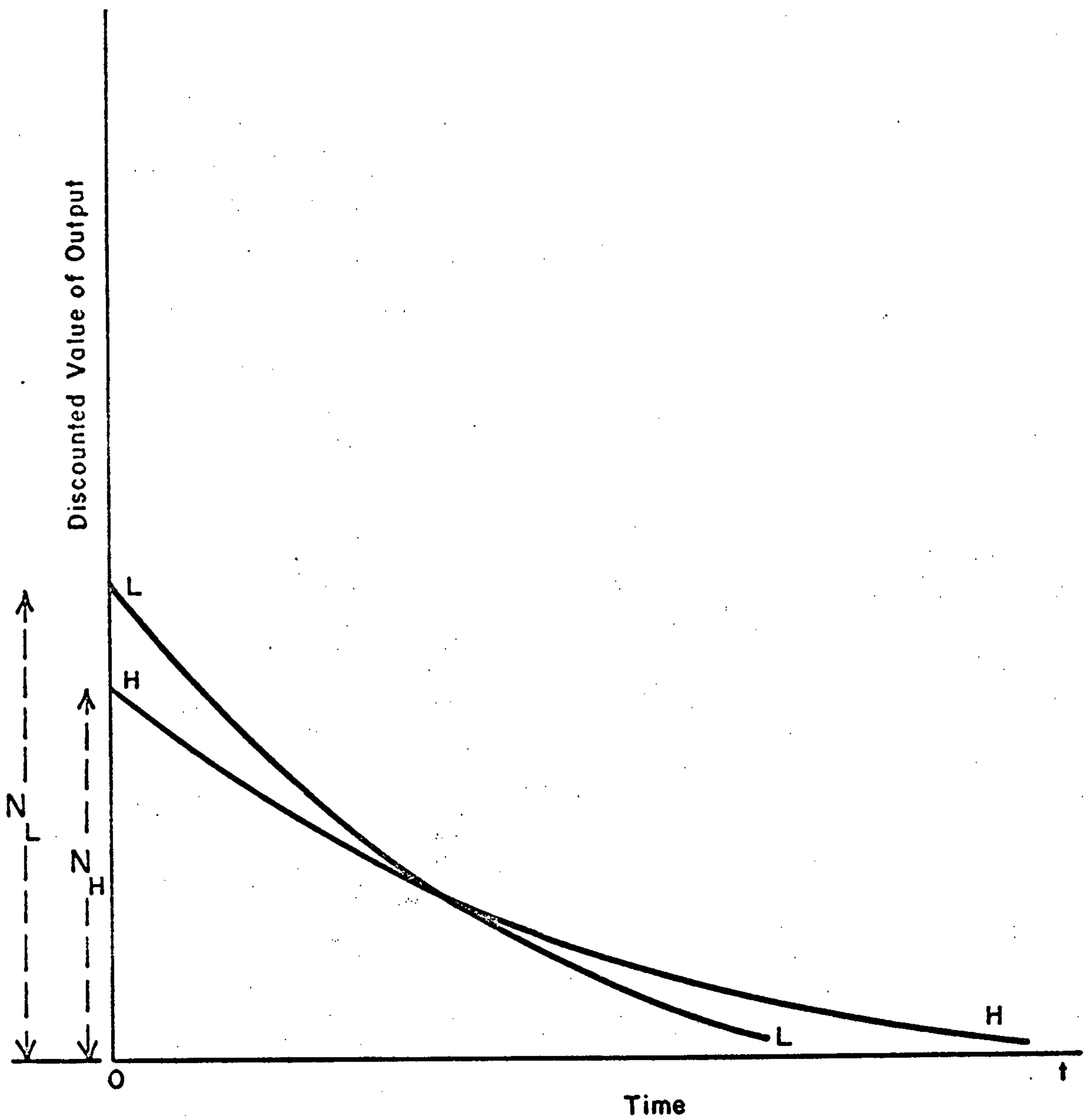
or

$$\int_0^\infty N_H \cdot e^{(g_H - i)t} dt$$

As $i > g_H$ the expression can be written as

$$\int_0^\infty N_H \cdot e^{-(i-g_H)t} dt$$

Fig. 11. Growth of discounted value of output with time when rate of discount is greater than the rate of growth.



$$= N_H \cdot \left[- \frac{e^{-(i-g_H)t}}{(i-g_H)} \right]_o^\infty$$

$$= \frac{N_H}{(i-g_H)}$$

Similarly, the area under L curve is

$$\frac{N_L}{(i-g_L)}$$

Therefore, technique H is better than technique L if

$$\frac{N_H}{i-g_H} > \frac{N_L}{i-g_L}$$

or

$$\frac{N_H}{N_L} > \frac{i-g_H}{i-g_L}$$

given that $i > g_H$, g_L.

This analysis may offer some help in the process of choosing the capital intensity of new projects in a developing economy but it can not be considered a complete guide in real life. The various complications introduced by trying to make the analysis more realistic are discussed by Sen (1960).

The complications are not only due to economic reasons but also political and social. Sen rightly held that a formal economic analysis can not throw much light on how capital intensities are determined. This is so because technological choice has consequences outside the field of economics and also because in life economics is not all that matters.

Whatever criteria are used for choosing the capital intensity at any time it is quite certain that the decisions made at different times will be different. The value of the α's in the model discussed herein will thus be different in different years. Yet, for the sake of simplicity all α's are given the same value in computer simulation.

THE COMPUTER PROGRAMME

Dr. A. Kozak of the Faculty of Forestry has written the simulation model programme. For simulating the growth of an economy various variables have been assigned arbitrary but not too unrealistic values. Also many assumptions have been simplified as given below.

The per capita consumption Cn in year n has been calculated by the gravity formula (10) and the value of f assumed as 8.

The values of all α's have been assumed to be equal to 0.33 when development is initiated. This figure has been chosen as it is representative of the developed countries of today from whom capital is borrowed or techniques learned by the underdeveloped. To show the stagnation stage of C in Fig. 1, α's have been taken as equal to 0.64. This may be realistic as poor countries have low capital-labour ratio.

The value of a has been assumed as unity.

The value of β initially, β_o, has been taken as 0.64.

The initial value of Y has been taken as \$50; that is, $Y_o = 50$. This is, or was, true of many underdeveloped countries.

The initial value of K is therefore $\frac{50}{.64} = 78.12$.

The initial population, i.e., P_o has been taken as one unit. This is not unrealistic as the unit can be defined as a thousand, or million or any other figure and the per capita results are not affected at all.

The depreciation rate d has been assumed to be 0.03 i.e., three per cent, and μ as equal to 0.85. These figures are comparable to available figures from some developed countries.

A further assumption has been made. At very low income levels, like \$50 per capita, stagnation has been the nature of things for long periods. The per capita consumption in fully adjusted state would be 0.85 x 50 or \$42.50, but it is actually subject to a lower limit of \$47.50 which is 0.95 of \$50.00. This assumption has been made because, at such extremely low levels, physiological requirements may override economic behaviour and a certain minimum consumption may be necessary for existence. Such consumption has been chosen as 95 per cent of per capita income because it has been noticed that many stagnant, underdeveloped countries show a saving ratio of only 5 per cent. Consequently formula (10) is subject to the condition that the actual consumption as defined by the consumption ratio will never go below $47.50.

The terms used for denoting various parameters and variables in the programmes are given in Appendix I. Some of these have already been discussed in the thesis and others are discussed in the next few pages. Appendix II gives a programme in Fortran IV for the growth of the economy and also shows the course of this growth for 95 years if the marginal output-capital ratio of the new investments is assumed to be 0.33 and the following arbitrary per capita foreign investments are made.

$$F_o = \$5.00$$

$$F_1 = \$5.00$$

$$F_2 = \$5.00$$

$$F_3 = \$5.00$$

$$F_4 = \$3.00$$

$$F_5 = \$2.15$$

$$F_6 = \$1.35$$

$$F_7 = \$0.61$$

$$F_8 = \$0.46$$

The main problem now is to find whether the economy reaches the take-off stage with these investments. If it does then when and where? The search for the take-off stage is made in the following way.

Defining the Take-off

In Fig. 1, an income level of OT signified the take-off. Therefore in the simulation model also the search is started with the "levels" of per capita income. The economy can be considered to have reached the take-off if the domestic savings in the fully adjusted state at any income level are sufficient to keep the income level from falling. From Fig. 1 it is noticed that there are only two such points, C and T, where such a thing can happen. If income is anything between OC and OT then domestic savings alone can not support that income level. If income is OT then domestic savings can, even in the fully adjusted state, maintain the level at OT. If income is already above OT then even in the fully adjusted state, domestic savings if invested can keep incomes rising further. If each income level above the stagnant state ($50.00) is maintained "forever" and the required foreign investments for the purpose in various years are determined, then it is possible to say whether take-off stage has been reached at that income level. If the "maintenance" schedule for any income level shows no foreign components after a certain time, then take-off has occurred at that income level in the year when the last of foreign investments is needed.

Maintenance of an income level "forever", in a literal sense, is an impossible task. Accordingly, the model is programmed to see for 80 years (which is considered a long enough period) only, whether foreign investments are needed to maintain any income level constant. If for 15 consecutive years, in this 80 year survey, the foreign investment requirements are nil, then it is assumed that at no time in future will any foreign assistance be needed. The programme in Appendix III searches for the take-off stage according to this criterion.

Once a take-off stage is recognized the benefits and costs connected with it must be identified. The cost in terms of foreign capital is the present worth of total amount (not just per capita) of foreign investments in the year 0. It can be easily computed for each investment schedule that brings about take-off.

It will be

$$SS_1 = \sum_{I=0}^{\infty} F_I \cdot P_I / (1+i')^I \qquad (17)$$

where F_I is the schedule of foreign investments that was needed to reach take-off and P_I the populations in corresponding years; and i' is the compound interest rate at which the foreign loans have to be repaid.

The benefits of development are in the form of incomes higher than the per capita income at stagnation. The present worth of the benefits will therefore be

$$SS_2 = \sum_{I=0}^{T} Y_I \cdot P_I / (1+i')^I - Y_o \cdot P_o \cdot \frac{\left[\frac{1+\pi_o}{1+i}\right]^{T+1} - 1}{\left[\frac{1+\pi_o}{1+i}\right] - 1} \qquad (18)$$

where T is the number of years required for reaching take-off; Y_I is the schedule of per capita incomes for the period from year 0 to take-off and P_I are corresponding populations; i is the rate of time preference of the country as a whole; Y_o, P_o and π_o are the per capita income, population and rate of population growth at stagnation stage (i.e., 50, 1 and 0.001895).

The difference (SS_2 - SS_1) is the net benefit from development. If a number of alternative foreign investment schedules that take the economy to the take-off stage are available, the best schedule is the one that has the highest net benefit during the take-off. An infinite number of foreign investment schedules capable of making the economy reach the take-off stage are possible. To reduce the number of possible schedules that must be considered while looking for the optimum schedule, some arbitrary restrictions are placed as already mentioned.

First, it is assumed that only one foreign investment (F_o) is initially made, in the year 0. This will raise the income in year 5 which could be easily shown by a programme like that in Appendix II. The income level of year 5 is now tried to be maintained in subsequent years and it is checked whether take-off occurs according to the criterion already described. If not, a higher value of F_o is taken and the process is repeated. When take-off occurs the SS_2 and SS_1 are calculated (using i = .06 and i' = .02 arbitrarily) and a still higher value of F_o is tried. The range between which various values of F_o are tried is determined by earlier trials and errors. Once the schedule of maintenace and the initial F_o that bring about take-off with the maximum $(SS_2 - SS_1)$ is determined, we have the full schedule of foreign investments corresponding to an optimal take-off provided only one F_o was initially to be made.

Next, two equal foreign investments F_o and F_1 between a suitable range are made. The growth of incomes due to these could be found from the programme of Appendix II. Each income level from year 5 onwards can now be tried by turns to see if take-off occurs at it. When take-off does occur the two initial equal investments plus the maintenance requirements make the full schedule that brings about take-off. The $(SS_2 - SS_1)$ for each of such schedules within a suitable range of the values of initial two equal investments can be calculated as before.

Appendix III shows a programme that searches for the take-off and calculates the $(SS_2 - SS_1)$ as well as gives the entire foreign investment schedule within specified ranges of the initial values of investments for one to eight equal investments. The suitable range of the initial values of investment was determined in the exercise by previous trials and errors. Appendix III also shows the results given for the initial five equal investments between the range \$4.00 to \$5.00. From the results in this appendix it can be seen that the optimal schedule if five equal investments are initially made is

$$F_o = \$4.90$$
$$F_1 = \$4.90$$
$$F_2 = \$4.90$$
$$F_3 = \$4.90$$
$$F_4 = \$4.90$$
$$F_5 = \$2.29$$
$$F_6 = \$1.52$$
$$F_7 = \$0.80$$
$$F_8 = \$0.14$$

The per capita income which was maintained for reaching the take-off was \$53.62 and the year of take-off was 9. The SS_2 and SS_1 were \$7.74 and \$27.93 respectively which give the net loss (negative-benefit) as \$20.19.

Results of other trials were also obtained and are given in Table 1. The last column of this table shows that the net benefits from the attempted development are always negative in this exercise and the best investment schedule is that with five equal initial investments.

TABLE 1

OPTIMAL FOREIGN INVESTMENT SCHEDULES

No. of initial equal invest-ments	Investment schedule $	Year of take-off	Per capita income maintained $	Present worth of foreign capital $	Present worth of income increases during take-off $	Net Benefit $
1	12.00;2.99;3.00;3.01;3.02	5	53.14	23.50	2.43	-21.06
2	8.00;8.00;3.08;3.09;3.10;1.28;0.91	6	53.56	26.64	4.04	-22.60
3	6.00;6.00;6.00;3.04;3.05;1.88;0.77; 0.55	7	53.33	26.31	4.97	-21.34
4	5.00;5.00;5.00;5.00;3.00;2.15;1.35; 0.61;0.46	8	53.11	26.39	5.62	-20.77
5	4.90;4.90;4.90;4.90;4.90;2.29;1.52; 0.80;0.14	9	53.62	27.93	7.74	-20.19
6	4.46;4.46;4.46;4.46;4.46;4.46;1.81; 1.22;0.67;0.15	10	53.70	29.01	8.67	-20.34
7	4.06;4.06;4.06;4.06;4.06;4.06;4.06; 1.58;1.13;0.72;0.15;0.01	11	53.69	30.08	9.18	-20.89
8	3.74;3.74;3.74;3.74;3.74;3.74;3.74; 3.74;1.50;1.16;0.71;0.14	12	53.65	31.13	9.49	-21.64

DISCUSSION

The programme in Appendix III after some modification can be used to show a stagnant economy. It is done if initially no foreign investments are made, the value of marginal output-capital ratio is assumed to be 0.64 which is the same as average output-capital ratio in the economy at time zero, and the income level of year 5 is tried to be maintained. The results of such a programme are given in Appendix IV. The maintenance requirements are shown in the foreign investment column and are very small. It is therefore possible to think of an economy remaining at the stagnant stage indefinitely if only small quantities of foreign aid or some internal changes that can have the same effect are added to it.

The limitation on the programme that 80 years is as good as "forever" seems to have caused difficulty in the search for take-off. From Fig. 1 and Fig. 9 it seems reasonable to assume that the per capita income level corresponding to the take-off stage would be higher than the income at which rate of population growth is highest. The results on Table 1 on the other hand show take-off occurring at a low per capita income level. An income of \$53 or \$54 qualifies for being considered the take-off point if the time horizon is only about 80 years but it may not be so if the course of the economy is watched for a longer time. It will therefore be useful to try to identify the real take-off stage which may be at per capita incomes higher than $150. Due to shortage of time available on the computer it has not been possible to make this change in the programme and to get new results in this thesis. The programmes, as they are given herein, were developed after more than one hundred trials and errors which took just above seven months to give the results that have been presented.

It is felt that, as it is, the programme in Appendix III offers an interesting method of determining the optimal investment schedules and choosing the best amongst them. It helps in resolving the problem of big and few early investments against small and many investments. Table 1 shows that spreading the number of foreign investments beyond 9, under the given circumstances is not advisable. It also shows that making initial foreign investments bigger than $4.90 in earlier stages is not the best way of handling this problem. It is also interesting to note that this optimum figure for foreign investments comes to about 10 per cent of the G.N.P. Results of Table 1 also show that the foreign aid requirement, at least in per capita terms, is comparatively larger in the early stages of development. By studying results like those in this table and the international political situation the planners in a developing country can decide the best schedule of foreign investments that they should have. The model presents a guide, admittedly rough but workable, that can be used by underdeveloped countries after modifications and refinements.

An interesting outcome of this analysis is that the per capita, and not the gross amount of foreign aid is the crucial factor in reaching the take-off. In gross terms a big country like India would require annual foreign investments of the order of 2.5 billion dollars a year for about five years and only slightly smaller amounts in the next four or five years before it could reasonably expect to reach the self generating stage. A small country like Taiwan or Israel has great advantages in this respect. The big country has advantages in large domestic markets, varied resources and versatility but suffers from a big handicap when it comes to availability of foreign aid.

By using various combinations of the values of f, μ, m, α, β, i', i, Y_o, π_o, and the Y-π relationship, the process of development and reaching of the take-off stage can be studied under various conditions. Such studies can not only offer some help in making decisions while launching a development programme but also give a preview of what is likely to happen when a certain decision is implemented.

A DIFFERENTIAL ANALYSIS OF THE MODEL

The simulation model has so far been presented as a "difference" analysis where discrete variables are used. It is shown below as a "differential" analysis when continuous variables are used.

The consumption function of Equation 10 will be written as

$$\frac{dC}{dt} = \sqrt{2f(\mu Y_t - C_t)} - ft \tag{19}$$

where C_t and Y_t are per capita consumption and per capita income at time t.

The rate of change of capital stock in the economy will be given by

$$\frac{dK}{dt} = a \left[Y_{t-m} + F_{t-m} - C_{t-m} \right] . P_{t-m} - \delta . K_t \tag{20}$$

where K_t is the total (not per capita) capital stock in the economy at time t; Y_{t-m}, F_{t-m}, C_{t-m} and P_{t-m} are per capita income, per capita foreign investment, per capita consumption and population respectively at time (t-m); a is the conversion factor for investment; and δ is the instantaneous rate of depreciation, the counterpart of d in the "difference" analysis.

The population growth can be explained by

$$\pi_t = f_1 (Y_t) \tag{21}$$

and

$$\pi_t = \frac{1}{P_t} \cdot \frac{dP}{dt} \tag{22}$$

The average output-capital ratio at any time will be expressed in the following two forms

$$\beta_t = \frac{Y_t \cdot P_t}{K_t} \tag{23}$$

$$\beta_t = \frac{a \cdot P_{t-m} \cdot \left[Y_{t-m} + F_{t-m} - C_{t-m} \right] \cdot \alpha_{t-m}}{\delta \cdot K_t} \tag{24}$$

In the simulation model the marginal output-capital ratios (α's) at different times have been assumed constant and so β_t approaches α as t approaches ∞.

If initial values of all variables are known, and a predetermined growth path of F is assumed then the growth path of Y can be obtained by solving Equations 19 to 24. The take-off occurs at that income level which can be maintained without any F's in the long run.

The best schedule of foreign investments for reaching the take-off is that which maximizes the net benefit from development in the process, i.e., which maximizes

$$\int_0^T Y \cdot P \cdot e^{-it} dt - Y_o \cdot P_o \frac{\left[\frac{1+\pi_o}{1+i}\right]^{T+1} - 1}{\left[\frac{1+\pi_o}{1+i}\right] - 1} - \int_0^T F \cdot P \cdot e^{-i't} dt$$

It may be theoretically possible to solve this problem but practically it can best be handled by a "difference" approach and with a computer.

CONCLUSIONS

Tracing the future growth path of per capita income in an economy is very difficult. The difficulties multiply in the case of an underdeveloped country. The decisions to be made in launching an economic development plan depend on a number of economic and extra-economic factors. The effect of these decisions can be best seen by a simulation model. It may be fruitful to make similar models for a two or multi-sector economy and to get more realistic previews of future and guides to decision making.

PART II

THE PLACE OF FORESTRY IN DEVELOPMENT

A CRITICAL ANALYSIS

CHAPTER FOUR

THE SCOPE OF FORESTRY

DEFINITIONS OF FORESTRY

The term forestry has been defined as "the theory and practice of the whole constitution and management of forests and the utilization of their products" by the Empire Forestry Association (1953). The Society of American Foresters (1958) defined it as "the scientific management of forests for the continuous production of goods and services". The Government of India (1960) defined it as "the theory and practice of all that constitutes the creation, conservation and scientific management of forests and the utilization of their resources".

It seems from these definitions, used in three different continents, that in North America, more than anywhere else, "forestry" is considered almost synonymous with "continuous production" or "perpetuation of forests". Dana and Johnson (1963) made it clear that they considered forestry as the "activity by which forest values are used, perpetuated, and enhanced" (emphasis added). In Canada, in almost all provinces the declared aim of government is to manage Crown forests on a "sustained yield" basis (Sisam 1961). Though the North Americans may appear to be more outspoken about it, almost all over the world, where "scientific" forestry is claimed to be practiced, "good forestry" and "perpetual forestry" are very nearly interchangeable terms. Thus, right in the beginning, either explicitly or implicitly, the principle of perpetuation of the forests without much regard for the costs involved in following it, is accepted. For such a long time and so dearly has this principle been held by most foresters in the world that it now has assumed almost a religious form. Even mildly critical comments on it are often looked on as acts of heretics. Simply for the sake of the pursuit of scientific enquiry, if for nothing else, it may therefore be useful to discuss this question in slightly greater detail.

THE CONCEPT OF SUSTAINED YIELD

The idea of management for perpetuation of timber crops originated in Central Europe in the Eighteenth and Nineteenth centuries when scarcity of timber began to be felt and elements of scientific forest management were being evolved. Wood had many important uses without which the pursuit of the aims of life, as it was then seen, was extremely difficult if not impossible. Forests provided wood for fuel, housing, ships, new industries that were gradually developing, and also for waging wars. Because of the constant danger of wars breaking out and, therefore wood from other countries not being available, there was a natural desire in each nation-state, and even region, to be able to produce its own wood. This could be done only by perpetuation of the forests. If forests were to be perpetuated then it was necessary to cut only such amounts from them which would not endanger future supplies. It was of course assumed that timber would be needed for all times to come for the same purposes and in the same way as it had been needed so far. The forest property was therefore looked at as capital which should be managed in such a way that only the interest accruing on it be used periodically and the capital itself left intact. This apparently was the origin of the concept of "sustained yield". It was the ideal way of ensuring the perpetual existence of forests. The capital or "growing stock" would have to be maintained in such a way that the required volume of wood, subject to the maximum possible, is produced as interest or "yield". In the equilibrium state these interests would be equal. The production of the required volume of wood annually or periodically in perpetuity was now ensured from a given forest land. The volume produced was called "sustained yield". It required that the "growing stock" be maintained in a particular way. The composition of age classes and their volumes must be in a particular proportion before the required annual or periodic increment took place. This growing stock was called the "normal forest".

The history of sustained yield in Europe and North America has been traced by Haley (1966). The shortcomings of the unquestioning acceptance of this concept in the context of contemporary situations have been discussed by Haley (1966), Waggener (1966) and Thompson (1966). A large number of benefits are claimed for sustained yield. However, many of these are not dependent on production of equal annual or periodic harvests but are the result of continuous forest production (Haley 1966).

Of the assumptions implied in adopting sustained yield as given by Waggener (1966) the main are:

(1) A stable flow of wood products is necessary <u>ad infinitum</u>.

(2) Each forest unit operates as a closed economy.

(3) Forest land and forest products are more scarce than labour and capital.

It is easy to see that these assumptions are unrealistic for any considerable length of time. In the United States, while the population doubled and GNP quadrupled between 1920 and 1962, the domestic consumption of timber products remained relatively constant and per capita wood consumption (exclusive of firewood) declined almost 50 per cent (Waggener 1966, United States Department of Agriculture, Forest Service 1965b). Changes in the market for wood products, in technology and utilization standards, and the cost structure of the forest industries have been too well known, in almost all developing countries. The assumptions underlying sustained yield do not hold good in such cases. The economy closest to one for which these assumptions may be true is probably the stagnant economy discussed in Part I. Population increases at a very slow rate, per capita income and technology remain constant, there is no trade and as a result every relevant thing remains constant. If sustained yield is practiced in this economy, there may be enough justification for it. But for economies that are growing, or want to grow, there is none.

One main reason why the goal of sustained yield forestry management has been so popular with forest managers is that it is intellectually very satisfactory and neat. It is an excellent if difficultly obtainable objective for the manager. Once the forest is converted to "normality", practice of sustained yield would mean that year after year the same volume or area of timber is cut. The staff required to supervise the works, equipment needed and labour to be employed would remain almost at a steady level. This would cut down the worries of a manager very greatly and he would be running an extremely smooth operation in perpetuity. The appeal of sustained yield for the forest manager was, and still is, tremendous.

For ultimately reaching such a stage a lot of difficult and complex questions had to be solved during the period of "conversion" of the unmanaged forest to a state of normality. During this period the task of management was to determine the "allowable cut" (Forest Club 1959) which, if followed, would make the forest normal. The conversion period was fixed on the basis of "practical" considerations and the allowable cut was revised from time to time. The texts on forest management deal with the various methods of determining and regulating the allowable cut (eg., Chapman 1950, Brasnett 1953, Davis 1966). The cut may be appreciably different from the sustained yield that could be removed from the forests after it had been converted to normality. But it is such that its removal <u>leads</u> towards normality. The cut is also so regulated that it does not vary too greatly from year to year. This is easy to understand. One could hardly advocate great fluctuations in the periodic cut during the conversion when at the end of this period the sustained annual yields were going to be all equal.

Few forests have so far been converted to normality and most of them are in the conversion period. The world has hardly practiced sustained yield. Nevertheless the cherished goal in most countries is the achievement of the stage when sustained yield will be practiced. To have such a goal is perfectly legitimate if the assumptions mentioned by Waggener (1966) and given earlier in this discussion, are expected to be fairly realistic after the conversion is complete. If these are not realistic, it is hard to see what justification can be found for having a sustained yield goal.

Justifications may be hard to find but the reasons for following the policy of sustained yield are relatively easy to see. One of them is that until about two decades back the entire problem was being viewed by forest managers only and not by economists. The difficulties involved in following a sustained yield policy were pointed out by Zivnuska (1949a) but it was Moore (1957) who criticised the objective of sustained yield rather vigorously and Smith (1962) who picked up Moore's battle cry. The manager had been looking at the problems of forest management from within the forestry sector. The economist looked at them from outside. His main concern was the economy as a whole and not forestry alone. The fear of scarcity of forests and other natural resources did not frighten him out of his wits. Physical scarcity did not matter so much to him as economic scarcity (Barnett and Morse 1963). In the changing technology of contemporary world he realized that the products of forestry could be provided to the society by other resources too, and therefore physical scarcity would not necessarily mean hardship.

Another reason why people have held to sustained yield is the fact that for very long this idea has been advanced by some of the most distinguished and respected intellectuals, scientists and public men in most of the advanced countries as being the best possible method of managing forests. The common man has been sold the idea by conservation-minded crusaders in much the same way as a new product in the market is popularized by efficient advertising. He may now actually be liking forests just because they are forests. Some kind of "love" may have developed.

As regards the underdeveloped countries it may be said that they usually take everything in the developed countries as rational and good. They either can not, or do not, think of most problems independently. It is quite likely that many, if not most, of them may be adopting sustained yield policy just because such an act gives them the comfort that similar policies are followed by the advanced nations, which they wish to emulate.

Most of the developed as well as the underdeveloped countries of the world thus believe that sustained yield is advantageous. The concept is their "sacred cow". They presumably value the satisfaction obtained by practicing sustained yield as greater than the costs involved in practicing the policy. Without the concept of the "state preference function" discussed later in this chapter, the sustained yield policy of conservationists in such countries and the ethical reasons

(Udall 1963) for perpetuating forests can not be justified from an economic standpoint.

Still another reason, perhaps, why foresters have remained satisfied with the goal of sustained yield is the fact that the goal itself has not been achieved in any sizeable area of the world so far. During the conversion period the latitude allowed in deviating from the allowable cut is comparatively large. The permissible deviations have been relaxed gradually due to the realities of the economic and managerial life. It is common to hear of a ± 50 per cent permissible deviation from annual allowable cut. Moreover the periods after which the accumulated deviations are averaged have been lengthening. Therefore no serious obstables have appeared in the economic life of a region due to the professed adherence to the goal of sustained yield. Not only year to year fluctuations from the allowable cut, which should average out to a small figure after some years, have been permitted, but even quite different goals, e.g., the goal of "expanding yield" (Westoby 1965), have been suggested. Such goals are completely different from "sustained yield" not only because "sustained" and "expanding" are different words but also because the absolute concept of "normal forest" becomes completely meaningless with expanding yields. It is the contention of the writer that only that goal or policy can be included within the term "sustained yield" which has a corresponding concept of "normal forest". This apparently has not been considered by many people and terms like "expanding yield" and "modulated yield" (Duerr 1966a) are erroneously thought of as variants of sustained yield. In fact, they are related to sustained yield only because "continuous production" is their common denominator.

The writer feels that this tendency to try to put all other goals of forest management under sustained yield is due to the fact that there is no recognized alternative theory of forest resource use. Zivnuska (1966a) has also pointed out that forestry needs an alternative goal in place of sustained yield. So great is the lack of known alternative theories of forest management that the moment some one criticizes sustained yield, it is often construed as a suggestion that forests must be cut down haphazardly and without any consideration of the future. Development of an intellectually satisfactory theory of forest resource use, which can stand on its own as a more rational rival of the sustained yield theory, is, therefore, a necessity before sustained yield can be handed over to the past.

The writer thinks that such a theory can be developed on the basis of the user cost concept (Scott 1953). Discussions in Gould (1962), Haley (1966), Nautiyal (1966) and Chapter Six of this thesis can probably be seen as attempts to lead to such a theory. The goal of maximization of present worth of net benefits from forest land can be the alternative goal which the foresters may try to achieve.

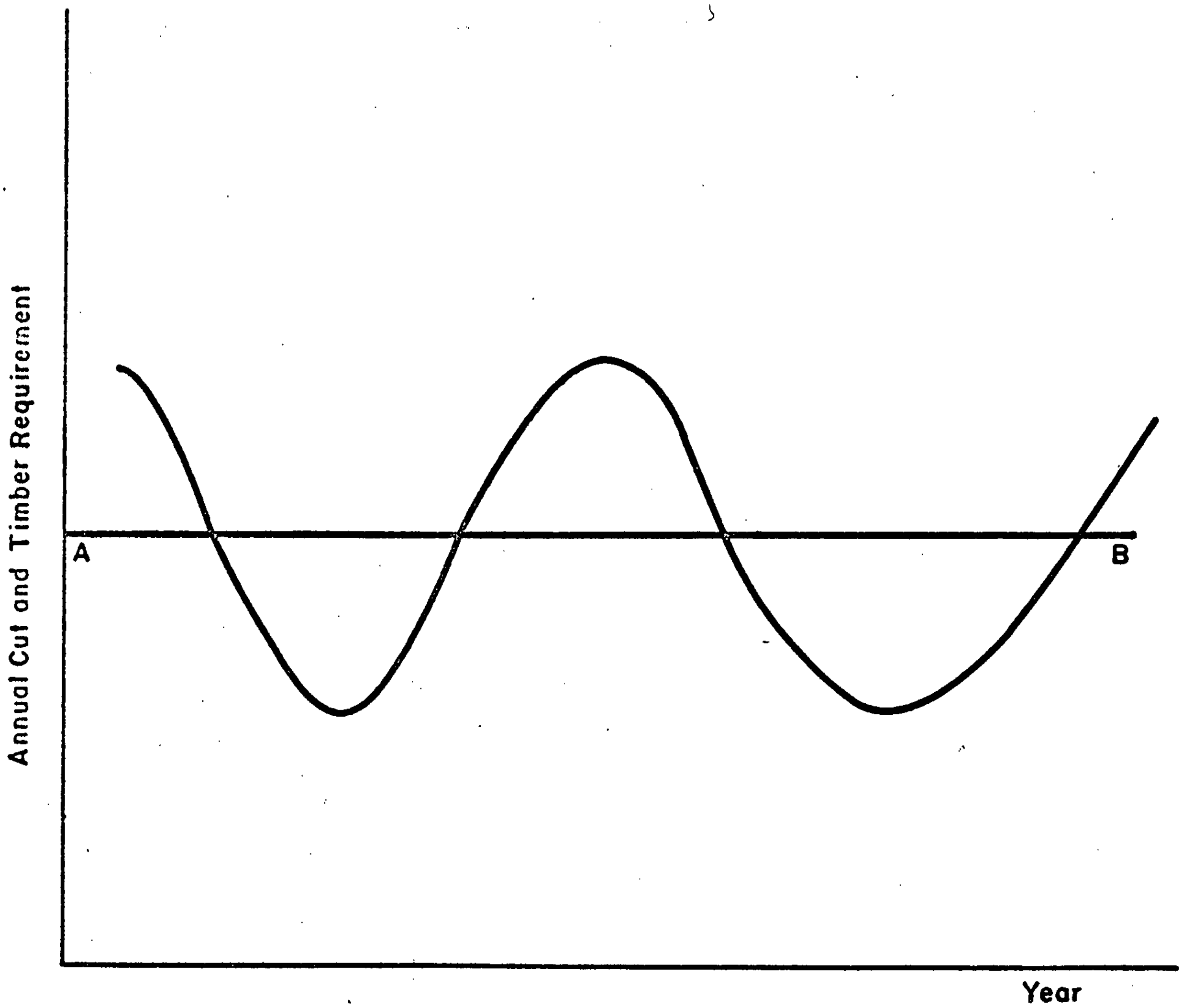
MAXIMIZATION OF PRESENT WORTH AS AN ALTERNATIVE TO SUSTAINED YIELD

In Fig. 12 the concept of rigid sustained yield is depicted by a horizontal straight line (AB). It shows that year after year the same volume of timber (OA) is cut from a forest. Due to the existence of business cycles and building cycles alone, the requirements of timber in an economy like that of the United States show considerable fluctuations (Zivnuska 1949a). The business cycles may vary in duration from more than one to ten or twelve years. The short building cycles vary over the same range but the long ones average 17 years and have ranged from 13 to 21 years. For the sake of simplicity, if it is assumed that all cycles are of the same duration and magnitude, then the sinuous line in Fig. 12 may represent the actual requirements of timber from year to year.

In the face of such fluctuations, a forest property should be organized as suggested by Zivnuska (1949a).

> "A forest property organized and managed so that the net growth was equal to the requirements of the peak years would involve an investment in growing stock which would be excessive in all other years. A forest property organized and managed so that net growth was equal to the requirements of the trough years would be inadequate to meet the needs of all other years. The practical solution appears to be to attempt to organize and manage the property to produce a net growth adjusted to the trend in requirements, and to vary the cut in accordance with cyclical changes, overcutting

Fig. 12. Cyclical fluctuations in timber requirements (level trend).



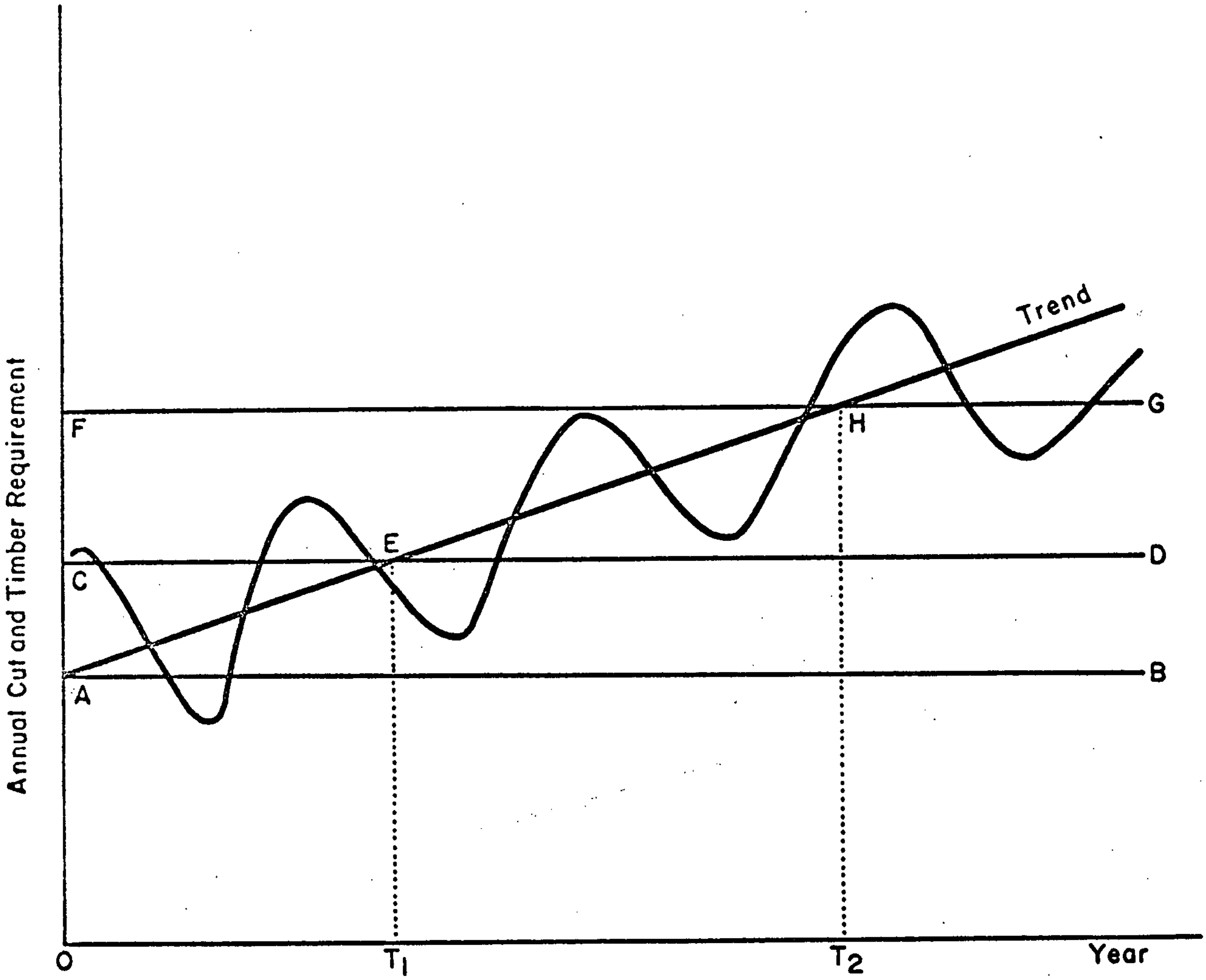
> the growth in years of high demand and undercutting in years of low demand." (emphasis added)

If the trend of the cycles is level, as shown in Fig. 12, and adjustments suggested by Zivnuska are made, then adoption of a sustained yield policy is perfectly legitimate. In this case the annual cut will vary from year to year but the average over a number of years will be close to the "allowable cut".

If, however, the trend appears to be upward sloping (Fig. 13) as in British Columbia, it becomes difficult to justify sustained yield represented by AB (Smith 1965). Terms like "expanding yield" (Westoby 1965) have been suggested as appropriate goals of forestry in such circumstances. Acceptance of an idea like expanding yield means rejecting the goal of sustained yield. If sustained yield is not rejected then the forest has to be geared to a higher level of <u>annual</u> sustained yield, like CD. This level will repeatedly have to be pushed up as long as the trend is rising.

In practice, even this incorrect adjustment is often made in a very faulty way. The level of allowable cut is pushed up periodically not on the basis of <u>future</u> trend but on the basis of the <u>past</u>. At time T_1 the past trend AE is observed and the allowable cut pushed to CD from AB. At T_2, the time of next revision, the past trend AEH is still found upward sloping and the cut is shifted to FG. Thus the new cut adopted is out of date even before it is enforced

Fig. 13. Cyclical fluctuations in timber requirements (upward sloping trend).



(Smith 1965).

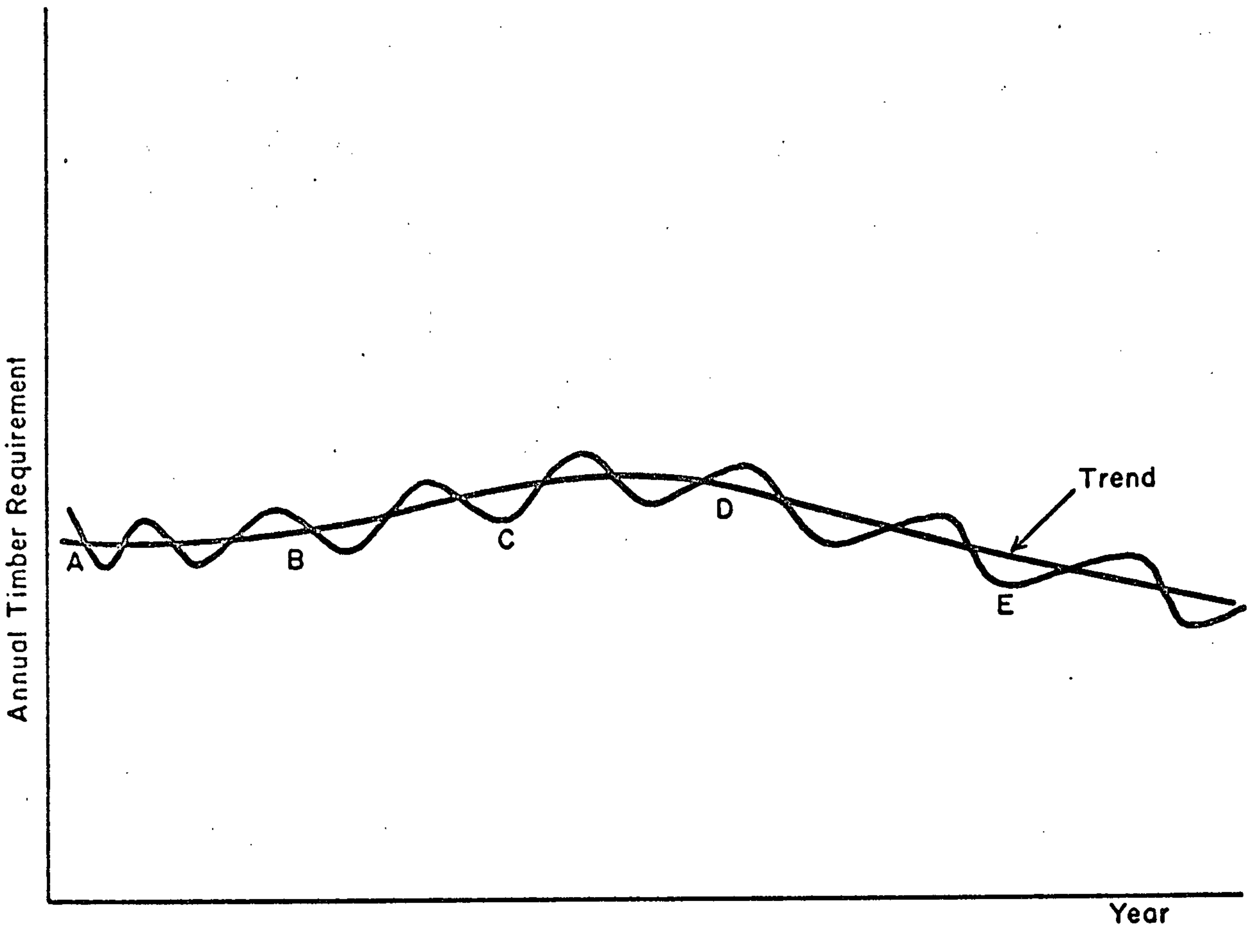
The investments required in following such a sustained yield policy will be much higher than those necessary for following the expanding yield policy on the basis of expected trend. This sustained yield policy could be realized only by gross misallocation of the economy's resources.

If the trend happens to be downward sloping, as it has been for firewood requirements in North America in the last few decades, then the appropriate policy to follow is neither expanding nor sustained yield but "decreasing yield". None of the three policies can be a universal prescription for forest managers. Most foresters in the Nineteenth century expected the trends in the future to be level. Accordingly, they thought that sustained yield was the most rational policy to adopt. It also so happened that for producing equal yields *ad infinitum* from a process that required a long production period, the size of inventory (and capital) required was very neatly given by the concept of a "normal forest". Such a concept has value only if the yields do not have to be changed for periods as long as the rotation. If the change comes earlier, then the required "normal forest" changes. The formation of the new normal forest also takes a very long time. It is possible that yield may have to be re-adjusted so that the required normal forest changes once again even before the one aimed at earlier was formed. In such circumstances the concept of normal forest loses all its meaning. As already mentioned, the term sustained yield and normal forest go together. Therefore, when one (normal forest) means nothing the goal of sustained yield means nothing also. In other words, the goal of sustained yield is not what one should seek when changes in requirements due to the trend of cyclical fluctuations occur at intervals smaller than forest rotations. Sustained yield is a meaningful and valid goal only when the trend is level as in Fig. 12.

If the trends of cyclical fluctuations were to be estimated for the past or the future, there is no reason to believe that they must necessarily be either level or upward sloping or downward sloping all the time. In fact the trend itself could be conceived of as fluctuating irregularly (Fig. 14). For those foresters who are at A and who can see the near future up to B the trend is level and sustained yield policy is appropriate. The same foresters when they are at B will clearly advocate expanding yields. When at C sustained yield will again be a relevant goal. But when at D decreasing yields will be appropriate. It would be a grave folly if foresters standing at A were to decree that for all times to come sustained yield was the most sensible policy to follow. Instead, they must only say that, for foreseeable future, a particular policy would be the best one to follow.

The farther away a point is in time the more difficult it becomes to predict the conditions corresponding to

Fig. 14. Fluctuations in the trend of business and building cycles.



it with any certainty. But this disadvantage is at least partly compensated by the fact that the "present worth" of the far distant future happenings is comparatively small. This is not because the future is undervalued by the process of discounting, but only means that the problems of the near future need more urgent attention than those of the distant future. Therefore, on the basis of the best possible estimates of the future, if decisions are taken "now" in such a manner that the present worth of the sum of all gains, in the present and future from the forest is maximized, then the resource will have been managed in the best possible manner. The concept of "modulated yield" given by Duerr (1966a) appears to be very close to this goal. This also seems to be the case with "balanced forestry" (Gould 1962, Smith 1963).

Flora (1966) argued that the maximization of present worth (in dollar terms) and the maximization of "satisfaction" for the forest owner may not be identical. Such arguments, even if valid, are applicable only to an economy where forests are mostly privately owned and the goal of the society is maximization of satisfaction. In a poor society, living close to subsistence level, the goal of maximization of present worth will also, almost invariably, achieve the goal of maximization of satisfaction. In any case the two goals are identical in an economy which is aiming at economic development as defined in Chapter One. The identity is reinforced if forests are owned mainly by the State which itself is committed to the goal of economic development. For the underdeveloped countries, therefore, the goal of maximization of present worth is the most appropriate one in forest management. For developed countries with private ownership of forests the same goal is valid, but the term present worth may be interpreted to mean present worth of "utility" or "satisfaction", where more dollars do not mean more satisfaction.

A possible argument that a believer in sustained yield forestry may give in favour of the old concept is that it tries to counteract the effects of cyclical fluctuations by supplying less than what is demanded during the boom years and by supplying freely during recession. There is no doubt that amelioration of the effects of such fluctuations is extremely important and must be attempted. But foresters must realize that they form a very small part of the aggregate economy in which causes of the cycles exist. In Canada, just more than 5 per cent of the GNP comes from forestry and forest industries (Canadian Institute of Forestry 1966), in United States, 6 per cent (Hair 1963) or probably less and, in India, 1.5 per cent (Forest Research Institute 1961). Zivnuska (1949a) pointed out that it was beyond the scope of forestry to control the cycles. Forestry must adjust itself according to these fluctuations and learn to live with them. Amelioration of the harmful effects of cycles can be partially attempted, in the aggregate, only by governments through fiscal and monetary policies. The limitations of these policies are great because:

> "Despite all the learned discussion of cycles, there is agreement neither as to their cause nor to their control." (McLeod 1964)

Forestry can not consider its role in this matter to be of much consequence.

The discussions so far have not explicitly considered the possibility of substitutes for forest products replacing them. Zivnuska (1963) discussed the future for wood in the existing conditions in the United States. He pointed out that in terms of meeting the challenge of modern competition between materials, the structure of the lumber industry was certainly obsolescent if not totally obsolete. Because there are no large enterprises in lumber industry which could afford sizeable investments in technological innovations and marketing, he thought that the industry would continually lose markets to other materials. As regards plywood and the wood-based sheet materials, Zivnuska felt that the technology and marketing in these industries were improving better than in lumber. They would therefore continue to expand for at least some time. He also noted, however, that much of the new markets being captured by plywood were from lumber.

The pulp and paper industry was the one amongst all forest industries, in the opinion of Zivnuska (1963), which had the brightest future. The research and development programmes in this industry were progressing well; yet they were not without difficulties. Plastics, metal foils, and other materials were offering competition in established paper markets. His point was that resistances to expansion were mounting, and that greater efforts would be required for further expansion than had been true in the past.

Very significantly, Zivnuska reported in this paper, that the president of a large pulp and paper company once told him: "If we should ever learn to make paper from sand instead of trees, we would swap our forests for deserts."

The failure of the lumber industry in keeping up with its competitors and the success of the pulp and paper industry can also be noticed from the data given by Potter and Christy (1962) for the United States. The deflated price of lumber between 1870 and 1957 showed a continuous increase. The per capita consumption and per capita output showed declines. The deflated price of pulpwood between 1900 and 1957 remained almost constant but the per capita consumption and output increased very greatly. Though Zaremba (1958) thought the price of lumber increased due to rise in per capita income, the main reason probably is lack of technological change and poor marketing.

The possibilities in the future of replacing forest products by substitutes should be shown in the expected future trends. Acceptance of the idea of sustained yield aims at producing timber even if people no longer want it and prefer the substitutes. The goal of maximization of present worth takes care of this factor.

The goal of present worth maximization is an all-embracing one and sustained yield is a special aim within this general goal. The specific aim is suitable only when certain conditions hold true. There is thus no conflict between the two in this respect. The policy of present worth maximization also includes the goal of "continuous forest production" if the benefits from it are sought by the society.

For the purposes of this thesis, nothing is implicitly or explicitly assumed "sacred" about a forest. It should be, and is, looked upon only as something that has a capacity to satisfy present and future human wants. Scott (1955) has pointed out:

> "If man had prized natural resources above his own product, he would doubtless have remained a savage, practicing "conservation".

Worrell (1959) wrote:

> "Forestry is not a good thing *per se*. It is good only if it produces goods and services that people want".

Zivnuska (1966b), while addressing the Society of American Foresters, said:

> ".....we must recognize that our responsibility is not to the trees, not to the land, not even to the environment. Our responsibility is to the increasing numbers of people who must find a means of and purpose for living within the fixed total environment...."

SPECIAL FEATURES OF FORESTRY

Natural resources, such as forests, are usually included under "land" in the traditional trichotomy of factors of production into "land", "labour", and "capital". This has been so because the classical economists considered them to be fixed or God-given like land, the supply of which could not be manipulated. It may be correct to think of factors like climate, acreage of land and inherent human qualities as God-given and thus fixed, but certainly we do not have the supply of forests as fixed. Man can re-create them if he wants to. In some instances just cutting down of the old growth and a little after care ensures a fairly good regeneration of valuable tree species. If it is not so easy to renew the forest, then in most cases planting can give rise to a new crop of trees. Time, capital and labour are needed to re-create the forest resource. Forests, and indeed all natural resources, are thus much like man-made capital and should be included under "capital" in the trichotomy. It does not matter greatly that the time required to create forests is far longer than that required to create other kinds of capital.

Literature on forestry economics emphasises the fact that the wood producing factory, i.e. forest, is also made of wood and that the period of production in forestry is very long.

> "One characteristic, then, of forest capital is that the timber product is also the timber-growing machine, but ultimately the machine is the product. This is more than just an interesting academic point. It is a basic feature of forestry, the consequences of which pervade forest management.
> A second characteristic of forest capital is the long period of production in which it is involved." (Duerr 1960)

Zivnuska (1949b) pointed out that the long period of production makes it very difficult, if not impossible, to adjust the actual production of wood (annual growth or increment of a forest) to the short-run requirements of the market. Observations in the market during the last few years may indicate a reduction in production of wood. This can be done only after a long time when the growing stock has been reduced. Because the "factory" and product are identical even this becomes difficult to do. When demand is declining the right thing to do would be to reduce the growing stock; actually, it is increased as even the full amount of increment is not cut due to low existing demand. Similar difficulty arises in the reverse direction when demand increases.

These characteristics are, no doubt, special features of forestry. But it should be realized that forest growing stock is not all the capital needed for producing wood. The other kind of capital needed is machines, seed, nurseries, pesticides and the like. Moreover, the long period of production seems to be gradually shortening as new fast growing trees are developed. With shorter rotations the proportion of non-timber capital in the "factory" is increasing.

As a result of these special features of forestry, the inventory of wood, required to be maintained by the wood grower or forester, is much larger than in other enterprises. But the nature of the capital and the product in forestry is such that the inventory can be run down rather easily when demand is high and the cost of holding the inventory when demand is low is not great because trees do not easily deteriorate on the stump.

Another relevant implication of the two features is that non-exploitation of the forest in itself is literally an act of investment. Therefore, the questions regarding investments in forestry are automatically answered -at least in part- while deciding the questions regarding exploitation.

A third feature of forestry is that its main product, wood, is very versatile and can be used for many purposes.

FORESTRY AND AGRICULTURE

Forestry is often treated as a part of the agricultural sector in many countries of the world. This is mainly due to two reasons:

(1) In the traditional practice of agriculture, forests have played a very important part in keeping the rural economy running. It was presumably this role of forests which neces-

sitated appointments of "superintendents of forests and forest produce" as early as the Mauryan Empire (321-185 B.C.) in India (Basham 1959). Not only did the forests provide timber for housing, agricultural implements and firewood for the farmer but also grazing and fodder for his cattle and protection from erosion for his fields. For these reasons forestry was considered the "hand-maiden" of agriculture in some places and has been treated as a part of it in almost all countries till recently.

(2) In areas where the basic producing unit -the farm- produced both agricultural crops and wood, to a considerable extent, there was a tendency to lump the two together.

Of these two reasons the first one is no longer valid for the "developed" countries where agriculture has been modernized and the farmer does not depend directly on the forest to any appreciable degree, for the agricultural productivity of his farm. Forests in these countries serve, not as necessary inputs for subsistence agriculture, but as source of raw material for manufacturing industries like pulp and paper, veneer and plywood and lumber. The primary forest product -stumpage- is not directly consumed as is the case with primary agricultural product -food- but undergoes various stages of transformation and addition of value before it is put to final use. In its final use much of the products of forestry go into investment, e.g., making houses, railroads, industrial buildings and in making of books and papers of various kinds which are forms of investment in human resources. The products of forestry and products of agriculture thus perform very different roles in an economy. One category is substantially meant for use in new investments and the other in final consumption. It therefore seems that, lumping the two into one would be over-simplification of the matter, at least in the case of developed countries.

As regards the underdeveloped countries which wish to change their status and move along the road to development, the role of investment and consumption is extremely important. Moreover, as countries start moving towards the "developed" stage they will gradually become more and more like the advanced countries in their economic structure and therefore a classification according to "what is expected to be" is probably far more appropriate than one according to "what has been". This is especially true when every attempt is to be made to change the old structure. It is therefore reasonable to treat agriculture and forestry as two independent sectors in economies which are either developed or wish to be developed.

The second reason why the two sectors have so far been lumped together is applicable only to certain parts of the world like the United States of America and parts of

Europe. In most of the underdeveloped countries, and certainly in India (Nautiyal 1965), very few forests are owned by farmers. Ownership of forest land rests mostly in the State in these countries and completely different units of production produce agricultural crops and stumpage. On this account also it is reasonable to reject the lumping of the two sectors in underdeveloped countries like India.

PRODUCTS OF THE FORESTRY SECTOR

The products of the forestry sector can be put in three major groups (Buttrick 1948).

1. Wood and wood derivative products

This group includes wood in the various stages of its use characterized by the degree to which the tree stem is broken down or subdivided in the process of making it ready for the final use. The different stages according to Duerr (1966b) are:

(a) Roundwood, featuring log cabins, corduroy roads and poles,

(b) Chunks, featuring firewood and the hewn tie and timber.

(c) Thick slices, featuring lumber.

(d) Thin slices, featuring veneer and plywood.

(e) Particles, featuring paper, paperboard and composition board.

(f) Molecules, featuring the nascent silvi-chemical industry.

Each successive stage represents an increasing fineness of division of raw material in the process of manufacture, and admits of fuller uniformity in the end product and thus closer adaptation to mechanized use. Each stage is more adaptable than its predecessor and more amenable to product research and development, and for greater proliferation of product types, styles, and uses. It can be seen that the more advanced and capital intensive an economy, the later the stages of wood use it would employ, and _vice versa_.

> "As a society undergoes economic growth -as per capita output and thus the value of human labour climbs- society is forced to make more and more sparing use of labour in manufacturing and to substitute more machines for labour, which in turn raises still further the value of labour and the incentives to economize in its use. It follows, then, that society's economic growth forces it into successively higher stages of wood use. The products appropriate to the earlier stages become inferior goods and take diminishing percentages of the total raw material. Reading the firewood line at the foot of Table 3 (showing proportionate consumption of firewood as percentage of all roundwood consumed in the years 1900, 1930, 1964 and 2000 (estimated)):
>
> 40.2, 36.1, 7.7, 2.5
>
> The stages just ahead of the wave of progress exhibit rising percentages, as for pulpwood:
>
> 1.4, 9.3, 28.4, 43.3
>
> As the wave moves on, the products appropriate to the successive stages of wood use are swept under, to become inferior goods. (Duerr 1966b)

Of all the forest products, the best organized markets exist for this group. As a result, the determination of the values of these products and consequently of that part of the forest resource that provides them, is easier than that in the case of groups discussed below.

2. Wildlife and non-arboreous forest plants

This group includes all forest-inhabiting animals that have any significance from a human point of view and all vegetable products of non-arboreous nature, such as forage, various edible and medicinal plants, and economically valuable mosses and lichens.

Wildlife has value not only because it provides a quarry for the hunter, or provides food, coats and hides, but also because some animals control harmful insects and rodents. It has value also because of aesthetic reasons. It is easy to establish these values but difficult to measure them (Allen 1955).

It is also extremely difficult to measure the value of grazing on a forest area with any reasonable degree of accuracy. Often the people who seek forage for their cattle from a forest are those who have been practicing grazing there for generations and are used to either no, or a nominal, payment for it. The receipts of grazing fee under such circumstances do not represent the value of grazing and do not take into consideration the actual costs inflicted on the forest owner for providing the service.

In both the cases the difficulty arises due to externalities involved in the transactions and the non-existence of a suitable market for wildlife and forage. It may be possible to create markets for these products but the task is extremely difficult as society very often does not want such markets to exist.

Markets for minor forest products like edible and medicinal plants, mosses and lichens are better organized but their value is usually so little that their omission does not affect the total value of forest products too much.

3. Intangible products and services

This group is also described as "forest influence" and "environmental values" and includes values which prevent or limit erosion, mitigate floods, conserve water, provide recreation and military defences (Buttrick 1948).

The values of the first two groups are derived exclusively from the removal of physical products but those of this group are very different in nature. They are affected by physical removal of other products but themselves can not be thought of as being physically removed. The utilization of some of these values does not affect the capability of the forest to provide them again. For example, one person may enjoy the scenic beauty of a forest park and get some degree of satisfaction, but this act in itself does not restrict the enjoyment of the second person who may seek a similar satisfaction. In the case of wood it is not so. If the first person has taken some wood then the second one can not take as much as he could have, if the first one had not been around. Such goods and services as scenic beauty and military defence are said to have "public good externalities" (Bator 1958). The efficient allocation of "individual goods" (as contrasted with "public" goods and services) is obtained when the marginal rate of transformation is equal to the marginal rate of substitution for <u>each</u> individual (Bator 1957). In the case of public goods the consumption by one individual does not lead to subtraction of another person's consumption and therefore the efficient allocation is obtained by the equality of the marginal rate of transformation with the <u>sum</u> of the marginal rates of substitution of all individuals (Samuelson 1954[2]). In such cases no set of prices can be available that will sustain <u>optimum welfare</u>. Whether the public goods should be produced can be decided only when the sum of utilities of all individuals in the society from these goods is known. This is impossible and Bator (1958) has described such situations as failure of the market to attain Pareto-efficiency allocations due to non-existence of the price configurations. Where such non-existence of prices occurs, any determination of the values of the goods and services is necessarily incorrect. Some of the intangible products of forestry like recreation and military defence in group 3 have "public good" attributes to a considerable extent and so they can not be fully evaluated even if a hypothetical market could be created for them as suggested by Haley (1966). Other goods like erosion and flood control

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2 See also Margolis, J., 1955. A comment on the pure theory of public expenditures. <u>Review of Economics and Statistics</u>, <u>37</u> (4): 347-9.

could conceptually be evaluated but practically the problem is extremely difficult.

In spite of the difficulties involved, economic studies of these services are being undertaken, e.g., ORRRC (1962) for recreation and Black, P.E. (1963) for water yields.

IMPORTANCE OF FOREST PRODUCTS FOR DEVELOPMENT

When development is defined in terms of increasing per capita GNP, as in this thesis, the importance of various products of forestry will have to be evaluated by the contributions each can make toward the increase in GNP. This contribution may be in the present and/or in the future. Thus a contribution of $5 to the GNP today is inferior to a contribution of $3 today plus some amount in the future, the present worth of which is greater than $2. When the future has to be taken account of in this manner it is necessary to arrive at the most appropriate rate of interest which should be used to discount the future values to the present. Each individual in a society may have a different rate of time preference (Duerr 1960) which is the annual percentage at which the individual subjectively discounts future values in his decisions about current *versus* future consumption. When the *per capita* GNP of the future is to be discounted to the present then the individual rate is not of much help as there will be many such rates and only one of them can actually be used for discounting. What is required in such a case is the *social time* preference rate.

The State Preference Function

There is controversy between economists like Ramsay (1928), Dobb (1960) and Sen (1960) who consider that pure personal time preferences do not adequately take into consideration the future generations and so would like to substitute a more rational government time preference; and Eckstein (1957), Bain (1960), Tinbergen (1956) and Marglin (1962, 1963) who would like to base the social time preference rate on public opinion. Feldstein (1964) argued that a social time preference rate reflecting the government's judgement of the relative social utility of consumption at different points in time should be used. He also suggested that this rate can be estimated and may vary through time in response to changes in consumption level and growth rates, the rate of population growth and the pure time preference rate. He thought the rate may be expected to rise as a function of time.

These views of Feldstein (1964) appear to be supported by Nath (1964) when he wrote: "In any case, if the majority prefers some position along the feasibility curve of position I to position II, then that (i.e. the majority approval) is the criterion, both necessary and sufficient, for the government's decision-making in a democracy; the economist cannot offer any alternative criterion."

If, however, Nath is interpreted as writing about each and every decision of government separately then he is diametrically opposed to Feldstein: "Our own view would be to allow administrative determination of the social time preference with whatever weight to the welfare of future generations these democratic administrators would allow. An administrative decision by an accountable government satisfies our notion of the requirement of democracy; democratic theory does not require that each decision represent a consensus, but that government action as a whole be acceptable to the electorate."

It is reasonable to assume that Nath meant his statement in a way that does not contradict Feldstein. It is so, because Nath was talking about the real world and there is hardly any democracy in the world where a consensus of the people is considered to be necessary for every government decision. It can therefore be taken to follow that the "will" or "preferences" of the society as determined by a democratically formed government can be superimposed on the individual preferences. When such a government, as a result of the overall desire of its people, is committed to the goal of economic development, then its preferences become very important in evaluating the relative importance of the products of forestry for development.

Not only for determining the rate of social time preference but also as a guide to action for achieving development in future, a concept of social preference function or "State preference function" (Drewnowski 1961), is essential.

This has also recently been suggested in the context of forestry and economic development by Beazley (1965).

Drewnowski argued that the population has two ways of achieving its economic ends; the direct and the indirect way or the individual and the collectivist way. The individual way consists of actions undertaken by individuals within the framework of existing restraints resulting from institutional, technological, and market conditions. The simplest pattern of those actions is made up of actions directed at acquiring income and actions directed toward spending that income to acquire goods that satisfy wants. The collective way consists of inducing the State authority to take actions that will satisfy the wants of the population.

It is a known fact that not all of the economic objectives of individuals can be realized by the individuals' actions. The economic objectives of a person as an individual may in most cases be achieved in a direct way. But his economic objectives as a member of a nation, class, party, or group connected with some sort of activity (peasant, scientist etc.), and also a number of long term objectives of consumption as an individual, can be achieved only by the indirect way. If he wants the economy to grow faster then his saving more will not achieve the objective. He can not vote for better public utilities, better working conditions and the advancement of science with his dollars but has to vote at the time of the polls to bring to power a government that would have these objectives.

The population as a whole never gives detailed prescriptions as to the activities the government of its choice must undertake. Only broad lines of economic policy are explicitly transmitted to the State. The State authority, being aware of the needs and wishes of the population, determines the particular objectives of its economic activity and makes appropriate decisions.

When people use the direct way to achieve their economic ends, they make their own decisions and act accordingly. Those decisions reveal their scales of values, which can be represented by individual preference functions. When the State makes decisions, it must have some implicit scale of values, and these are represented by the "State preference function". Drewnowski (1961) made it quite clear that this function is not any sort of total of individual preferences, but is determined by the State on the basis of the wishes of the individuals.

> "In the national economy there exist, therefore, two systems of valuation: the multiple system of individual preference functions and the single State preference function.
>
> The important point to bear in mind is that these two systems of valuation are not mere theoretical models but do exist in actual fact. They exist in the sense that the decisions based on each of them are a reality. The preference functions may not be consciously plotted by the subjects that "have them", but they can be "revealed" by analysis of the decisions based on them." (Drewnowski 1961)

He went on to point out that the dual system exists both in capitalism as well as socialism. The boundary between the spheres of influence of these two functions serves as a definition of capitalism as against socialism.

With the existence of the State preference function, and a State committed to bring about sustained increases in per capita GNP, it is now easy to visualize that in an economy those products which can be measured in monetary terms are most important in terms of this particular objective.

Forest products of groups 2 and 3 described in the previous section do not lend themselves to an easy and correct evaluation. Also, whatever value they reveal in monetary units is usually very small as compared to the values of group 1. Therefore it is natural that, while analysing the role of different products of forestry to economic development, as defined here, most of the attention be paid to wood and wood derivative products. Within this group, also, those products are more important which have higher value attached to them, and which can create more of further monetary values.

The State preference function is helpful in explaining an aspect of forestry which crops up in those countries that have cultivated their forests, as a matter of public policy, on traditional German forestry management lines for a considerable period. These countries have been sold the ideas of "conserving" their forests for the sake of conservation, and slogans like "forests are our national heritage", with such success that a large proportion of the population probably genuinely loves the forests as such and would like to keep them in their present state by incurring extra costs, if necessary, for as long as possible. As already pointed out in this chapter, their case is like that of those consumers who are affected by advertising and come to develop likings for new products. For such populations "forests" are a consumption good. They are prepared to pay a price for this consumption. If such a population has a government that implements this desire of the people by enforcing some "conservation" regulations, there is hardly anything that an economist can object to. All that he can, and should, do is to point out that such desires of the people may come in the way of achieving other social objectives. Depending on the relative values that the State attaches to these conflicting goals it will reach a trade-off point and decide how much of each to have.

Usually such countries are the "developed" ones of our contemporary world and these probably value "forests" as consumption goods more highly than the other things they could have by cutting them down. In the case of underdeveloped countries a desire for "forests" as consumption goods may turn out to be too "costly" in terms of opportunities of development foregone. The government of such a country must resolve the relative priority of "forests" and "development" before it can decide how to use its forests for economic development.

The national aspirations for "self-sufficiency" in forest products are also to be understood in the same terms. Such aspirations are often motivated by strategic reasons.

MULTIPLE USE FORESTRY

When forests are managed as a business they often end up producing more than one product. Whatever the importance of one product or the other for development, as long as there is some value attached to other products and the forest owner is trying to maximize his net revenues, it may be profitable to produce other goods and services also.

The economics of multiple use forestry has been discussed by Gregory (1955). For profit maximization the output of each product must be such that the marginal contribution towards net revenue from each product be equal.

The concept of multiple use of forests was the main theme of the Fifth World Forestry Congress at Seattle in 1960. But it is probable that not enough thought has been given to what it really implies (Beresford-Peirse 1962). Whatever it may really mean, it certainly is an approach in forest management that is superior to a single use concept and should be followed by a profit maximizing forester. However, it is not an easy approach (Zivnuska 1961).

In the United States of America multiple use is a major concept of forest policy and "The Multiple Use – Sustained Yield Act of 1960, Public Law 86-517" is the statutory policy directive which underlies management of all National Forest resources (United States Department of Agriculture, Forest Service 1965a). Leading companies in the wood-using industries and many private landowners also follow multiple use forest management programmes in the United States (International Paper Company 1962) and studies are conducted on the various approaches to multiple use analysis (e.g. Worley 1966).

For the sake of simplicity and due to ease of assigning monetary values to products of wood, this thesis does not consider any products other than wood or its derivatives for its economic analysis.

CHARACTERISTICS OF FOREST INDUSTRIES

There are four main primary forest industries:

1. Sawmilling (lumber)
2. Pulp and paper
3. Plywood
4. Board products

Other minor, but primary, industries are charcoal, wood-wool, wood distillation, tanning, resin and lacs. The secondary forest industries are furniture, container, box, match, woodworking and various paper converting industries.

A relative idea of the primary industries can be had from Table 2. It will be seen that the pulp and paper

TABLE 2

SELECTED RATIOS: WORLD'S PRIMARY FOREST INDUSTRIES (1960)

Forest Industry	Gross value of output per unit of raw material	Investment per person employed	Investment per unit of raw material	Employment per unit of raw material
	$ per cubic meter (round)	Thousand $	$ per cubic meter (round)	Number per thousand cubic meters (round)
Sawmilling	27	2.6	15	5.7
Pulp and paper	57	23.8	151	6.4
Plywood	40	4.2	45	10.5
Board products	57	9.3	74	8.0

Source: Westoby (1962)

industry and board products yield the highest gross product per unit of raw material. Moreover, they do not make use of high value timbers but utilize to an increasing extent wood residues, both from other forest industries and from forest operations. The value added per unit of raw material is more in these industries than in sawmilling. It is also clear from the table that the pulp and paper industry is far more capital intensive than the others and the board products industry is also fairly capital intensive as compared to sawmilling and plywood.

Of the total world industrial wood output in 1960, 65.2 per cent went to sawmilling, 29.3 per cent to pulp and paper, 4.4 per cent to plywood and 1.1 per cent to board products (Westoby 1962). The corresponding figures for the gross value of output were 48.4, 45.1, 4.7 and 1.8 per cent, respectively. The principal economic features of each of these industry groups are briefly discussed below.

Sawmilling

Both the raw material (logs) and the finished product (lumber) are bulky and costly to transport in this industry. The raw material is more bulky; for this reason the industry is often located near the forests. Value added in processing is small and there are no significant economies of scale (Duerr 1960). Value added per man-hour hardly depends on capital intensity in the industry (Hildebrand and Liu 1965) and is mostly explainable by labour. Typically, the cost of logs delivered to mill represents 50 to 70 per cent of mill production costs. Because of this, and because of the need to carry an adequate stock of logs to assure continuous operations and of processed sawnwood to meet customers' requirements, working capital needs are heavy, often amounting to as much as fixed investment. A large proportion of the raw material entering the saw mill, a proportion ranging from 25 to 50 per cent, emerges from the process in the form of slabs, edgings and saw dust (Westoby 1962). This material can be, and is, turned to industrial account if there are appropriate forest industries in the vicinity. It usually happens in the advanced countries.

Saw milling is mostly the first forest industry to be established. It does not require a high degree of technical skill on the part of the labour force but only on the part of a few technicians. It is much more flexible in location, in size of plant and in finished product than any of the other primary forest industries. Both conifers and hardwoods are used in the industry.

Pulp and Paper

The investment requirements of this industry are by far the largest in forestry. It has grown very rapidly in the last 15 years, world production almost doubling. Wood costs represent the main item (30 to 50 per cent) of total production costs in this industry too, thus a cheap source of wood is essential. Capital costs and other items like chemicals and power are also important. As a consequence, it is more heavily localized than sawmilling. Because of a number of indivisibilities in the technological process there are considerable economies of scale. Due to needs for large quantities of water and power, the sites of hydro-electric dams are excellent locations for pulp and paper mills in developing countries. The labour requirements in the industry are modest but a fairly high proportion (35 to 45 per cent) needs to be skilled (Westoby 1962). Coniferous species are used commonly for pulping but the proportion of hardwoods has been increasing recently.

Plywood

In the last 25 years world plywood production has become almost six times the 1938 figure of 3 million cubic meters (Westoby 1962). Availability of large diameter trees is important for location of plywood mills. Losses on conversion are very high (50 to 70 per cent in plywood and 40 to 60 per cent on veneer manufacture). Blockboard industry and particleboard industry have a tendency to integrate with plywood industry not only because residues of plywood can be used by others but also because they serve the same consuming sectors, construction and furniture. Cost of wood raw material is 30 to 50 per cent as in pulp and paper. Other important process materials are adhesives. Labour needs vary with degree of mechanization and log sizes. Twenty to 35 per cent of labour needs to be skilled (Westoby 1962). Probably more hardwoods than softwoods are used in the industry.

Fiberboard and Particleboard

Fiberboard industry has affinities with the pulp and paper industry. Wood costs account for 20 to 40 per cent of the total. Economies of scale are possible. As in the pulp and paper industry, an adequate supply of fresh water is needed in wet processes and power requirements are sometimes even more than in pulp and paper. Labour needs are modest. Often both conifers and hardwoods can be used separately and in mixture. Debarking of trees is usually not necessary and sometimes even sawdust can be utilized. The dry processes of manufacture do not need large supplies of water and their investment needs are also low. They however need resins for bonding.

In the case of particleboards, many kinds of wood residue, both coniferous and broad leaved, as well as agricultural residue, can be used. Water is not needed and power requirements are modest as are those of labour. Cost of resins is very important, being 15 to 35 per cent of production costs (Westoby 1962).

CHAPTER FIVE

A REVIEW OF CURRENT VIEWPOINTS REGARDING ROLE OF FORESTRY IN DEVELOPMENT

VIEW OF THE FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Forestry as a sector in an economy has long been recognized, but its role in development has not been explicitly studied until recently. This is not unnatural as economists and social scientists have been especially pre-occupied with the phenomenon of economic development only since the end of World War II (Ginsburg 1965), and could hardly be expected to start with the study of forestry. The increasing interest in the subject now is reflected by the appearance of as many as three articles on economic development in a single recent issue[3] of Unasylva.

Attention to the role of forestry in economic development was probably first called by the Food and Agriculture Organization (FAO) of the United Nations, the biggest agency studying the subject. The idea of the FAO is that forestry is an important sector for the purposes of development. This is suggested in a paper by Westoby (1962) that has been called "...in originality and logic....one of the few classic contributions to the literature of forest economics" by Zivnuska (1966a). Westoby has argued that forestry should find a significant place in national development plans in the underdeveloped countries.

To begin with, he explained that public intervention in economic affairs of underdeveloped countries was necessary and "while the solution will depend on the structural conditions and the physical endowments (that is, the data) of the economy concerned, the main element of choice is political, since the difinition of the general ends of the plan is mostly the result of a political decision." He also pointed out that the benefits and the costs of investment policies and projects should be evaluated with the aims of the plan (i.e., the entire community) in view and may therefore often diverge from the private criteria of evaluation. He further showed that wood

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[3]Volume 18 (4); Number 75; 1964

products, directly or indirectly, had a large share of final demand which was spread over a very large number of items. Also,

> "In 1953 the sector of forest and forest products (including both wood products and furniture and paper products) accounted for 7.2 per cent of the total value added and for 9.25 per cent of total world employment of mining and manufacturing industries in terms of value added and fourth in terms of employment. The breakdown for the two main branches is the following: 4.2 and 3.1 per cent of value added and 7.9 and 2.2 per cent of employment respectively for wood products and furniture, and for pulp, paper and paper products. This shows a remarkable difference between the two main branches in labour productivity, which is higher than the average in paper and paper products and much lower than the average in the other branch." (Westoby (1962)

To measure the "spread" of uses of forest products or the extent to which they enter into other products (the degree of indirectness of the sector) Westoby suggested two coefficients that can be determined from input-output tables. The first coefficient is the ratio of the value of purchased inputs to that of total production of a sector, which indicates how far production in a sector involves the indirect use as compared to the direct use of capital and labour. The other ratio is the value of intermediate demand to that of total demand for the products of a sector, which shows the extent to which the sector sells its output for further use in production (Chenery and Clark 1959). The comparison of these ratios for a given sector with the ratios for the whole economy will reveal whether the linkages (Hirschman 1963) -both forward and backward- of the sector in question are stronger or weaker than the average.

He has given such ratios for four developed countries-Japan, Italy, the United States of America and Norway. These ratios along with the ratios for an 'underdeveloped' country-India- based on a 31 x 31 sector input-output table for 1960-61 (Manne and Rudra 1965) are given in Table 3.

A study of these figures is meaningful only when cautiously done. All the countries concerned can not be assumed to have included the same items in each sector. Moreover the ratios are for different years for each of the countries. In addition, each country may have differentiated "intermediate demand" and "final demand" in a different manner. For example, construction is treated as an "intermediate demand" in the Indian input-output table but is probably in "final demand" in other tables as suggested by Westoby (1962).

From the comparison of the ratios in Table 3, Westoby has observed that in the 'developed' countries (except U.S.A. for wood and wood products) in both sub-sectors the ratio of the value of purchased inputs to the value of total production is considerably higher than the average. He noted, however, that the purchase of inputs is concentrated in agriculture and forestry from where the raw material is taken. He has also observed that the paper and paper products sub-sector has a very much higher ratio of intermediate demand to total

TABLE 3

INDICES OF INTERDEPENDENCE OF FOREST INDUSTRIES

Country	Ratio of value of purchased inputs to value of total production			Ratio of value of intermediate demand to value of total demand		
	Average all industries	Wood and wood products	Paper and paper products	Average all industries	Wood and wood products	Paper and paper products
Japan	48.7	68.2	62.8	46.1	29.5	80.2
Italy	43.8	71.6	53.8	41.1	43.1	75.3
U.S.A.	42.6	42.1	56.6	41.9	40.4	79.2
Norway	36.4	51.5	55.7	30.4	29.1	42.5
India	46.3	5.0	--	40.4	95.9	--

N.B. The ratios for paper and paper products for India could not be calculated because the input-output table does not have "paper and paper products" as a separate sector. This is presumably so due to the small size of the sector.

demand than the average for all industries and the ratio for wood and wood products is lower than average but not very much lower. In his opinion this ratio would probably not have been lower than average if the 'construction' sector were treated as an intermediate demand. From these observations he concluded that the sector of forest products as a whole has a high degree of indirectness and of interdependence with other sectors.

It appears that this conclusion of Westoby can lend itself to some refinement. Firstly, the fact that in developed countries the ratio of value of purchased inputs to value of total production of wood and wood products is mostly above the average for the whole economy, is not of much significance if the inputs demanded are mostly from agriculture and forestry itself. This is so because under such circumstances the demands placed on other sectors by an expansion of the forestry sector are very little. In other words the backward linkage effect of forestry is poor.

This conclusion can also be drawn for an underdeveloped economy like that of India where the value of purchased inputs is only 5 per cent of the total value of production. Whatever be the expansion in the forestry sector it will stimulate the demand from other sectors very little. The great difference between these ratios for developed and underdeveloped countries shows that more mechanized methods of production are used in the former. It also points out that a forest owner in an underdeveloped country can expand his production rather easily as he may not need much capital.

Secondly, the ratios of the value of intermediate demand to value of toral demand of wood and wood products, in the case of the four developed countries under discussion, are most probably underestimated in the table because of classifying construction as final demand. The figures in Table 3 for the wood and wood products sub-sector are so close to the average figures, in most cases, that it is possible that the correct ratios would be higher than the averages. If that is so the wood and wood products sub-sector would have stronger forward linkages than all industries taken together and would be stimulated a little more than the whole economy if other sectors expanded. In the case of India, however, the forward linkages are very strong and even a small expansion of other sectors using wood and wood products would place heavy demands on the sub-sector. Alternatively, expansion of forest products at economic prices will give impetus to industries using these products as inputs.

Thirdly, the ratio of the value of purchased inputs to value of total production would be more useful if by "purchased inputs" was meant "domestically purchased inputs". This ratio in the case of paper and paper products for the developed countries is considerably higher than the average figures for the whole economy. Moreover the purchases in this case would not be as much in the agriculture and forestry sector as in the case of wood and wood products. In other words, the backward linkages of this sub-sector would be substantial. Such would be the case even for an underdeveloped economy because the machinery and chemicals required would not be different from those in the developed countries. It can be concluded that the paper and paper products sub-sector has stronger backward linkages than wood and wood products sub-sector and an expansion in it will lead to greater demands on other sectors than an equal expansion by the wood and wood products sub-sector.

Fourthly, the ratio of the value of intermediate demand to value of total demand in the case of paper and paper products for three of the four developed countries is very much higher than the corresponding ratio for the whole economy. This means very strong forward linkages. Such a conclusion can be made for an underdeveloped country also as the most important uses of paper there are for cultural purposes (Nautiyal 1965), i.e., printing and writing which are intermediate demands.

In general, the conclusions are that wood and wood products have poor backward and strong forward linkages while paper and paper products have moderate backward and very strong forward linkages. Thus, from the point of view of Hirschman (1963), the paper and paper products sub-sector is more important for development than the wood and wood products sub-sector. Investments in the paper and paper products sub-sector will stimulate the economy more than an equal investment in wood and wood products.

In his Table 2 Westoby (1962) has given the average annual production, total consumption and consumption per head of the main categories of forest products for the years 1957-59 for the developed and underdeveloped countries of the world. A part of his table concerning apparent consumption is reproduced below as Table 4.

Besides pointing out that production of forest products is very heavily concentrated in the developed world, Westoby has mentioned that consumption is even more highly concentrated in them as can be seen from Table 3. The less developed countries rely on the advanced regions for a considerable proportion of their supplies of certain categories of forest products. They can not meet even their meagre demands in full. The consumption per head is extremely low in the underdeveloped countries, being only one seventeenth to one twenty-eighth of the developed areas.

These facts only serve to show the differences between the two groups of countries but do not throw any light on the part that forestry can play in development. Probably the figures would have been more meaningful in this respect if the term "apparent consumption" could be split into two components: 'investment requirements' and 'current consumption'. Most of the sawn wood goes into building construction which may be treated as mainly investment. In less developed countries rural construction may have to be considered as consumption but urban construction, especially industrial construction, is most certainly investment. Much of paper and board requirements in underdeveloped countries may be treated

TABLE 4

APPARENT CONSUMPTION OF FOREST PRODUCTS
1957-59 AVERAGE

	Unit	A Developed Countries	B Underdeveloped Countries	Ratio A:B
Population (1958)	Million	923	1956	0.47
Apparent consumption: Total				
Sawn wood	million cu.m. (sawn)	286.7	35.0	8
Wood-based panel products	million cu.m. (round)	38.3	3.0	13
Paper and board	million metric tons	58.1	5.3	11
Apparent consumption: per 1000 capita				
Sawn wood	million cu.m. (sawn)	310.0	18.0	17
Wood-based panel products	million cu.m. (round)	41.7	1.5	28
Paper and board	million metric tons	63.0	2.7	23

Source: Westoby (1962)

as investment as education is investment in human beings but uses of paper such as those for toilet purposes can be considered as current consumption. In the same way it is possible to classify the uses of all other forest products into investment and current consumption categories. Presumably the proportion of investment needs of forest products to the current consumption needs would be higher in underdeveloped countries. If it is not higher then it means that development has not yet been attempted and should be made higher by initiating development. Existence of abundant forest resources in a country can prove handy in increasing investments. But there is, as yet, no reason to believe that creating more forests is justifiable for development. All one can say at this point is that if there are enough forests in a country which wants to have economic development, then it should use those forests if possible for creating more productive kinds of capital than the wood capital so that the productive capacity of the whole economy increases. Westoby (1962) has pointed out that in many underdeveloped countries the raw material (forest) is ready at hand but is not used for conversion into other kinds of capital even though the techniques required in many cases are not too complex.

He has next gone on to show the dynamic nature of the demand for forest products. This is a most important characteristic from the point of view of the forester. He must realize that most of the forest products lend themselves to substitution rather easily. The income elasticity of paper and paper products is as high as 2.5 to 3 at income levels of around $100 per capita; at levels of around $200 to $400 per capita it ranges from about 1.5 to 2.5. At European income levels, roughly $500 to $1,000, it is well over unity. For the United States, with an income per capita of well over $2,000 it is below unity (Westoby 1962). Thus at low income levels a slight increase in income level per head can increase the demand for paper and paper products very greatly. As most of the paper needed at this level is for reading and writing, which is an investment use, such demand must be satisfied for ensuring further increases in per capita income. It is also worth mentioning here that so far no significant substitute for paper made from cellulose is known to man for writing and printing purposes, therefore the value of paper is great for development. But this does not mean that value of forests is also necessarily great. Westoby has failed to mention that in the tropical and sub-tropical countries of the world which are almost all underdeveloped, and have large quantities of agricultural residues (like sugar cane bagasse in India), such materials can be substituted for forest products in the process of manufacture of paper. This is already beginning to happen in India (Nautiyal 1965). Forests will remain important for paper and paper derivative production only as long as they can provide raw material of acceptable quality at more economic prices than agricultural residues. If they can not do so their importance is indeed little.

In regard to wood products other than paper the case for forestry is even more difficult to make. The relationship between income elasticity and per capita income is not as well defined for these products as for paper and paper board (Westoby 1962). This is because factors other than income influence the demand very heavily. One of such factors is the availability of wood in the country (Gregory 1966). The prices of substitutes is another very important variable. Gregory (1966) has shown that countries with low incomes and a shortage of available timber have high consumption elasticities with respect to both income and wood availability. As either wood availability or income or both increase the elasticities drop substantially.

The prices of substitutes go on changing due to the advances in technology which affect the prices of forest products also quite substantially. The technological progress makes relative scarcities of raw materials very different from year to year (Landsberg 1965) and the prices move correspondingly. Under such circumstances, unless the forester can ensure that the technological changes in forestry and forest products manufacture are of such significance that wood of required quality continues to be more economical than other raw materials, the importance of forestry as implied by Westoby (1962) will gradually vanish. Quite impressive advances in sawmilling such as reported by Dobie and McBride (1964), British Columbia Lumberman (1966a, 1966b) and Dobie (1967) indicate that the cost of milling small trees may be reduced very considerably in future. Fast growing trees like eucalypts (Van Laar 1961, Nautiyal 1965) and sycamore which can be grown for pulpwood at rotations that may be as short as 2 or 3 years (McAlpine et al. 1966) may be indications that foresters can succeed in keeping wood as the best and most economical raw material for many end products. The research of Woods (1960), Reifsnyder and Lull (1965), and others, point out that forests are the principal organic recipient and storer of solar energy. When concentrated solar energy in the forms of fossil fuels - coal, oil and natural gas - is depleted the only sizeable storage of energy may be in forests. Forests not only store solar energy but are the most efficient means of storing it in vegetation (Deevey 1965). In the very-long-run they may still have important role to play in human welfare.

Westoby (1962) has also given estimates of forest products requirements in the underdeveloped countries up to 1970. The estimates were prepared by the FAO in collaboration with the regional Economic Commissions of the United Nations. These estimates suggest that the annual consumption of sawnwood, wood-based sheet material and paper and board will increase from 35 million cubic meters (sawn), 3 million cubic meters (round) and 5.3 million metric tons in 1957-59 to 67, 11 and 13.9, respectively, in 1970. Such estimates would have to be based on the projected per capita income growth in the underdeveloped regions and as it is extremely difficult to do that, the projections of forest products demand would be very rough at best. The difficulties of predicting future per capita incomes can be visualized from the large number of variables involved and the complicated way in which they interact in even as simplified a model as that in Chapter Three. This is not to say that the projections given by Westoby (1962) are meaningless, but to point out that they convey their full meaning only when the assumptions on which they are based are given clearly.

Assuming that the estimates mentioned above are realistic, Westoby has gone on to compute the cost of importing all the additional requirements as $3,780 million and the cumulative cost of capital required to set up productive capacity large enough to meet all demands within the underdeveloped countries up to 1970 as $5,007 million in that year. Thus, it is argued that cumulative costs of only $5,007 million in 1970 are incurred in setting up domestic capacity while every year for ten years $3,870 million would have to be spent to import the forest products from the developed regions. On the very face of it, setting up capacity in underdeveloped regions therefore appears as more economic. The capital costs, however, presumably do not include the costs of procuring raw materials and would be greater than $5,007 million if these were included. Also the comparison of the two kinds of costs should be done in a more sophisticated manner by compounding or discounting all values to a single point in time. It is quite possible that such comparisons would also show that setting up new capacities is a better alternative to importation. If they do, then there is a comparative advantage (Renne 1958) in producing forest products in underdeveloped countries. Analyses should be done not only regarding forest products but other industries also in developing countries to take decisions on matters of setting up new capacities. These analyses could take the form of benefit-cost analysis (Hirshleifer et al. 1961, Sewell et al. 1961, Haley 1966) after incorporating the economies of scale, if any, and a given period of time into it. If forest industries pass such tests they could certainly help achieve economic development. Westoby clarified this point when he stated:

> "First the problem of comparing costs and benefits is economic and not financial; all benefits, direct and indirect, short as well as long-term, should be considered and weighed against costs for the community, that is, social costs.
>
> Secondly, the problem cannot be given a ready-made solution on the basis of the traditional doctrine of international trade and specialization. A static theory cannot account for dynamic phenomena, nor can it justify the results of past trends, such as the concentration of forest industries (or of any other industries for that matter) in more advanced areas. Traditional international trade theory takes for granted that industries are where they are, but cannot explain why they are there. Such a theory is founded on a given distribution of external economies and is valid within its limits, but it cannot be used to infer that such distribution is the optimal one or that it cannot or should not be altered. Very few advantages are really rational, in the sense that they cannot to some extent be created in the long-run. In the case of forest products the natural element underlying the existing forest industry pattern might be the distribution of conifers. This in turn

> depends, however, on the favoured position of conifers, which technical progress, especially if consciously oriented, could undermine, not to speak of the fact that it might also be possible to alter the existing distribution of conifers. In any case, all arguments in favour of maintaining the status quo which are based on the theory of international specialization are only valid when long-term advantages in terms of accumulation and reinvestment and social advantages in terms of external economies, are neglected - that is, only when applied to a static context - but cease to have any relevance when the question is exactly that of creating those advantages in order to change the status quo."

He has considered the following features of forest industries as relevant to development.

1. Import Saving Effect

At present the underdeveloped countries consume forest products at very low levels but substantial parts of even these are imported by them. In their attempts to industrialize, their demands for imports of capital goods are likely to increase very considerably and consequently the trade deficit will also increase. If forest industries are developed then the imports of forest products can be eliminated or reduced. This will partly help the balance of payments position. Moreover, the pattern of trade in forest products between developed and underdeveloped countries is such that mostly unprocessed hardwood logs are exported by the underdeveloped regions and processed products like pulp and paper are imported. Investment in plywood and pulp industries could improve the trade situation in favour of the poorer countries by increasing the value of product exported (plywood and veneer in place of logs) and by reducing the imports of pulp and paper - at least partly.

This argument in itself is not sufficient as investments in other industries, which also produce goods with high income elasticity, may be able to have a greater import saving effect. From the point of view of import saving and export promotion not just those industries which have these effects should be promoted but those which have the biggest such effects should be favoured. Sawmilling and plywood are such industries that they may be amongst those which have the biggest effect in countries that export unprocessed logs, provided new markets can be developed.

2. Technological Advantages

The technologies in use in forest industries are such that a wide range of production function and a great flexibility relative to scale is possible. In producing wood a high degree of mechanization and extensive use of unskilled labour or both are usually possible. When capital is scarce mechanization can be postponed and employment for a large labour force provided. Moreover, in timber growing and primitive logging by hand only those skills are required on the part of labour that are normally plentiful in rural areas of underdeveloped countries. Very often the rural population and other resources are unemployed during parts of the year when the pressure of agricultural work is not great. These resources by their very nature and in the cultural settings of an underdeveloped country are immobile and incapable of being employed in sectors other than agriculture or forestry. Thus the wood growing and harvesting part of forestry is probably the sector that can most efficiently use the unemployed rural resources in a productive way. The social costs of such operations would be very little.

In such circumstances in the rural areas small scale industry can also be profitable. Resin extraction in the Himalayan chir pine forests is an example.

3. External Economies

The wood resource is so heterogeneous and can be used for so many purposes that establishment of an industry usually makes it possible for other industries to develop. Sawmilling produces sawdust which can be used as a fuel in areas where firewood due to its bulk could not be transported easily. This leads to development of a small scale sawdust stove industry based on scrap sheet metal. Such chain reactions have occurred and are occurring in parts of India.

A few 'chip and saw' mills could lead to a small pulp mill based on the chip residues and so on. As forests are usually far away from the centres of population, the forest industries tend to be established away from urban areas due to resultant economies in transportation of raw material. This usually results in new road and rail development which often has sizeable external economies of which other sectors can make use. Due to their strong forward linkages forest industries can induce considerable investment in other industries.

Finally, Westoby (1962) has discussed how a plan for forest resources development may be made and fitted into the national development plan. This involves estimating future demands and estimating the availability of forest resources. It also requires knowing fairly clearly what the objectives of the national plan are and how it is proposed to achieve them in general. The FAO has been actively trying to help the underdeveloped countries in this respect by first sending experts to make a general assessment of the situation (e.g. Smith 1964) and then making detailed plans.

Not only has the FAO been concerned about the theory behind the role of forestry in economic development of the less developed countries but also technical forestry education in them. Its role has been very important in disseminating knowledge not only in the fields of logging, utilization, tree breeding and silviculture but also in "educating" the policy makers of the underdeveloped countries regarding the way forestry education should be imparted there (FAO Staff 1964, Shirley 1964, Sisam 1964). The special features of forestry education in tropical developing countries have been reviewed by Champion (1965) also, though not under the framework of the FAO.

The FAO in addition has been trying to help the developing countries by promoting plantations of fast growing species. It has been pointed out (F.A.O. Staff 1965) that future wood needs can be more economically met by plantations than by old growth forests.

VIEWS OF THE AGENCY FOR INTERNATIONAL DEVELOPMENT AND FORESTRY ECONOMISTS IN THE UNITED STATES

The United States of America contributes the largest amount towards the development loans given by the developed to the underdeveloped countries. From 1958 to 1964 loans authorized totalled 5.57 billion dollars (United States Government 1966). Almost all of these loans are administered by the Agency for International Development (AID). With such a large involvement in the development programmes of the developing countries, it is only natural to expect that the forestry economists in the U.S. would get interested in the subject in which the FAO's role has just been discussed. Beazley (1965), in a paper presented to the Society of American Foresters, emphasized that some of the conflicts that are faced by economic decision makers in a developing country can be resolved only by recognizing that the state preference function exists and by making use of shadow prices. Though some aspects of economic planning have been dealt with very clearly in his paper, little help has been offered in decision making for the forestry sector. In a very general way it has been suggested that activity analysis be used for the purpose and all sectors of the economy be dealt with at the same time. There is no doubt that such an approach which seeks to answer the questions about all sectors simultaneously is probably the best. But, in the absence of any practical method for solving an actual set of a very large number of linear programmes for an economy so that the optimum levels of investments in each may be determined, it is not clear how a planner is any better off than before.

Another American contribution to the subject, probably as a result of the AID programmes in Latin America, is by Gregory (1965). He pointed out that so far forests had been ignored in South America as bases for development, though they form 54 per cent of total land area there. This, it was observed, was the highest forest area/total land area ratio of all continents. Gregory (1965) argued that no theory of natural resources in economic development can be forwarded till a general theory of economic growth is developed. In fact, it was impossible, he argued, to say anything about the role of natural resources in development simply by looking at case histories of various countries. Nations like the United States, Canada and the Soviet Union have made use of their natural resources in raising their standards of living. Countries like England and Switzerland have achieved high levels of income even without being endowed with natural resources. Countries like Brazil, Chile or Indonesia, on the other hand, have not succeeded in improving their lot even with large endowments of natural resources. These examples probably demonstrate that the role of natural resources is only permissive in economic development. They can facilitate growth but not cause it. Moreover, they are on a world basis and not indispensable.

While not getting involved in the general role of natural resources - especially forests - in economic development, Gregory (1965) pointed out that the forest resources in Latin American have some advantages which can be made use of in directing investments in forest industries. The advantages are discussed below.

1. The expanding internal market

Even at present, with low levels of per capita income, Latin America spends more on forest products imports than the value of such material exported. If incomes increase in the future then the demand for forest products, especially pulp and paper, will increase very considerably and tend to widen the forest products trade deficit. This can be reduced if investment in forest industry is made. Also the total investment costs for producing the forest products at home have been shown to compare favourably with the costs of importations over a period of few years. It has also been pointed out that if products like pulp and paper are not made available to an economy its development is severely impaired. Producing at home is a better alternative than importing because, in addition, it has a multiplier effect in the domestic economy.

2. Capital requirements are low

Forest industries have a high proportion of the total production costs as wood costs. This means that the capital costs are relatively low when compared with many other industries. Consequently the establishment of forest industries is not very difficult in underdeveloped areas which have scarce capital but plentiful labour.

3. Investment range is wide

Forest industries range from very labour intensive sawmilling to capital intensive paper industry. This means that any kind of investment can be made in it depending on the circumstances.

4. Labour is flexible

Rural labour that is seasonally unemployed can be utilized in forest industries without much difficulty. Moreover, this labour gets gradually trained in mechanical jobs in these industries and thus becomes more mobile than before. Though the second point regarding training of labour will generally be accepted, Wilson (1965) adopted the first point with reservations and pointed out that demand for woods labour in many tropical forest areas may coincide with the peak demand for labour in the fields due to seasonal aspects of both.

5. Economic linkage

On the basis of figures for Italy, Japan and the U.S.A. given by Hirschman (1963), which are themselves based on Chenery and Watanabe (1958), it has been argued by Gregory (1965) that forest industries have strong forward and backward linkages. This may not be so, especially in underdeveloped countries as discussed earlier in this chapter. It is probably more reasonable to assume that forest industries have strong forward but weak backward linkages. Possibly the only exception to this could be the pulp and paper sub-sector of forest industries.

6. Forests and land reform

In Latin America many countries have most of the arable land in the hands of a few landlords and a very large number of rural people have extremely small holdings. This position can be eased to some extent by opening some of the vast forest areas of these countries to agriculture.

It will be seen from these arguments that most, but not all, of the points raised by Gregory (1965) for Latin America are covered by Westoby (1962).

In spite of the fact that the AID has been participating in the forestry development programmes of many underdeveloped countries in the general context of their economic development (e.g. Yuan 1964, Hsia 1958, Sheng and Kang 1961) and provides training in this field to foresters from various countries (Huckenpahler 1967), no theoretical work seems to have been published by it on the role of forestry in development.

Two other American works in this field - both doctoral dissertations at Duke University - are also worth mentioning. One is by Somberg (1962) who outlined a programme for economic development of the Republic of Honduras through investments in forestry. It has been mentioned that the capital-output ratio in forestry sector is low and as a result investment in it is good. At the same time it is a long term enterprise and so benefits are very much delayed. The other is by Baird (1965) in which the feasibility of investing in forestry in an underdeveloped region of a developed country (Appalachian Region in the U.S.A.) is discussed. It has been concluded that under existing types of management about 38 per cent of the forest land in Appalachian Region is capable of returning at least 3 per cent return on investment during the future 50 years. Under an improved programme suggested in the study, about 80 per cent of the forest land is capable of returning at least 3 per cent, 45 per cent is capable of returning at least 4 per cent and 14 per cent of returning at least 5 per cent on investment.

A Master's thesis at the University of Washington (Catano 1964), while discussing the role of forestry in the economic development of Mexico, has criticized the restrictive part of conservationists in furthering the growth of economy through forest industries. In Catano's opinion conservation will mean transferring income from the present generation of poor to the future generations which will be richer anyway.

VIEWS EXPRESSED AT THE SIXTH WORLD FORESTRY CONGRESS AT MADRID IN 1966

A number of papers on economic development and forestry were presented at the Sixth World Forestry Congress. Santa Cruz (1966) spoke of the role of the forestry sector in the processes of the economic and social development of the underdeveloped world with special emphasis on the institutional aspects. He pointed out that the dificiencies of suitable institutions constitute the principal obstacle to the rapid progress of economies. He felt that the forestry operations in these countries should be institutionalized. This, he stated, could be done only by the State accepting its responsibility in this direction. He suggested that forest services in developing countries must have the following characteristics.

1. Planning of its activities.

2. Strategic use of its personnel.

3. Undertake socio-economic works.

The contribution of Santa Cruz is valuable in the sense that it goes to a very fundamental issue but has little relevance if one is concerned only with the way forest exploitation and investment must be planned and it is assumed that forestry institutions already exist. This thesis is concerned with the economic aspects of forestry alone and the institutions are taken for granted.

In another paper Lewis (1966) has discussed the role of forest industries in industrial development of tropical Latin America. It has been pointed out that forests can help capital formation by 1) replacing imported woods and thus reducing outflow of foreign exchange and 2) increasing the exports of domestic wood. Surprisingly, it has not been stated clearly that domestic forests can also help capital accumulation by providing cheaper building material than other sectors. This probably is the most significant way in which forestry can help in creating more productive capital than the forests themselves. The arguments of Lewis (1966) do not seem to be very sound when he said:

> "Any nation that considers increasing the exploitation of its forests for capital accumulation must either set definite limits on the level of cutting or be prepared to accept a greatly diminished forest resource in the future."

He has apparently not considered the possibility that by accumulating more productive capital, that nation may in future be in such a position as to find effective substitutes for forest products or recreate the forests if necessary (Zivnuska 1966a). He also seems to have too great a faith in the uniqueness of forests and in the principle of sustained yield.

Another way in which forests can help economic development is given by Lewis (1966) as the role forest industries play in training the labour required for industrialization.

A third helpful role of forestry has been given as that of augmenting the agricultural sector by providing more land and infra-structure for the purpose. This argument, though essentially correct, has significance only in places like Latin America where large tracts of forest areas suitable for agriculture exist with little accessibility at present.

In his paper entitled "The role of forestry development in national planning with particular reference to the developing countries in the Mediterranean and Near East region", Chapman (1966) seemed to think of forestry as important only in sustaining increasing incomes. He did not give much attention to the role that forestry can play in pushing incomes up. If incomes are rising, he has argued, then demand for forestry products increases very considerably and so foresters must plan well in advance to meet these demands. He has been at pains to point out that in the region of his study politicians and administrators have not yet appreciated this problem.

Chapman (1966) criticized the current policy of improving far off, degraded, mountain forests on poor soil for the sake of conserving them for the future. Instead, he has suggested that forest policy must be oriented towards much higher local production in the near future. It is so because, even with slight increases in per capita income, the requirements of forest products will increase very much in these countries. If they are not in a position to produce them locally, such nations will end up spending huge sums in importing them and may in fact have difficulty in finding enough money for these imports. He has accordingly suggested that timber trend studies for these countries be undertaken like similar studies in other countries (e.g. United States Department of Agriculture, Forest Service 1965b). To meet the higher domestic future needs he has suggested that, among other alternatives, forest planners take into consideration planting of fast grown exotics.

Algvere (1966), in his paper, has suggested that for progress in forestry (and presumably in economy), investment decisions must be based on benefit-cost analyses. Such analyses are a basis not only for managerial decisions on enterprise level but also for outlining general policies on the national level.

Of all the papers on economic development presented at Madrid, the most comprehensive, rational and forceful contribution was by Zivnuska (1966a). It is entitled "The integration of forest development plans and national development plans. How to make the forestry case at the national level". It points to the fact that only four countries in the world - Mainland China, India, the U.S.S.R. and the U.S.A. - had populations of more than 100 million in 1962 while some 80 nations had populations of less than 5 million each. This means that at the present world average per capita consumption level, one of these smaller nations could not consume the output of a single 500 metric ton per day pulp mill, even if that output were sufficiently varied to cover the wide range of pulp requirements represented by modern paper and paper board production. For such nations, which can not provide big enough internal markets for the giant mills of modern industry, it is probably necessary to form some kind of a joint unit with their neighbours.

Zivnuska has accepted the model of Ranis and Fei (1961) and Fei and Ranis (1963) for economic development. In this model it is assumed that development takes place when agricultural productivity increases and simultaneously industrial employment opportunities are generated. This results in shifts of population from the agricultural sector to the manufacturing sector. At the same time consumption is held low and the savings are so allocated to the two sectors that balanced increases in productivity take place. In this model what should be the appropriate rate of development and investment into the forestry sector? This is the question to which

Zivnuska (1966a) has addressed himself.

The nature of the forestry sector is such that it is in an intermediate stage between the rural agriculture and urban manufacturing. It is far more easy for the released agricultural labourer to shift to the forestry sector than to the highly urbanized and mechanized industries. The social and economic costs of housing him in small forest industry townships are lower than the costs in big cities. The labourer also finds that the skills he already has are not completely useless in his new job and the new skills he is required to learn are not too difficult. Some of the forest industries like logging and sawmilling are such that they can be either labour intensive or capital intensive. So, in the earlier stages of development, when labour is plentiful but capital is scarce, the labour intensive methods of logging and sawmilling can be used, whereas in later stages the proportion of capital can be increased according to need.

The forestry sector can also make very good use of the externalities involved in the development of infrastructure that is necessary for improving the productivity in subsistence agriculture. The setting up of forest industries can permit the locked wood capital to be converted into more liquid and productive forms and thus increase the total productivity of the economy. Opening up of the forests and setting up of the forest industries can also reduce the imports of wood products and save domestic capital. These, in the opinion of Zivnuska, are the advantages that forestry has over other sectors in claiming substantial allocations of investment funds in a developing country.

An interesting feature of forestry is that it often is self-sustaining. If some initial capital can be had for starting logging, then the export of logs can generate capital for sawmilling and lumber exports can earn enough to start a plywood and a pulp mill. At this stage the residues from the sawmills can also be used in the pulp mill and, if existing forests are not enough to meet growing demands of wood products, capital can be invested in creating new forests of fast growing species.

In very unambiguous terms Zivnuska has stated that the static sustained yield concept is obsolete and is suitable only if no development is conceived of. Foresters should therefore not remain bogged down in the unreal world of static sustained yield forestry but act boldly if they want to participate in economic development.

> "Historical experience has repeatedly demonstrated that the sustained yield concept is not applicable to the conditions of rapid economic growth. The widely cited and generally misunderstood North American assault on the forests of the continent is a major example of this.
>
> Today the nation has reached a level of economic growth and degree of affluence such that it is now able to reinvest capital in natural resources, that alternate materials are available to replace the traditional forest product in many uses, and that total forest growth is some 60 per cent greater than the annual cut.

> The challenge to foresters is to develop a regulatory theory which is responsive to the requirements of economic change without violating the silvicultural constraints." (Zivnuska 1966a)

All the advantages of forestry sector discussed so far are meaningful only for those countries which have sufficient forests in relation to their population. For countries like those in West Asia and India and China, these arguments are fruitful only for certain regions which are forest rich. In the forest poor areas, decision to invest in creation of forests will depend on other alternative channels available for using scarce investment resources. Investment should be made in the most profitable enterprise. When forests are very scarce, and substitute products are also not available, then investment in forestry may prove to be the most beneficial and should be carried out. These kinds of investments were made in South Australia (Bednall 1966) and New Zealand (Hart 1966) and proved to be beneficial for economic development. When labour is unemployed and its social cost is almost nil, it can be used in very labour intensive afforestation programmes. The crucial factor deciding the matter should be the question "What are the alternatives?".

In places like India and Pakistan, where large agricultural areas are completely devoid of forests or any other fuel, cow dung is commonly used for burning purposes after drying it into cakes. Existence of plantations of fuel wood could release the dung in such cases for being more properly used as manure in the agricultural fields. The returns of an investment in fuel plantations must take into account the possible increased agricultural productivity in such areas. But the returns must be compared with returns from other enterprises before deciding where to invest.

> "A scarcity of forests will constitute an obstacle to development in any nation, just as would a scarcity of any other major resource - but this does not necessarily justify the investment of limited capital in direct efforts to develop such resources. In any exchange economy, comparative advantage should control the flow of investment. Some regions will surely find it more advantageous to direct all their efforts to other sectors rather than to attempt to develop their own forest products out of some misguided wood fundamentalism." (Zivnuska 1966a)

Finally, Zivnuska has mentioned that there is a case for forest development planning not only for individual nations but the whole world. The entire globe must be looked at as one unit with some rich and other poor regions. This is in remarkable conformity with the concluding remarks of Hahn and Matthews (1964) in their article "The theory of economic growth: A Survey" wherein they have recommended that research on growth and development be so directed that the whole world is studied as an underdeveloped unit.

CHAPTER SIX

EVALUATING THE IMPORTANCE OF FORESTRY IN DEVELOPMENT

THE CRITERION

It has already been argued that nothing can be presumed as unique about forestry. It is just one of the many sectors which produce the desired output in an economy. Therefore, it would seem that each sector is as important as any other which is not the case, as a closer scrutiny will show.

Sectors can be of all kinds, depending on the initial definitions and groupings. If the economy is divided into two sectors - the consumer good producing and the capital good producing - then for purposes of development the capital good producing sector is more important. To ensure a sustained increase in per capita output the capital stock must be increased at a rate greater than a certain minimum. Development requires not only current increases in income but also future increases. The future increases come from capital accumulation. The forestry sector is, to a considerable extent, a capital producing sector. It gives raw material for making buildings, railroads, books, wagons and factories. Therefore it is more important than,for example, the cosmetics sector which produces consumer goods only.

Capital production takes time. If the time taken is "too long" then the capital may be obsolete by the time it is finally produced. Diverting large amounts of resources into creation of such capital which has a high probability of becoming obsolete before its production is complete can hardly be considered wise from the point of view of economic development. Even if the time taken is not too long, but the technological changes occurring in the economy are very rapid, then the capital will be obsolete before it is produced. So to simply say that the capital good producing sector is more important than the consumer good producing sector is not a sufficient criterion to evaluate the importance of a sector. Within the capital producing sector those sectors are more important which have less probability of their products becoming obsolete before their production is complete. Sectors like forestry which have long gestation periods are therefore less important than others. Their importance from this point of view goes on diminishing more and more as technology in other sectors advances faster and faster and produces substitutes for wood. A few centuries ago, progress of technology in other fields (e.g. ship building), was so poor that some countries in Europe planted oak trees in the Seventeenth and Eighteenth century so that oak wood for making ships in the 20th century would be available. This must have appeared a very sensible idea at the time and was being acted upon till as late as 1850 (Edlin 1956). But technology moved so fast in the Nineteenth century that it made these trees at their maturity absolutely unwanted for making ships. The progress of technology has been accelerating since the beginning of mankind (Duerr 1966b) and shows no signs of slowing down.

The oak planters mentioned above, did not consider a few hundred years as "too long" a gestation period. They relied on their past experience regarding the pace of technological progress. Plantings of the Fourteenth and Fifteenth century would certainly have given them what they needed but their estimates for future on the basis of projections of past, were incorrect. If today's decision maker wants to avoid such mistakes he must recognize the accelerating pace of technology. Even a few decades may be "too long" a gestation period today.

This period is not the only thing that determines the importance of a capital producing sector. The nature of the product itself is also a factor to be considered. A product that can be used in many processes is better than the one that has a very limited range of uses. The sector producing the "versatile" capital which can easily replace other kinds of capital must be considered more important than the "specialized" capital producing sector in a world where the probability of technological changes making certain uses obsolete always exists. As an example within the forestry sector the conifers that are suitable both for pulping as well as making lumber and plywood are more important for economic development than the hardwoods that can not be economically pulped and do not lend themselves to easy peeling. In the case of a country like India the versatile teak is more important than the specialized rosewood: the former can be used for making railroad ties, bridges, buildings, beams, rafter, furniture, veneers, and plywood. The latter is fit only for making intricate and expensive carvings or for other decorative uses. A developing country with scarce resources will generally find it more reasonable to invest in versatile than in specialized capital because it may be a more conservative strategy aimed at avoiding big set backs (Baumol 1965) in case the worst happens.

The forestry sector has a considerable advantage over many other sectors in this respect. Its product, wood, is admirably versatile. Not only can it be used in a number of different processes but it can also be stored on the stump without much cost if economic conditions are not suitable for its harvest. If the product of the forestry sector is looked at as cellulose then its versatility becomes still greater.

The short period for production and physical suitability for being used in many processes is not all that must be considered. The final test is that the cost of producing it must be less than the cost of alternative products. Not only must the produce of the sector be physically capable of substituting other products but it must be economically feasible to use it there. In economies that have vast areas under forests, not too far from centres of populations and of species that have important uses, forestry may be a very important sector for development. Wood can be used for a variety of purposes already discussed if it is cheaper than other products like coal, electricity and steel. Such conditions existed in the United States (Zivnuska 1966a) and Canada and these countries made use of their forests in development. Wood was cheap because large forest areas existed and still exist on the North American continent. The only costs incurred were in cutting them down, milling and transporting. The conclusion finally is that forestry was a very important sector in the economic development of North America.

With all this knowledge if America were to be discovered again and found without many forests would one of the obvious good advices given to the settlers be "Plant large areas of forests"? The answer is "NO". The decision whether planting should be done or not depends not on what we know from past knowledge but from the comparisons of future benefits that may accrue and the current costs necessary for getting those benefits. The existing forests are like an inventory and the decision regarding running it down is completely independent of the decision to build it up. Forests are important enough to be invested in and created if the cost at which their product can be supplied is less than the cost of other products which can substitute forest products. In the re-discovered America forests would be important if they could be grown cheaper than developing alternatives. They could not be important for development if the costs of raising the forests and thus providing their produce were higher than the costs of acquiring alternative factors of production.

The conclusion appears to be that the importance of a sector depends on the costs of producing its output. Because of risks and uncertainties involved in the future some allowance must be made for the versatility of the product. But after making such an allowance the sector concerned must be able to supply its produce cheaper than the substitutes if it is to be considered more important than the substitute sectors. The social costs of producing wood are fairly low because forestry does not compete away too many resources from other sectors but makes use of the unemployed resources to a considerable extent. The existence of joint products in forestry also permits many of the "by-products" to be available at low prices. These advantages may make the forestry sector an important one from the view point of economic development in countries that have existing forests. But in countries where there are few existing forests the forestry sector involves creating new forests and usually the long period of production makes the costs very high. In addition the uncertainties of the future suitability of wood for the purposes for which it is originally planted may make the forestry sector a very unimportant sector in such countries.

No generalizations can perhaps be made regarding the importance of forestry in economic development. The case for each sector must be evaluated on its own merits. Where wood at more economical prices than alternatives can be supplied by the forests, there forestry is an important sector. Where the other alternatives are less expensive it is not. This is the criterion for evaluating the importance of the forestry sector in development. It means that forestry is just as important as foresters can make it.

OPTIMUM INVESTMENT IN FORESTRY

It may be easy to conceptualize a criterion like that discussed above but such a criterion does not make it possible to grade different sectors in order of importance. Even if it were possible to rank sectors in such a way the really important thing to know about them is not just the order but the optimum amount of investment that must be made in each sector every year. Having decided the total investment that must be made in the economy in any one year, how much of it should go to each? Especially, how much should go to the forestry sector? The decision regarding total volume of aggregate investment can be taken from a model like that in Chapter Three. Foresters in underdeveloped countries have lately been arguing in favour of larger outlays in the forestry sector (e.g. Tisseverasinghe 1964). Without the use of analytical economic tools such arguments usually fail to impress the aggregate economists. In forestry, decisions regarding investment are dealt with simultaneously with the decisions regarding exploitation as discussed in Chapter Four. If the forest owners in an economy are assumed to be like the entrepreneurs of Robinson (1956) who do not consume their incomes but only save and invest in the most profitable ventures, then the act of exploitation of forests means availability of liquid funds for investment in forestry and other sectors. If forests are almost entirely owned by the government, as in India (Nautiyal 1965), and the government is committed to the goal of economic development, then the biggest role that forests in such a country can play in pushing the economy towards the take-off stage, is by providing the maximum revenue to the government. This means the acceptance of the goal of maximization of present worth of the forests by the forest managers and a will on the part of government to invest in those sectors that are the biggest limiting factors to increase in productive capacity.

Before demonstrating how simultaneous decisions regarding the optimum amounts of forests to be exploited in any year and the optimum amount of "investment funds" to be put into creation of new forests or regeneration can be taken, some of the recent literature on the subject of forest investment will be reviewed.

Dowdle (1962) suggested that forest investment alternatives can not be ranked only on the basis of the present net worth of each alternative. This is so because the economic uncertainties and other sources of variation associated with expected returns from each investment are different. The highest return-giving alternative may be most uncertain and the not-so-high yielding alternative may be more certain. In such circumstances the former is not necessarily the best. The theoretical framework proposed by him as a means of analyzing forestry investment alternatives is based on the "expected returns-variance of returns rule" (EV rule) developed by Markowitz (1952, 1959).

> "Generally, investors will not view expected returns on an investment as having a single, most likely value, which is assumed in the traditional discounted net-worth approach to forestry investment analysis. Rather they visualize a distribution of values around the one believed most likely to occur. A commonly used measure of the dispersion in a distribution is the standard deviation, which Markowitz proposed using as a measure of expected variation of returns.
>
> The EV rule provides a theoretical framework within which an investor may find a balance, based on his attitude towards risk, between investments or combinations of investments that are considered speculative, but which have high expected returns and investments with lower

> expected returns that are considered safer or less risky." (Dowdle 1962)

Aubertin (1966) pointed out that forest investments present three major disadvantages which explain the reasons for the very slight interest taken in such investments by governments.

These are:

1. They are long term investments.
2. They very rarely present a problem where a great number of people are affected or scope of interest involved is wide and therefore has political importance.
3. The basic data rendering it possible to economically justify them are inadequate.

Spears (1966) mentioned that the following features of forestry are of importance and governments should therefore take action to encourage forest investments.

1. Forests provide a versatile and renewable raw material resource suitable for the manufaçture of an extremely wide range of products.
2. Forest products have high income elasticity of demand, particularly at low income levels.

   Forest industries have a pronounced linkage effect with other sectors.
3. Forest industries can help to speed up the "pay-off" time of investments in infrastructural facilities such as roads, power and water supplies.

4. Due to their location in rural areas, forest industries disseminate technical skills and help the transition from a subsistence to an industrialized economy.
5. Forestry and forest industries have a high degree of flexibility especially with respect to choice of product to be harvested, forest crop rotation, and scale of industrial operation.
6. They can earn foreign exchange and save imports.
7. They can increase the taxation base.
8. The underutilized rural resources can be easily used in forestry.
9. Forests have values other than wood and wood derivatives.

He considered lack of data and the lack of most economic methods of handling and transporting forest raw materials and finished products as the major problems which limit investment in forestry.

While discussing forestry investment from the industry's point of view Ticoulat (1966) pointed out that investment in developing countries is attracted by stability of government, realistic controls by government, incentives that do not conflict with the economic and social growth of a country, access to forests in order to manage, cut and plant commercial species, and confidence in those who manage the forest land.

Waris (1966) discussed the financing of forestry investments, especially in Scandinavia. As such investments take a long time to mature, credit has to be provided through special institutions such as those founded to finance the development of agriculture.

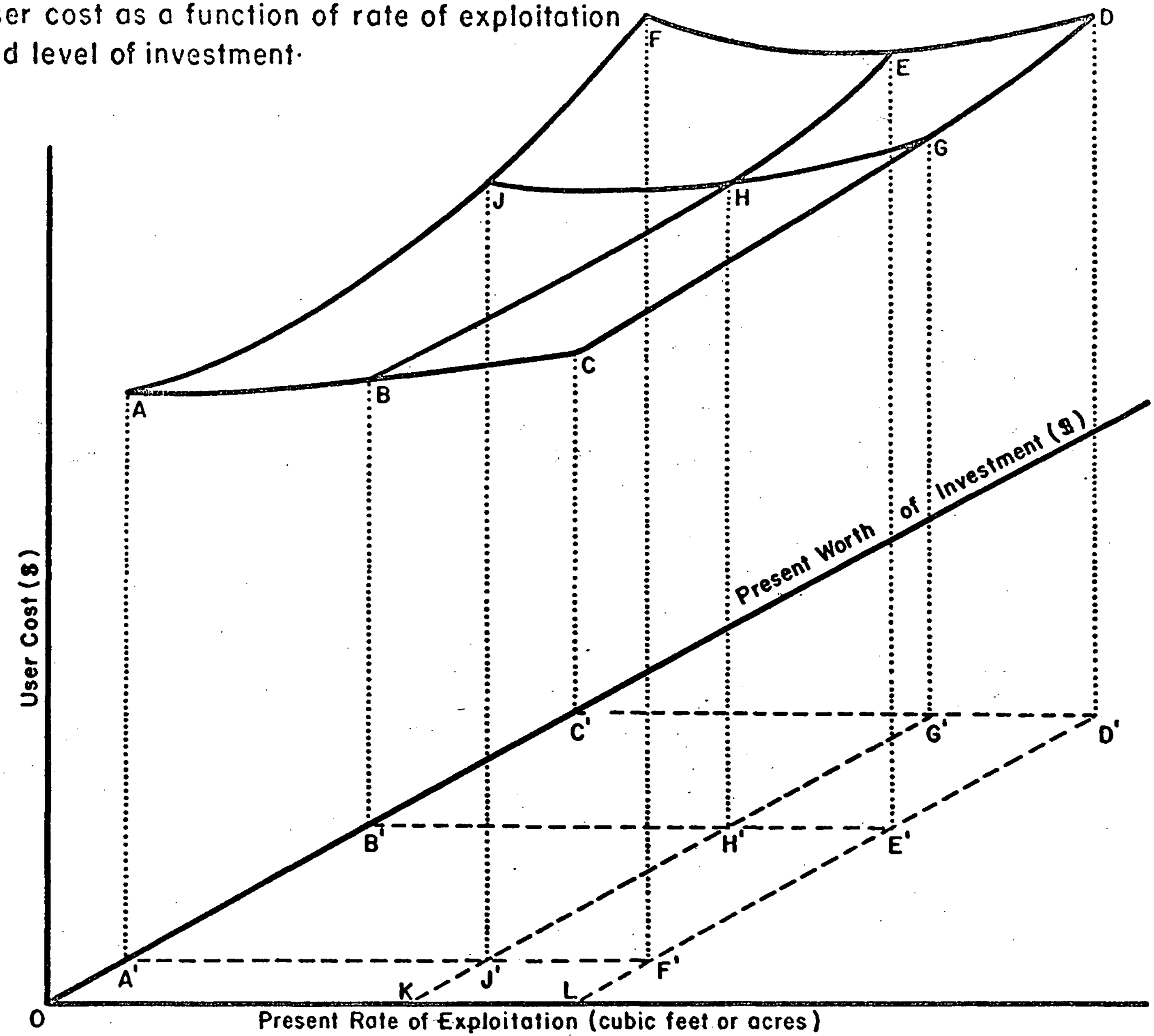
A theoretical framework for the determination of optimum rate of forest exploitation was given by Nautiyal (1966). It employs the user cost concept (Scott 1953) to strike a balance between present exploitation and future exploitation. The balance between the requirements of existing land, labour and capital by forestry exploitation sector on the one hand and by other sectors on the other hand is achieved by Lerner's Rule (Lerner 1946). The combination of user cost and Lerner's Rule can give optimum rate of harvesting that is efficient both in space and time. Nautiyal (1966) has also argued that the slope and position of the user cost curves of the two identical forests, one having regeneration and the other not, will not be identical. The user cost curve of the forest that can regenerate naturally will be lower and flatter than that of the forests which can not regenerate. This will be so because the future profits foregone in the regenerating case will be less than those in the non-regenerating case. As a result the user cost curve of a non-regenerating forest could be pushed down a little by incurring some expenditure (investment) in planting after felling the old crop. Up to a certain limit, the higher the level of investment, the lower and flatter the user cost curve would be pushed. It will therefore be more appropriate to represent the user cost curve as a function of both (1) the rate of current exploitation and (2) the present worth of the investment. Such a user cost surface is shown in Fig. 15, as ABCDEF.

With an investment level of OA' the user cost curve in terms of present rate of exploitation is AJF. With investment increased to OB' the user cost curve becomes BHE. Similarly with the investment level at OC' the curve becomes CGD. With no exploitation in the present the user cost curve in terms of investment level will be ABC and probably gently sloping down towards the investment axis as the level of investment increases. With current rate of exploitation at OK the curve will be JHG. With rate of exploitation at OL it will be FED. All the three curves will be sloping down. The user cost surface is thus such that any of its sections parallel to the plane at right angles to the investment axis is upward sloping. Any section parallel to the plane at right angles to the rate of exploitation axis is downward sloping. If user cost is expressed as UC, present worth of investments as x and rate of exploitation as y then the surface in Fig. 15 may be described by

$$U.C. = F(x,y) \tag{25}$$

When the total present revenue and total present cost

Fig. 15. User cost as a function of rate of exploitation and level of investment.



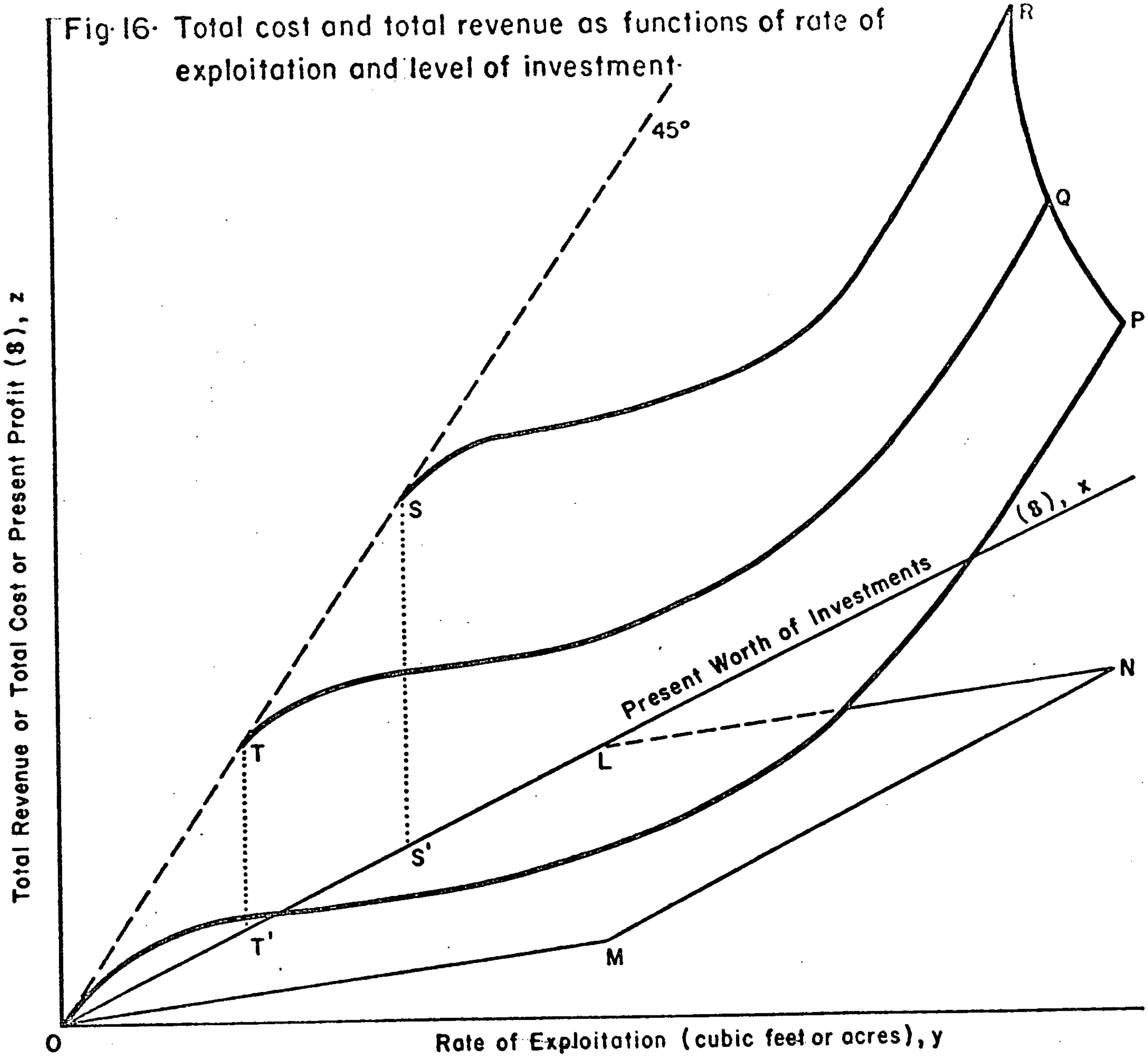
in a forestry operation with a given amount of capital are also shown as functions of the investment and the rate of exploitation, their diagramatic representation will be as in Fig. 16.

For the present let all the investment be thought of in such terms as plantings, better strains of trees and more fertilizer, which increase current costs but have no effect on current revenues. When no investment is made and a fixed amount of capital is used the relationship between rate of exploitation and total costs will be like the ogive curve OP. It shows economies of scale at low rates of exploitation and diminishing returns to the fixed factor capital at higher rates. When an investment of OT' is made, the costs increase by the same amount at all rates of exploitation and the total cost curve will be TQ in the plane parallel to the paper and passing through T'. Because the costs increase by the same amount as the level of investment, the distance OT' and TT' have been made equal in the diagram. With an investment level of OS' the total costs function will be SR so that OS' = SS'. The surface OPQRST represents the total costs of exploiting the forests. Algebraically it can be written as

$$\text{Total cost} = f_1(x,y) \qquad (26)$$

In the same way the total revenue function can also be shown on the diagram. The current level of total revenue is

Fig. 16. Total cost and total revenue as functions of rate of exploitation and level of investment.



independent of the amounts invested and so a section of the total revenue surface parallel to the revenue-investment plane will be a straight line parallel to the x-axis. It would be in contrast to a similar section of the total cost surface which will be a straight line inclined at 45° to the x-axis. The section of the total revenue curve on the plane of the paper (revenue-exploitation plane) will be a curve sloping upwards from the x-axis initially and dropping down later. This would be due to a downward sloping demand curve for the forest product (stumpage). In the diagram a perfect market for the stumpage has been assumed and so the total revenue curve at zero investment level is the straight line OM with a slope of p to the y axis. The total revenue surface in this case will be OMNL which is a plane passing through the x-axis and inclined to the x-y plane at an angle the tangent of which is p. The surface could be described by

$$\text{Total revenue} = f_2(y) \tag{27}$$

For each combination of x and y the difference between total revenue and total cost gives the present profit (z) which can be expressed as

$$z = f_2(y) - f_1(x,y) \tag{28}$$

The optimum rate of exploitation and investment in the forest under consideration will be where the difference between the present profit (28) and user cost (25) is maximum, i.e., where

$$z\text{-U.C.} = f_2(y) - f_1(x,y) - F(x,y) \tag{29}$$

is maximum. This point is found by partially differentiating (29) with respect to x and y in turn and setting each derivative equal to zero (Baumol 1965).

Thus

$$\frac{\partial f_1}{\partial x} + \frac{\partial F}{\partial x} = 0 \tag{30}$$

and

$$\frac{\partial f_2}{\partial y} - \frac{\partial f_1}{\partial y} - \frac{\partial F}{\partial y} = 0 \tag{31}$$

The solution of two equations (30) and (31) will yield the required values of two unknowns x and y. The optimum rate of exploitation of the forest under question and the optimum level of investment in plantations is now known.

Investment could be thought of in two kinds. First, of the type already discussed which affects only future profits, i.e., in plantations and second, investment in capital needed for exploitation in the present. An investment of the second kind increases the capital with which the forest is log-ged and so the cost curves like OP of Fig. 16 show economies of scale for a longer and higher range of the rate of exploitation. The diminishing returns to the fixed capital are pushed farther to the right on the diagram. At the lower levels of exploitation the costs may increase. The expression for the total cost surface will now be

$$\text{Total cost} = f_1(x,y,v)$$

where v is the second kind of investment and x is of the first kind. This surface is in four dimensions and can not be shown in a diagram.

The total revenue surface will still remain the same, i.e.

$$\text{Total revenue} = f_2(y)$$

But the user cost surface will change because the present additions to capital will affect the future best rates of exploitation and profits. Therefore

$$\text{U.C.} = F(x,y,v)$$

The function to be maximized now is

$$f_2(y) - f_1(c,y,v) - F(x,y,v)$$

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$$\text{U.C.} = F(x,y,v)$$

The function to be maximized now is

$$f_2(y) - f_1(x,y,v) - F(x,y,v)$$

The values of x, y and v that will yield the highest value of this function are obtained by solving the following three equations.

$$\frac{\partial f_1}{\partial x} + \frac{\partial F}{\partial x} = 0$$

$$\frac{\partial f_2}{\partial y} - \frac{\partial f_1}{\partial y} - \frac{\partial F}{\partial y} = 0$$

and

$$\frac{\partial f_1}{\partial v} + \frac{\partial F}{\partial v} = 0$$

The best level of investment in a forest is (x + v) of which x should go towards increasing future supplies of timber and v towards increasing the capital needed for exploitation.

The total investment in forestry in the economy can be determined as a sum of the investments thus indicated for each forest management unit. The total forestry investment obtained this way does not, in the beginning, seem to have any connection with the best aggregate investment level of Chapter Three. A closer look however shows that the two are related through the user cost. The future profits foregone depend on the future prices which in turn are dependent on the per capita income and the structure of the economy in the future. The user cost concept used so far in these discussions covers the future profits from the supply side of timber only.

It does not consider the effect of changing per capita incomes on the possible future profits. Once the levels of gross investments to be made in the economy for reaching the take-off point are decided, the demand side of the future profits is also covered as some idea of future per capita income and prices can now be had. If the entire investment schedule from year 0 to take-off in the model of Chapter Three is denoted by the variable I then user cost should be expressed as

$$U.C. = F(x,y,v,I)$$

For a predetermined I the user cost function will vary only with x, y and v.

Though these will not be discussed in this thesis, the actual solutions for optimum x, y and v can be worked out by linear programming techniques as shown by Nautiyal and Pearse (1967) for a simple case where prices are assumed constant and no investments are considered. The variable v need not be considered as investment in logging capital only but also in research and development of new techniques.

As pointed out by Dowdle (1962) expectations in the future are not viewed as having a single most likely value. Rather a distribution of values around the one believed most likely to occur is visualized. It is possible, mostly subjectively and some times even objectively, to assign a certain probability to the occurrences of a certain value. The user cost and present profit surfaces discussed in this chapter are thus not to be looked at as certainties. Instead, they are solids of some thickness made by piling the surfaces together. A number of optimum points now occur where each of the surfaces in one pile has a slope equal to that of the surface from the other pile. Each of these points has a probability value attached to it. This value may be known or be possible to estimate for some of the points but not for others. The final decision taken in matters regarding the amount invested and forest exploited will be based on the various criteria of "Decision Theory" (Luce and Raiffa 1957, Baumol 1965, Haley 1966). The attitude of the decision maker and his psychological make up will weigh considerably in making the final decision.

THE LINEAR PROGRAMMING APPROACH

Another way of determining the amount to be invested in forestry is that suggested by Beazley (1965). He felt that a model for the whole economy showing all sectors including forestry should be made. It should include: (1) inter-activity current input-output coefficients, (2) inter-activity capital coefficients, (3) labour-output coefficients, (4) demand expectations, suitably categorized and identified for various future time horizons, and (5) man-power estimates.

What Beazley (1965) was discussing was probably a von Neumann (1938) type of model of economic growth where the amounts to be invested in forestry would be determined simultaneously with the amounts to be invested in other sectors if the maximum rate of growth has to be maintained.

Linear programming does not seem to have been used for this purpose in forestry. It has been used for allocating logs among several utilization processes (Pearse and Sydneysmith 1966) and for determining the amount of forest harvest within or without the framework of sustained yield forest management (Loucks 1964, Curtis 1962). From the forester's point of view it would be extremely interesting to find out the place of forestry in development from a model such as indicated by Beazley (1965). Obviously, the more generalized forms of the von Neumann model (Radner 1961, Karlin 1959, Morishima 1960) may have to be taken as starting points. Techniques and concepts introduced and discussed in Allen (1963), Dorfman _et al._ (1958) and Chenery and Clark (1959) will probably be necessary. The subject is beyond the scope of this thesis and so is not discussed further.

Some kind of a combination of this model and the one in Chapter Three could be used for application of simulation to test responses of development to various kinds and amounts of forestry investments.

METHODS OF CHOOSING AMONG ALTERNATIVE COURSES

Some approaches to the determination of the importance of the forestry sector for development and the methods of determining how much of the forest should be cut each year and what amount invested have been discussed so far. These are matters of interest to the highest level of policy makers and planners in a country. The average forest manager who has to take decisions within a given framework and has relatively few alternatives to choose from is not helped much by such discussions. This is so, not only because the decisions are so far-reaching that they can not be taken by him, but also because the information required for such decision making is beyond his reach in most cases. For such a manager the following methods are more useful.

1. Budget Method (Duerr 1960)

In this method, anticipated revenues and costs of each of the alternatives are tabulated and the best alternative selected from the comparison of the results. The method is suitable for complex problems. When more than one year's revenues and costs are involved then bringing all to a single point in time may be done. The cash-flow method (Leonard 1965) is a special type of budget method where only the cash is considered. Discounted cash-flow method (Canadian Pulp and Paper Industry 1966) is a better guide than simple cash-flow method.

2. Marginal Method (Duerr 1960)

When there is a wide range, especially a continuous series of alternatives, and it is possible to identify the marginal revenues and costs associated with the series, this method is applicable. The alternative that equates marginal revenue and cost while marginal revenue is falling is the one that shows greatest excess of revenue over cost.

3. Break-even Method (Duerr 1960)

At low levels of operations a certain alternative may be better than the other. But beyond a certain level the second may be better. In such cases it is helpful to know the break-even point where the two are equally good. The decision regarding the process to be chosen may now be taken easily if the level at which work has to be done is known.

4. Benefit-cost Analysis

This method was developed for use in the field of water resources but can be adopted for any situation in which a choice has to be made between alternative projects. It is particularly useful when a number of intangible factors are involved (Haley 1966). The method has been described in detail by Hirshleifer *et al.* (1961), Haver *et al.* (1961), Sewell *et al.* (1961) and Prest and Turvey (1965). It will only be mentioned herein that, while being used at the highest levels of decision making, the ratio of benefits (B) to cost (C) should be maximized so that maximum benefit for each unit of cost is obtained. While being used at a lower level where there is a budget restraint the best course is to maximize the net benefit or (B-C) so that maximum benefit is obtained by using all the resources available for spending.

5. Cost-revenue Analysis

This method is similar to the benefit-cost approach but takes into account only those benefits and costs that can be measured in monetary terms. It is thus suitable for alternatives where few or no intangible factors are involved. When the goal is to maximize the future availability of timber, investments large enough to equate costs with revenues are undertaken (Algvere 1966).

6. Pay-out Period Method

In circumstances where the aim is to recover the expenses incurred in the shortest possible period or within a given period (Turvey 1963), this method can be used. It involves ranking of various alternatives in order of their pay-out periods. For those alternatives which have a pay-out period less than the given maximum, the benefit-cost or cost-revenue method can be used to select the best.

7. Rate of Return Method

In this method the rate at which the invested capital grows in value is calculated. The criterion does not take into account the time for which the return is earned and is therefore not suited for alternatives with different life spans.

But, in circumstances where all earnings are again necessarily invested to increase the existing capital, it is the best criterion of judging the suitability of an alternative (Turvey 1963). In the case of an underdeveloped country which wants to accumulate capital as quickly as possible, it is a very appropriate method. A procedure for evaluation of reforestation and timber stand improvement projects based on this criterion is described by the United States Department of Agriculture, Forest Service (1966). The use of this criterion has been suggested by Spears (1966) and a method of computation given by Turner (1965). When feasibility of different forest projects is tested by comparing the present worth of their net profits, as done by Smith (1964) for Taiwan, then a modified rate of return method is used. Only projects that have a rate above the going rate of interest can qualify in such a test. The rates of return from some of the fast growing tree species in many parts of the world are often very high. In South Africa, Grut (1965) estimated that the annual returns from Pinus patula and Pinus radiata were 29.0 and 15.2 per cent, respectively. Eucalypts yielded from 5.0 to 28.6 per cent and poplars returned 8.0 to 16.0 per cent on investments in that country. Such high rates of return can justify investments in forest plantations by withdrawing funds from other low yielding projects.

Improvements in methods of processing management data and in understanding the application of existing theories are badly needed but considered to be beyond the scope of this thesis.

CHAPTER SEVEN

FORESTRY AS A PROPULSIVE SECTOR IN DEVELOPMENT

In the earlier chapters an attempt has been made to show that there is nothing very special in forestry that may make it more important than other sectors for achieving the goal of economic development. It is true that a few characteristics give this sector some advantages over others, but some are distinct disadvantages. In fact this is true not only of forestry but also other sectors. There is probably no _one sector_ that can be called a propulsive sector. The development of one sector is not possible without the development of some others. At most there may be _propulsive sectors_ which play a more important role than others but the point should not be stretched too far. Manne and Rudra (1965) found that the Indian economy showed three distinct groupings of sectors from the input-output table. Two groups - agriculture and manufacturing - did not depend on each other very much and could be almost called independent. The third group of transport, chemicals, and some services was the supplier of substantial inputs to both these goups. This third group of universal input producers could therefore be called the group of propulsive sectors. They noted that such groupings existed in the U.S. economy also.

The universal group, even if called propulsive, can not push the economy very hard. In fact its role is more permissive than propulsive. Expecting an all round growth of output simply by increasing the output of this group would be like trying to push with a string. It is therefore felt that the enquiry into the question whether forestry is a propulsive sector or not may not be too fruitful. At the same time it must be recognized that there are elements in forestry and other sectors which have some kind of a propulsive character. The use of wood in capital production is an example. Also, development once underway may increase the demand of wood and so the forestry sector has a permissive role too. But the importance of both the roles for development may not be too much in view of the fact that forestry sector contributes only a small fraction of the GNP in most countries. As noted earlier, this fraction is 1.5 per cent in India (Forest Research Institute

1961) and 6 per cent in the United States of America (Hair 1963).

This chapter is concerned with only those characteristics of forestry that have a propulsive effect. Chapter Eight deals with the permissive role.

CHARACTERISTICS OF FORESTRY THAT HAVE A PROPULSIVE EFFECT

One of the most important characteristics of forestry (and some of the forest industries like sawmilling) which are helpful in economic development is its nature by which unemployed or underemployed rural resources can be easily utilized in it. This means that the opportunity cost or social cost of expanding these industries are very little. It is a point that is probably not made very clear by the foresters to the planners, in most underdeveloped countries. By a reasonably close study of the forestry sector the planners may finally be convinced of this argument. But this in itself, and the consequent changes in plan allocation for forestry sector, do not ensure that any worthwhile gains in the movement towards the take-off stage will have been made. What is necessary for utilizing the underemployed rural resources is not just the favourable characteristics of the forestry sector but good organization on the part of the foresters. It is organization (Dale 1965) in particular and management (Dale 1965) in general which can ensure that the needs of forestry for the rural resources do not arise at the same time when these resources are needed in agriculture. Very efficient management is a 'must' in such matters and may be not easily forthcoming in underdeveloped countries. It is generally recognized that underdeveloped countries lack sufficient management skill. Yet many authors, e.g. Reynolds (1963), Galbraith (1964b), Lewis (1964) and Beazley (1965), have mentioned that countries like India do not suffer from its scarcity. The writer, being an Indian himself, feels, however, that "management" may be the most crucial factor that is in short supply in India at present. Indian management may possibly be better than that of many of the other underdeveloped countries. But it may not be good enough for India's present needs. Such may be the case with many other similar countries.

John Tyzack (Dale 1965) said:

> "Management, like war, is made up of long periods of routine divided by short bursts of intense activity and peril."

When economic development is being consciously attempted then the "short bursts" of intense activity and peril may not be too short. In these extended periods, there is a danger that management may relapse into routine again. The main problem in the management of underdeveloped countries may be of sustaining the morale of the managers for a sufficiently long period.

A frequently quoted definition of management is "Management is decision making and getting things done through other people". But as Hayes (1960) pointed out the definition must be read as: "Management is getting things done through other people" and not as: "Management is getting things done through other people".

In the absence of sufficiently good managerial talent the advantages of any sector for economic development may be lost completely. The case of the forestry sector is no exception.

The second important characteristic of forestry is its versatility. Timber planted today for producing veneer after 50 years can be used for lumber if it is uneconomical to use it in veneer and plywood. If it is uneconomical in lumber it can be used for pulping. This characteristic reduces the degree of uncertainty involved in a long period enterprise or in a field where technology may change very fast. For a unit volume of wood, decorative veneer may bring in the maximum return. Lumber and other veneer and plywood may be next, followed by pulp and firewood. If the return per unit volume of wood only were the objective then from an economic point of view most forests would probably be planted with decorative veneer producing species. But, as it happens, the veneer producing forest requires to be grown for a very long time and therefore the present worth of the ultimate returns is very small if at all it is possible to estimate the final value with any reasonable accuracy. Due to the short growing period involved plantations of fast growing species for fuelwood, pulp, plywood or lumber are probably therefore the only sound propositions in forestry that can be considered.

The third characteristic of forestry that will now be considered is its position as a supplier of raw material for making paper. In the developed countries of the world almost all the pulp and paper is manufactured from trees - mostly coniferous. Paper is a most important item in the implementation of literacy programmes, the plans to foster higher and technical education and also to develop democratic tendencies in the masses through the popularization of newspapers. In fact, paper is a capital good and not consumption good in the underdeveloped countries as already argued. Forestry as a source of raw material for making paper is, therefore, very important for the success of economic development plans. This argument is not wrong but is applicable only to those circumstances where trees are the most economical raw material for pulping. Even in places like the United States where it is so, attempts are being made to develop more economic sources of cellulose. The research in the U.S. in bamboos (Naffziger et al. 1960) is an indicator of this. Growth of bamboo cellulose, however, may also be considered as part of forestry though it is a little different from the usual kind of forestry as understood over much of the globe. But there are serious rivals outside forestry also, the vast quantities of agricultural residue. It has been argued that paper is a capital good and very important for development. But no one can argue that it must be paper made from forest produce. It will be equally good as capital - though slightly different - whether produced from the cellulose contents in trees or jute sticks or sugar cane bagasse. Whichever raw material is more economical should be used if economic development is sought quickly and efficiently. With all this said, it still is very likely that many countries will find that the forestry sector is the most economical supplier of raw material for pulp.

The fourth characteristic often mentioned is the import substitution and foreign exchange earning role of forestry in underdeveloped countries. As already shown by Westoby (1962) and discussed earlier in this thesis this is a very likely possibility. India imported wood and wood products worth Rs 181 million (about U.S. $38 million at the 1959 exchange rates) in 1959 (Forest Research Institute 1961) and the import bill has been increasing since then. The amount is very small and will probably not have much effect on the economy as a whole even if all saved, but that is no reason why it should not be saved if it can be done by incurring a relatively small investment expenditure. The saving of foreign exchange could be very substantial if India could produce its own viscose pulp for manufacture of celluloid films. It is the second largest movie producing country in the world and spends sizeable sums of foreign exchange for importing all its requirements of raw film. Forests could probably play a very major role in saving this exchange by providing raw material for making viscose pulp. This potentiality of forestry can be fully explored only by detailed economic analyses of the types of projects mentioned above. As suggested in Chapter Six, benefit-cost analysis may be very useful for the purpose. The export of furniture by India has been increasing for the last few years and could probably be increased much more if the seasoning of wood were given more attention.

The fifth characteristic of forestry in fuel hungry countries like India and Pakistan, as already noted, is that it can provide cheap fuel to the peasants who now use dried cow dung cakes as their primary fuel. The same dung, if used as manure in the fields could improve agricultural productivity which is so important for economic development. But unless the wood fuel is cheap enough the peasant will not use it. The underemployed rural resources can here be utilized to raise cheap plantations of some very fast growing trees. But, as suggested earlier, this requires first class organization which is not easy to come by. If fuel plantations can not be raised at a cost that is almost negligible then a better alternative may be to provide chemical fertilizers for agriculture and allow the dung to be burnt. This advantage of forestry can thus be exploited only with a very high degree of understanding on the part of the peasants and so may not be easily available.

The sixth characteristic of forestry is that even when it may not have a substantial role to play in the general economic development of a nation, it can play such a part in regional development. Consideration of regional development can be very important, especially in an underdeveloped country where every region is asking for more and there is not enough to satisfy all. Regional studies have importance in the developed countries also and an entirely new science - The Regional Science - is developing (Isard 1960, Friedmann and Alonso 1964). Therefore, when regional development in the long run is also the goal of national economic development policy then it is legitimate to study the role that forestry can play in such development. Such studies are being undertaken in Canada (Canada Department of Forestry 1966). Lefeber (1964) discussed the regional allocation of resources in India from this point of view and warned that attempts to industrialize retarded regions ahead of time and at the cost of slowing down the growth of more vigorous areas will put off the date of bringing relief to the former. But he also noted that unless distant benefits of current patience and sacrifice are spelled out in the form of explicit long-term plans the retarded regions may not co-operate with the national development effort. Some logic of regional allocation of investment has been analysed by Rahman (1963) and interregional transmission of economic growth has been discussed by Hirschman (1963).

The role of forestry in regional development must be evaluated after taking all these points in consideration. In regions where forests are abundant and easily accessible they can help local capital formation in the ways already discussed for the national economy. When the role of forests is recognized to be national rather than regional then forest capital in one region may be used for making other kinds of capital in other regions if this is more beneficial than other alternatives. In the regional role this possibility is severely restricted. From the point of view of underdeveloped countries the national role of all resources is, in the long run, more advantageous for all, but regional rivalries and political considerations may make such a policy difficult to follow.

POLICY IMPLICATIONS

What are the policy implications of all these discussions for an underdeveloped country like India? About 24 per cent of the land surface of India is covered by forests (Forest Research Institute 1961) and almost 97 per cent of it is owned by the State (Nautiyal 1965). The very high density of population leaves the per capita forest area in the country as only one half of one acre (Forest Research Institute 1961). The productivity of much of the forest area is not high (Nautiyal 1965) and the traditional agricultural practices in most regions near forested areas depend fairly heavily on the adjoining forests. The most extensive agricultural areas in the Indo-Gangetic Plains of the North and the Coastal Plains of the South are almost devoid of forests and do not depend much on them.

In spite of its low per capita income and obvious backwardness in many fields, the organization of forestry is well developed in India. For more than one hundred years the forest areas in many parts of India have been worked under recognized principles of forestry. At present there is hardly any area of the State forests that is not covered by a working plan which is revised regularly every ten to fifteen years. The basic feature of these working plans is to determine the allowable cut for the forest unit concerned. The allowable cut is almost invariably fixed in such a manner that ultimately the forests are converted to "normality" and a sustained yield is obtained from them. The early British foresters in India were very heavily influenced by the German School of Forestry. In fact, the first three Inspectors General of Forests - Brandis, Schlich and Ribbentrop - were Germans themselves. The foundations of sustained yield forestry and conservation were very soundly laid in India. The follow-up has been, and still is, most faithful.

If the statistics on the annual amounts of timber cut from Indian forests during the last half century are perused the relative constancy of the annual output will be found as quite remarkable. In the State of Uttar Pradesh 11.33 million cubic feet of lumber was cut from government forests in 1924-25 and 19.55 million cubic feet in 1962-63 (F.E.O., U.P. 1964).

In view of the fact that the area of government forests increased between 1947 and 1962 due to take over of private forests by the State, the average annual output per acre has increased very little indeed. Even in the United States where sustained yield is held so sacred a principle, almost 20 years back Zivnuska (1949a) had pointed out the need for adjustment in this policy for counteracting the effects of business and building cycles. Vaux (1949) had also pleaded as early as that, about the need in forestry to analyse the goals and concepts involved. But in India, the traditional concepts of forestry have been so firmly entrenched that no questions seem to have been asked, until recently, about the wisdom of rigidly following the sustained yield policy. This is not too surprising if one reflects that:

> "Traditionally, Indians emphasized stability and preservation of tradition more than change and progress. All significant truths were discovered ages ago, and the present task is only to interpret, comment upon, and to perpetuate these ancient and sacred truths. Since these traditions successfully guided past practices, they are therefore the most appropriate guides for present and future practices." (Ames 1966)

Unfortunately, no data could be obtained on the prices of the timber output from Uttar Pradesh given above. Otherwise it would be interesting to see how much the price rose between 1924-25 and 1962-63. Much of the price rise would probably be due to the relative inelasticity of the timber supply schedule. From his memory the writer thinks that the stumpage prices for <u>chir</u> pine (<u>Pinus</u> <u>roxburghii</u>) increased from about Re 1.25 in 1924-25 to Rs 6.00 or more per cubic foot in 1962-63. Thus, in four decades, the quantity supplied increased by about 55 per cent while population increased by about 65 per cent (Nautiyal 1965) and prices by about 500 per cent. This might mean that demand increased during the period. That the demand for timber has increased since the late forties or early fifties in India can also be inferred from the fact that even with a strict implementation of sustained yield policy, the share of national income in India contributed by the forestry sector increased from about 0.8 per cent in 1948-49 to 1.5 per cent in 1957-58 (Forest Research Institute 1961). Much of the demand may have been due to the development plans initiated since 1951 (Planning Commission 1962) and can therefore be assumed as that for capital formation. The increase in the share of forestry sector in the national income could mean that forestry made required raw materials available at more economic prices than other competing sectors did. This conclusion, however, would be valid only if it is assumed that the inputs were purchased in such a way that costs were minimized and the prices reflected the scarcities of the inputs. In a country where forests are almost entirely owned by government and much of the development activity and so capital formation is also initiated by it, these assumptions may not be correct. The government could just set aside some timber for use by the railways (which are also government owned) or by other "public sector" industries. If it happens, the relative role of forestry in development becomes more difficult to determine.

Let each forest management unit (a Forest Division or Forest District in India) be asked by the government to maximize the present worth of its forest property. Also, while using timber for any works in the "public sector" let the government pay the market price to the forest management units. If timber is so very important for the public sector industries they should be prepared to pay higher prices for it (State preference function valuing stumpage higher than individual preference function). If it is not, they should buy other substitutes. With such a set up not only will the importance of forestry be realistically reflected in the prices of stumpage, but the forest administration will have the right incentives to invest, or not invest, in forestry. If research in forest products or other forestry fields is indicated a far sighted and rational forest manager will try to have that pursued. In other words, the market could then play its legitimate role in deciding what to do in which sector. When the forester finds that his products are threatened by competition from other sectors, let him improve his technology, develop a new way of making plywood, or pulp, or growing trees faster or develop a new hybrid. If there is competition, then doubtless the other competitors would be doing the same. If the principle of "let the best man win" is adopted and every one is encouraged to win then not only will the most economical raw materials be used but also new and more economical ones will be produced. Not only will the importance of forestry sector be possible to determine from time to time but the most important sector will be used as much as it should be.

As already discussed, the suggestion that the forest management unit should have "maximization of present worth" as its goal is not entirely in tune with the existing sustained yield policy in India. The present policy is "maximize net revenue subject to sustained yield". In view of what has so far been discussed the current policy can not let market forces play their legitimate part in development. As Haley (1966) has observed, sustained yield may actually hinder economic growth. In Chapter Four sustained yield was shown to imply that almost the same volume of timber will be required by the economy year after year. This is true only of an absolutely static economy where not only the per capita income and populations are stationary but also the tastes and technology are constant.

For the British Empire, with its vast territories and population of natives who did not much matter except for living at subsistence level, this outlook was understandable. It appeared as if the Empire would last indefinitely. The British people were already experiencing unprecendented growth in their income, the subject people neither aspired to nor deserved such riches, and so it was prudent to preserve whatever resources existed in the Empire. They would prove handy in the event of wars and also for the growth of British economy if needed. The situation at present is completely different. The policies that were formulated with no anticipated appreciable overall increase in the standard of living of the Indian people can not be justified today. An effort is being made to improve the lot of the people which could not even be dreamt of fifty years ago. If the effort has to succeed then the shackles which bind the Indian economy must be thrown off. The most obvious of these shackles in the forestry sector is the principle of sustained yield.

> "Unhappily static forestry, like static economies, does not apply to conditions of dynamics. And even more unhappily, although economists have turned to the theory of economic development, forestry theorists have not yet truly come to grips with the problem of change and growth.
>
> The challenge to foresters is to develop a regulatory theory which is responsive to the requirements of economic change without violating the silvicultural constraints." (Zivnuska 1966a)

As already mentioned in Chapter Four, attempts at evolving such a theory are being made.

Other matters in forestry which may be of relatively large benefit to the Indian economy as a whole are:

1. Research in the utilization of tropical hardwoods, especially development of economical pulping processes. The aim must be to convert as many of the currently valueless species into those which can be used economically in some process.
2. Benefit-cost analyses of various possible pro-

jects that use forestry sector's products as inputs. Such analyses should be revised and brought up to date frequently so that their use in the changing world may be possible.

3. Work studies (Morrow 1946, Sammett and Hassler 1951, Niebel 1955, Barnes 1957, 1963, International Labour Office 1964, Maynard 1963, Currie 1959) in various fields of forestry. "Work study" can be defined as "the systematic, objective and critical examination of all factors governing the operational efficiency of any specified activity, in order to effect improvements". The results and recommendations of such studies must be undertaken in the underdeveloped countries on the lines of Europe and North America (e.g. Forrester 1962, Crowther and Toulmin-Rothe 1963, Crowther 1964, and other Work Study Papers of the Forestry Commission, Lussier 1960, 1961, Matson and Rapraegar 1950, Sundberg 1963, Hamilton 1966). Such studies will help in adoption of more efficient methods of working in the forests and forest industries.

4. Introduction of those modern methods of logging which are more economical than the existing ones. Sjöstedt (1966) felt that logging in Indian forests was in urgent need of improvement.

The benefits will accrue not just by study of these matters but by implementing their results. The need for good management in underdeveloped countries can not be overemphasized.

CHAPTER EIGHT

FORESTRY DEVELOPMENT FOR KEEPING ABREAST WITH INCREASES IN DEMAND DUE TO ECONOMIC GROWTH

In Chapter Seven some of those characteristics of forestry and forest industries were discussed which have potentialities for pushing an economy towards the take-off stage in economic development. Most of the other characteristics of forestry are like those of consumer good industries. When incomes show an increase, that is, when economic development gets underway, then the demands for products from forestry and forest products sectors increase (Zaremba 1961, Gregory 1966, Reed 1966). To sustain the increases in income it is necessary to satisfy these demands, if not fully, then at least to an appreciable extent. Some of the demands may not be directly for forest products but may be indirect. For example, with increased incomes the general purchases will be more and so more shopping bags will be needed and hence the demand for pulpwood will increase. The forestry sector must be prepared to meet the direct and derived demands for its products.

Seen this way, the general development model of Chapter Three or the development plan as a whole is of tremendous importance to the planners of forestry sector. The more ambitious the general plan, that is, the greater the investment doses in Chapter Three model, the greater must be the outlays in forestry to meet the future needs. Forestry development, as usually understood, is this role of forestry and involves the estimation of future demands and determination of the action that must be taken in the present to meet these needs. The timber trend studies are attempts to do this work. They try to predict not only the demand functions in the future, as was formerly done, but also the supply functions, as suggested by Vaux and Zivnuska (1952). Examples of timber trend studies are United States Department of Agriculture, Forest Service (1965b) for the trends in the U.S.; Davis _et al._ (1957) for Canada; FAO and UNECE (1953, 1964) for Europe; FAO and UNECAFE (1961) for Asia-Pacific Region; UNECLA (1963) for Latin America and FAO and UNECA (1963) for Africa. Projections of important forest products like paper have also been made for the future (FAO 1960) for the whole world. World trends and prospects for wood on the basis of timber trends for different regions mentioned above have been consolidated by the FAO (1966). Planning to meet these needs, on the global or national or regional basis, is planning for forestry development. It includes intensification of forest management if the extensive margin (Renne 1958) has already been reached.

The role that forestry plays in the current economic situation is extremely helpful in assessing what role it may have to play in future. Studies like those by Hair (1963) and Zivnuska (1965) are examples of works that have assessed the current role of forestry in developed countries. For looking into the future from the present, methods such as shown by Gregory (1966) may have to be used.

The demands in future can be divided into two main categories that can be easily distinguished from an input-output table. When an increase in the production of many sectors is contemplated in the future the demands created by them for the output of forestry sectors can be put into the first category. These demands are due to the forward linkages of the forestry sector and are interindustry demands. The second category is of final demand for forest products like, say, fuel wood and panelling material. Both categories have high income elasticities of demand, especially at low levels of per capita income. To be reasonably successful forest development planners, foresters must have better ideas of the values of these elasticities. Considerable work needs to be done in this field.

The role of forestry mentioned in this chapter is a passive one, i.e., of following economic development rather than pushing it. From the point of view of the forester it is as important as the propulsive role. As this thesis is not concerned with the more detailed analysis of the passive role, it is not discussed any further.

CHAPTER NINE

SUMMARY AND CONCLUSIONS

Forestry is one of the many sectors of production in an economy. Its products do not go directly for final use in most cases, but act as raw materials or inputs for producing other final products. These in turn may be demanded for investment purposes or for consumption. The role of forestry in economic development can be conceptually divided into two parts. One is the propulsive role where the inherent characteristics of forestry make it a desirable sector, the output of which must be increased. The other role is of consolidating the economic development that may be occurring due to other forces.

The main characteristics of forestry which have a propulsive effect are:

1. It can utilize rural resources easily.
2. Its main product, wood, is versatile.
3. It is a supplier of raw material for paper which is a very important item in human investments in a developing country.
4. It can save foreign exchange by import substitution and export promotion in many cases.
5. In some countries by providing cheap fuel it can release cow dung for use as a manure in agriculture.
6. It can play a substantial role in regional development where large forest areas exist.

With increasing per capita incomes greater quantities of forest products are demanded, both for investment and consumption purposes. This increase is very great at low per capita incomes but becomes less as incomes continue to rise. Thus, the poorer the country the more important role could forests play in its development if it has any significant amount of forests. If there are not enough forests in an underdeveloped country it usually does not pay to create them for the propulsive effects. It may, however, still be an economic proposition to create forests for meeting future needs of forest products due to increasing incomes. The final conclusion that creation of forests is required depends only on the results of careful economic analysis of such afforestation projects.

Forests would contribute their utmost to the attainment of the take-off stage in economic development and meeting the future needs due to development if they are so managed as to maximize their present worth. This involves exploiting and investing at an optimum level in forest enterprises. For this the "user cost" concept can be used, and it is necessary that some kind of a preview of the future economic situation be had. This in turn means that the extent to which other sectors are going to try to push the economy towards take-off must also be known.

As there is nothing inherently very good or very bad in forestry or most other sectors for the purposes of economic development, a sector is only as good as it is economical. The most important sector in a dynamic situation is that which can keep its products more economically supplied than others. The forestry sector is thus only as important as the foresters can make it economically efficient. Quick technological change and aggressive marketing in competition with its substitutes can make and keep forestry an important sector. Nevertheless, its importance may not be too much as it forms a very small part of the aggregate economy.

Underdeveloped countries must not only change their traditional patterns of social behaviour in favour of more economical responses, but must also be prepared to change old technology and philosophy. In the field of forestry the sustained yield philosophy and physical criteria of rotation need to be rejected and replaced by the goal of "maximization of present worth of the forest property" and economic criteria of rotation in all countries that desire continued development of their economies. If the economic policies of underdeveloped countries are such that the true costs of production are reflected in its price, and all enterprises respond to the call of profit or present worth maximization, then forestry and all other sectors can play their full part in economic development.

BIBLIOGRAPHY

ACKLEY, G., 1961. Macroeconomic theory. MacMillan, New York. 597 pp.

ADELMAN, I., 1964. Theories of economic growth and development. (First published 1961) Stanford University Press, Stanford, Calif. 164 pp.

AGARWALA, A. N. and S. P. SINGH (Editors), 1963. The economics of underdevelopment. Oxford University Press, New York. 510 pp.

ALLEN, R. G. D., 1963. Mathematical economics. (First published 1956) MacMillan, New York. 812 pp.

_____, S. W., 1955. Conserving natural resources: Principles and practice in a democracy. McGraw-Hill, New York. 347 pp.

ALGVERE, K. V., 1966. Comparative analysis of costs and revenues as a requirement of planning for progress in forestry. Paper presented at the Sixth World Forestry Congress, Madrid, June 1966. No. 6 CFM/G/CTX/10. F.A.O. 11 pp.

AMES, M. M., 1966. The future prospects of Indian civilization, Part II: The values of traditional India. Indo-Canadian, Fourth Quarter 1966: 2-4.

ANDO, A. and F. MODIGLIANI, 1963. The "life cycle" hypothesis of saving: Aggregate implications and tests. American Economic Review, 53 (1): 55-84.

AUBERTIN, D., 1966. Forest investments level. Paper presented at the Sixth World Forestry Congress, Madrid, June 1966. No. 6 CFM/G/P1.4/10. F.A.O. 10 pp.

BAIN, J. S., 1960. Criteria for undertaking water-resource development. American Economic Review, 50 (2): 310-32.

BAIRD, C. O., 1965. Gauging the potential investment efficiency of the forest resource in a depressed area: A study in methodology with application to the Cumberland plateau section of Appalachia. Bulletin 17, School of Forestry, Duke University, Durham, N.C. 133 pp.

BARNES, R. M., 1957. Work sampling. (First published 1956). Wiley, New York. 283 pp.

__________, 1963. Motion and time study. (First published 1948). Wiley, New York. 739 pp.

BARNETT, H. J. and C. MORSE, 1963. Scarcity and growth: The economics of natural resource availability. Resources for the Future Inc. John Hopkins Press, Baltimore. 288 pp.

BASHAM, A. L., 1959. The wonder that was India: A survey of the culture of the Indian sub-continent before the coming of the Muslims. (First published 1954). Grove Press, New York. 568 pp.

BATOR, F. M., 1957. The simple analytics of welfare maximization. American Economic Review, 47 (1): 22-59.

__________, 1958. Anatomy of market failure. Quarterly Journal of Economics, 72 (3): 351-79.

BAUMOL, W. J., 1965. Economic theory and operations analysis. (First published 1961). Prentice-Hall, Englewood Cliffs, N.J. 606 pp.

BEAZLEY, R., 1965. Planning and development requirements in forestland sector of less developed countries. Proceedings, Society of American Foresters, 1965. Detroit, Mich.: 79-91.

BEDNALL, B. H., 1966. Trees and all that. Commonwealth Forestry Review, 45 (2): 138-49.

BERESFORD-PEIRSE, H., 1962. The evolution of forestry. Unasylva, 16 (4): 163-7.

BHAGWATI, J., 1966. The economics of underdeveloped countries. World University Library, McGraw-Hill, New York. 254 pp.

BLACK, E. R., 1963. The diplomacy of economic development and other papers. Atheneum, New York. 176 pp.

_____, P. E., 1963. Timber and water resource management. Forest Science, 9 (2): 137-45.

BLAUG, M., 1962. Economic theory in retrospect. Irwin, Homewood, Ill. 633 pp.

BRANNEN, T. R. and F. X. HODGSON, 1965. Overseas management. McGraw-Hill, New York. 238 pp.

BRASNETT, N. V., 1953. Planned management of forests. Allen and Unwin, London. 238 pp.

BRITISH COLUMBIA LUMBERMAN, 1966a. Less than 3 per cent waste in whole log processing. British Columbia Lumberman, 50 (2): 52-4.

__________, 1966b. Logging stage set to supply smallwood mill. British Columbia Lumberman, 50 (3): 32-4.

BUTTRICK, P. L., 1948. Forest economics and finance. Wiley, New York, 484 pp.

CANADA DEPARTMENT OF FORESTRY, 1966. Agricultural rehabilitation and development act: Federal-provincial rural development agreement, April 1, 1965 to March 31, 1970. Queen's Printer, Ottawa. 29 pp.

CANADIAN INSTITUTE OF FORESTRY, 1966. Resolution 1; 66 in the 58th Annual Report of the Canadian Institute of Forestry. Forestry Chronicle, Supplement, December 1966: 26-7.

_____ PULP AND PAPER INDUSTRY, 1966. How to separate enthusiasm from reality: Discounted cash-flow provides evaluation of capital projects. Canadian Pulp and Paper Industry, December 1966: 32-3 and 53.

CANTRIL, H., 1962. The politics of despair. Collier Books, New York. 285 pp.

CATANO, A. R., 1964. Role of forestry in the economic development of Mexico. Unpublished Master's thesis, Faculty of Forestry, University of Washington. 97 pp.

CHAMPION, H. G., 1965. Tropical forestry education. In Proceedings of the Duke University Tropical Forestry Symposium, April 21-26, 1965, Bulletin 18, School of Forestry, Duke University, Durham, N.C. 195 pp.

CHAPMAN, G. W., 1966. The role of forestry development in national planning with particular reference to the developing countries in Mediterranean and Near East region: Paper presented at the Sixth

World Forestry Congress, Madrid, June 1966. No. 6 CFM/E/Pl.2/20. 9 pp.

CHAPMAN, H. H., 1950. Forest management. Hildreth Press, Bristol, Conn. 582 pp.

CHAPPELLE, D. E., 1966a. Economic model building and computer in forest research. Journal of Forestry, 64 (5): 329-33.

____________, 1966b. A computer program for calculating allowable cut using the area-volume check method. Research Note PNW-44, Mimeographed, Pacific Northwest Forest and Range Experiment Station, United States Department of Agriculture, Forest Service, Portland, Ore. 30 pp.

CHENERY, H. B., 1953. The application of investment criteria. Quarterly Journal of Economics, 67 (1): 76-96.

____________ and P. G. CLARK, 1959. Interindustry economics. Wiley, New York. 345 pp.

____________ and T. WATANABE, 1958. International comparisons of the structure of production. Econometrica, 26 (4): 487-521.

COALE, A. J. and E. M. HOOVER, 1958. Population growth and economic development in low income countries: A case study of India's prospects. Princeton University Press, Princeton, N.J. 389 pp.

CROWTHER, R. E., 1964. Extraction of conifer thinnings. Forestry Commission Booklet 11, Her Majesty's Stationery Office, Edinburgh. 74 pp.

____________ and I. TOULMIN-ROTHE, 1963. Felling and converting thinnings by hand. Forestry Commission Booklet 9, Her Majesty's Stationery Office, Edinburgh. 31 pp.

CURRIE, R. M., 1959. Work study. Pitman, London. 232 pp.

CURTIS, F. H., 1962. Linear programming the management of a forest property. Journal of Forestry, 60 (9): 611-6.

DALE, E., 1965. Management: Theory and practice. McGraw-Hill, New York. 743 pp.

DANA, S. T. and E. W. JOHNSON, 1963. Forestry education in America today and tomorrow. Society of American

Foresters, Washington, D. C. 402 pp.

DAVIS, J., A. L. BEST, P. E. LACHANCE, S. L. PRINGLE, J. M. SMITH and D. A. WILSON, 1957. The outlook for the Canadian Forest Industries. Royal Commission on Canada's Economic Prospects. Queen's Printer, Hull. 261 pp.

_____, K. P., 1966. Forest management: Regulation and valuation. (First published 1954). McGraw-Hill, New York. 519 pp.

DEEVEY, E. S., 1965. The human population. In BURTON, K. and R. W. KATES (Editors), Readings in resource management and conservation. University of Chicago Press, Chicago. 609 pp.

DOBB, M. H., 1960. An essay on economic growth and planning. Routledge and Paul, London. 119 pp.

DOBIE, J., 1967. Increased productivity with chipper headrigs reduces small log milling costs. Canadian Forest Industries. In press.

_____ and C. F. McBRIDE, 1964. Lumber and pulp chips from small logs - a new method. British Columbia Lumberman, 48 (9): 60-4.

DOMAR, E. D., 1947. Expansion and employment. American Economic Review, 37 (1): 34-55.

_____, 1957. Essays in the theory of growth. Oxford University Press, London. 272 pp.

DORFMAN, R., P. A. SAMUELSON and R. M. SOLOW, 1958. Linear programming and economic analysis. McGraw-Hill, New York. 525 pp.

DOWDLE, B., 1962. Investment theory and forest management planning. Bulletin 67. School of Forestry, Yale University. New Haven, Conn. 63 pp.

DREWNOWSKI, J., 1961. The economic theory of socialism: A suggestion for reconsideration. Journal of Political Economy, 69 (4): 341-54.

DUBLIN, L. I., A. J. LOTKA and M. SPIEGELMAN, 1949. Length of life: A study of the life table. (First published 1936). Ronald Press, New York. 379 pp.

DUERR, W. A., 1960. Fundamentals of forestry economics. McGraw-Hill, New York. 579 pp.

____________, 1966a. Paper read at the 66th Annual Meeting of the Society of American Foresters, September 12-15, 1966. Seattle, Wash.

____________, 1966b. Man and the forest: Resource management in the face of change and uncertainty. Lithographed. State University College of Forestry at Syracuse University, Syracuse, N.Y. 274 pp.

DUESENBERRY, J. S., 1949. Income, savings and the theory of consumer behaviour. Harvard University Press, Cambridge, Mass. 124 pp.

____________, 1950. Some aspects of the theory of economic development. Explorations in entrepreneurial history, 3 (2): 62- 102.

ECKSTEIN, O., 1957. Investment criteria for economic development and the theory of intertemporal welfare economics. Quarterly Journal of Economics, 71 (1): 56-85.

EDLIN, H. L., 1956. Trees, woods and man. Collins, London. 272 pp.

ELLIS, H. S. and C. WALLICH (Editors), 1961. Economic development for Latin America: Proceedings of International Economic Association. MacMillan, London. 478 pp.

EMPIRE FORESTRY ASSOCIATION, THE, 1953. British Commonwealth forest terminology. The Empire Forestry Association at the Royal Empire Society, London. 163 pp.

F. A. O., 1960. World demand for paper to 1975. Food and Agriculture Organization of the United Nations. Rome. 159 pp.

__________, 1966. Wood: World trends and prospects. Unasylva, 20 (1-2): 1-136.

__________ and U. N. E. C. A., 1965. Timber trends and prospects in Africa. Food and Agriculture Organization of the United Nations. Rome. 165 pp.

__________ and U. N. E. C. A. F. E., 1961. Timber trends and prospects in the Asia-Pacific region. Food and

Agriculture Organization of United Nations, Geneva. 224 pp.

F. A. O. and U. N. E. C. E., 1953. European timber trends and prospects. Food and Agriculture Organization of the United Nations, Geneva. 315 pp.

_______ and U. N. E. C. E., 1964. European timber trends and prospects: A new appraisal 1950-1975. Food and Agriculture Organization of the United Nations. New York. 233 pp.

_______ Staff, 1964. Forestry schools and faculties. Unasylva 18 (4): 3-4.

_______, 1965. Fast growing tree species for industrial plantations in developing countries. Unasylva, 19 (4): 159-67.

FARRELL, M. J., 1959. The new theories of the consumption function. Economic Journal, 69 (276): 678-96.

FEI, J. C. H. and G. RANIS, 1963. Innovation, capital accumulation and economic development. American Economic Review, 53 (3): 283-313.

FELDSTEIN, M. S., 1964. The social time preference discount rate in cost benefit analysis. Economic Journal, 74 (294): 360-79.

F. E. O., U. P., 1964. Uttar Pradesh Van Vibhāg Sānkhyikiya Simhāvalokan (In Hindi). Forest Extension Officer, Uttar Pradesh. Lucknow, U. P. 34 pp.

FLORA, D. F., 1966. Time discounting by certain forest landowners. Bulletin 69, School of Forestry, Yale University, New Haven, Conn. 55 pp.

FOREST CLUB, 1959. Forestry handbook for British Columbia (First published 1953). The Forest Club, University of British Columbia, Vancouver, 800 pp.

FOREST RESEARCH INSTITUTE, 1961. 100 years of Indian Forestry. Vol II - Forests. Manager of Publications, Delhi. 381 pp.

FORRESTER, S., 1962. Aids to working conifer thinnings. Forestry Commission, Booklet 8. Her Majesty's Stationery Office, Edinburgh. 35 pp.

FRIEDMAN, M., 1957. A theory of consumption function: A study by the National Bureau of Economic Research, New York. Princeton University Press, Princeton. 243 pp.

FRIEDMANN, J. and W. ALONSO (Editors), 1964. Regional development and planning: A reader. M. I. T. Press. Cambridge, Mass. 722 pp.

FURTADO, C., 1964. Development and underdevelopment (First published in Portuguese 1961). Translated by R. W. DE AGUIAR and E. C. DRYSDALE. University of California Press, Berkeley and Los Angeles. 181 pp.

GALBRAITH, J. K., 1964a. The affluent society (First published 1958). New American Library of Canada, Toronto. 286 pp.

________________, 1964b. Economic development (First published 1962). Houghton-Mifflin, Boston. 109 pp.

GINSBURG, N., 1965. Natural resources and economic development. In BURTON I. and R. W. KATES (Editors), Readings in resource management and conservation. University of Chicago Press, Chicago. 609 pp.

GITTINGER, J. P., 1955. Economic development through agrarian reform. Unpublished Ph.D. thesis. Iowa State College, Ames, Iowa. 506 pp.

GOULD, E. M., 1962. Forestry and recreation. Harvard Forest Papers 6. Harvard Forest, Petersham, Mass. 17 pp.

____________ and W. G. O'REGAN, 1965. Simulation: A step toward better forest planning. Harvard Forest Papers 13. Harvard Forest, Petersham, Mass. 86 pp.

GOVERNMENT OF INDIA, 1960. Indian forest and forest products terminology. Indian Forest Records (New series) Silviculture. 10 (6). Manager of Publications, Delhi. 215 pp.

GREENBERGER, M., 1961. Simulation of a complex economic system. In BANBURY, J. and J. MAITLAND (Editors), Proceedings of the Second International Conference on Operational Research, Aix-en-Provence, France, September 5-9, 1960. English Universities Press, London: 511-7.

GREGORY, G. R., 1955. An economic approach to multiple use. Forest Science, 1 (1): 6-13.

____________, 1965. Forests and economic development in Latin America: A challenge for the American forestry profession. Journal of Forestry, 63 (2): 83-8.

____________, 1966. Estimating wood consumption with particular reference to the effects of income and wood availability. Forest Science, 12 (1): 104-17.

GREW, F. J., 1959. Wealth and the common man. Wisdom Library, New York. 184 pp.

GRUT, M., 1965. Forestry and forest industry in South Africa. Balkema, Cape Town. 115 pp.

GUTMANN, P. M. (Editor), 1964. Economic growth: An American problem. Prentice-Hall, Englewood Cliffs, N.J. 181 pp.

HABERLER, G. VON, 1964. Haberler on Schumpeter. In SPIEGEL, H. W. (Editor), The development of economic thought. (Abridged edition), Wiley, New York. 486 pp.

HAHN, F. H. and R. C. O. MATTHEWS, 1964. The theory of economic growth: A survey. Economic Journal, 74 (296): 779-902.

HAIR, D., 1963. The economic importance of timber in the United States. Miscellaneous Publication 941. United States Department of Agriculture, Forest Service, Washington, D. C. 91 pp.

HALEY, D., 1966. An economic appraisal of sustained yield forest management for British Columbia. Unpublished Ph.D. thesis, Faculty of Forestry, University of British Columbia, Vancouver. 313 pp.

HAMILTON, H. R., 1966. Highlights of the Battelle Study of Southeastern pulpwood harvesting. American Pulpwood Association, Technical Release 66-R-10, New York. 25 pp.

HANSEN, A., 1953. A guide to Keynes. McGraw-Hill, New York. 237 pp.

HARROD, R. F., 1939. An essay in Dynamic theory. Economic Journal, 49 (193): 14-33.

HARROD, R. F., 1952. Towards a dynamic economics: Some recent developments of economic theory and their application to policy. (First published 1948 as "Lectures delivered in the University of London in February 1947"),Macmillan, London. 168 pp.

HART, S. G. P., 1966. Private forestry in New Zealand. Commonwealth Forestry Review, 45 (2): 128-37.

HAVER, C. B. and ASSOCIATES, 1961. An economic analysis of evaluation practices for water resource development. Mimeographed. United States Study Commission, Texas. 174 pp.

HAYES, J. L., 1960. A seminar by the Dean of School of Business Administration Duquesne University at the Rochester Institute of Technology on October 17, 1960. (Quoted from Dale 1965).

HEILBRONER, R. L., 1962. The making of economic society. Prentice-Hall, Englewood Cliffs, N. J. 241 pp.

__________, 1963. The great ascent. The struggle for economic development in our time. Harper and Row, New York. 160 pp.

__________ and P. L. BERNSTEIN, 1963. A primer on government spending. Vintage Books, Random House, New York. 120 pp.

HICKS, J. R., 1965. Capital and growth. Oxford University Press, Oxford. 343 pp.

HIGGINS, B., 1959. Economic development, principles, problems and policies. Norton, New York. 803 pp.

HILDEBRAND, G. H. and TA-CHUNG LIU, 1965. Manufacturing production functions in the United States, 1957: An interindustry and interstate comparison of productivity. New York State School of Industrial and Labour Relations, Cornell University, Ithaca, New York. 224 pp.

HIRSCHMAN, A. O., 1963. The strategy of economic development. (First published 1958). Yale University Press, New Haven, Conn. 217 pp.

HIRSHLEIFER, J., C. DeHAVEN and J. W. MILLIMAN, 1961. Water supply: Economics, technology and policy. University of Chicago Press, Chicago. 378 pp.

HOFFMAN, P. G., 1966. The rich and the poor: 1966. Saturday Review. September 17, 1966. 22-5.

HOLLAND, E. P., B. TENCER and R. W. GILLESPIE, 1960. A model for simulating dymanic problems fo economic development. Centre for International Studies, M. I. T., Cambridge, Mass. 203 pp.

HORVAT, B., 1958. The optimum rate of investment. Economic Journal, 68 (272): 747-67.

HOUTHAKKER, H. S., 1958. The permanent income hypothesis: A review article. American Economic Review, 48 (3): 396-404.

HSIA, E. C. H., 1958. Land use conditions in Taiwan. (First edition 1957). Series 5. Chinese-American Joint Commission on Rural Reconstruction. Taipei, Taiwan. 57 pp.

HUCKENPAHLER, B. J., 1967. International forestry staff, United States Department of Agriculture, Forest Service, Washington, D.C. Personal communication. 2 pp.

INTERNATIONAL LABOUR OFFICE, 1964. Introduction to work study. (First published 1957). Atar, Geneva. 355 pp.

__________ PAPER COMPANY, 1962. Multiple use of the forests: A progress report from International Paper Company, New York. 32 pp.

ISARD, W., 1960. Methods of regional analysis: An introduction to regional science. Technology Press of the Massachusetts Institute of Technology and Wiley, New York. 784 pp.

JOHNSTON, B. F. and J. W. MELLOR, 1961. The role of agriculture in economic development. American Economic Review, 51 (4): 566-93.

KAHN, A. E., 1951. Investment criteria and development programs. Quarterly Journal of Economics, 65 (1): 38-61.

KARLIN, S., 1959. Mathematical methods and theory in games, programming and economics. Vol. I (Matrix games, programming and mathematical economics). Addison-Wesley, Reading, Mass. 433 pp.

KEENLEYSIDE, H. L., 1966. International aid: A summary with special reference to the programmes of the United Nations. McClelland and Stewart, Toronto. 343 pp.

KEMENY, J. G., O. MORGENSTERN and G. L. THOMPSON, 1956. A generalization of the von Neumann model of an expanding economy. Econometrica, 24 (2): 115-35.

KEYNES, J. M., 1964. The general theory of employment, interest and money. (First published 1936). Macmillan, Toronto. 403 pp.

KINDELBERGER, C. P., 1965. Economic development. (First published 1958). McGraw-Hill, New York. 425 pp.

KUZNETS, S. S., 1946. National product since 1869. National Bureau of Economic Research. New York. 256 pp.

____________, 1964. Empirical evidence on Rostow's stages. In MEIER, G. M. University Press, New York. 572 pp.

LANDSBERG, H. H., 1965. Technological advance and resource projection. In BURTON I., and R. W. KATES (Editors), Readings in resource management and conservation. University of Chicago Press, Chicago. 609 pp.

LEFEBER, L., 1964. Regional allocation of resources in India. Reprinted from the original of 1961 in FRIEDMANN, J. and W. ALONSO (Editors), Regional development and planning: A reader. M. I. T. Press, Cambridge, Mass. 722 pp.

LEIBENSTEIN, H., 1963. Economic backwardness and economic growth. (First published 1959). Wiley, New York. 295 pp.

____________ and W. GALENSON, 1955. The investment criteria. Quarterly Journal of Economics, 69 (3): 343-70.

LEONARD, W. G., 1965. Financial management in Canadian business. McGraw-Hill, Toronto. 235 pp.

LEONTIEF, W. W., 1951. The structure of American economy 1919-1939: An empirical application of equilibrium analysis. (First published 1941). Oxford University Press, New York. 264 pp.

LERNER, A. P., 1946. The economics of control. Macmillan, New York. 428 pp.

LEWIS, G. D., 1966. The role of forest industries in industrial development in tropical Latin America. Paper presented at the Sixth World Forestry Congress, Madrid, June 1966. No. 6 CFM/E/Pl. 2/3 F.A.O. 17 pp.

LEWIS, J. P., 1964. Quiet Crisis in India. (First published 1962). Doubleday, Garden City, N.Y. 383 pp.

_____, W. A., 1955. The theory of economic growth. Irwin, Homewood, Ill. 453 pp.

LINDAHL, E., (Editor), 1958. Knut Wicksell: Selected papers on economic theory. Harvard University Press, Cambridge, Mass. 292 pp.

LITTLE, I. M. D. and J. M. CLIFFORD, 1965. International aid: A discussion of the flow of public resources from rich to poor countries, with particular reference to British policy. Allen and Unwin, London. 360 pp.

LIVIATAN, N., 1965. Estimates of distributed log consumption function from cross section data. Review of Economics and Statistics, 47 (1): 44-53.

LOUCKS, D. P., 1964. The development of an optimum program for sustained-yield management. Journal of Forestry, 62 (7): 485-90.

LUCE, R. D. and H. RAIFFA, 1957. Games and decisions: Introduction and critical survey. A study of the Behavioral Models Project, Bureau of Applied Social Research, Columbia University. Wiley, New York. 509 pp.

LUSSIER, L. J., 1960. Use of operations research in determining optimum logging layout. Pulp and Paper Magazine of Canada, 61 (Convention) Woodlands Section: 280-9.

_______________, 1961. Planning and control of logging operations. The Forest Research Foundation, Université Laval, Quebec. 135 pp.

MANNE, A. S. and A. RUDRA, 1965. A consistency model of India's fourth plan. Sankhya, Series B, Vol. 27, Parts 1 and 2 (September 1965): 57-144.

MANTESH, T. J., 1964. Computer simulation of the economies of the United States softwood plywood industry. Agricultural Experiment Station Special Report 180. Oregon State University, Corvallis, Ore. 18 pp.

MARGLIN, S. A., 1962. Economic factors affecting system design. In MAASS, A. et al., Design of water resource systems: New techniques for relating economic objectives, engineering analysis and governmental planning, Harvard University Press, Cambridge, Mass. 620 pp.

MARGLIN, S. A., 1963. The social rate of discount and the optimal rate of investment. Quarterly Journal of Economics, 77 (1): 95-111.

MARKOWITZ, H., 1952. Portfolio selection. Journal of Finance, 7 (1): 77-91. (Reprinted in Cowles Commission Papers, New Series, No. 60, 1952)

____________, 1959. Portfolio selection. Cowles Foundation Monograph 16. Wiley, New York. 344 pp.

MARTY, A. L., 1964. The neo-classical theorem. Under "Communications", American Economic Review, 54 (6): 1026-8.

MASON, E. S., 1964. Foreign aid and foreign policy. Harper and Row, New York. 118 pp.

MATSON, E. E. and H. A. RAPRAEGER, 1950. Fall creek second-growth Douglas fir thinning study. Research Note 70, Pacific Northwest Forest and Range Experiment Station. United States Department of Agriculture, Forest Service, Portland, Ore. 13 pp.

MAULDIN, W. P., 1964. The population of India. In FREEDMAN, R. (Editor). Population: The Vital Revolution. Doubleday, Garden City, New York. 274 pp.

MAYNARD, H. B. (Editor), 1963. Industrial engineering handbook. (First published 1956). McGraw-Hill, New York. 1869 pp.

McALPINE, R. G., C. L. BROWN, A. M. HERRICK and H. E. RUARK, 1966, "Silage" sycamore. Forest Farmer, 26 (1): 6, 7, and 16.

McLEOD, A. N., 1964. Timing and capital expenditures. Paper Industry, 46 (3): 189-91.

MEADE, J. E., 1961. A neo-classical theory of economic growth. Oxford University Press, New York. 146 pp.

MEIER, G. M., 1963. International trade and development. Harper and Row, New York. 208 pp.

____________, (Editor), 1964. Leading issues in development economics. Oxford University Press, New York. 572 pp.

MODIGLIANI, F., 1949. Fluctuations in the saving-income ratio: A problem in economic forecasting. Studies in Income and Wealth, Vol. II, National Bureau of Economic Research, New York. 450 pp.

_____________ and R. E. BRUMBERG, 1954. Utility analysis and the consumption function: An interpretation of cross-section data. In KURIHARA, K. K. (Editor), Post-Keynesian economics. Rutgers University Press, New Brunswick, N.J. 442 pp.

MORISHIMA, M., 1958. Prices interest and profits in a dynamic Leontief system. Econometrica, 26 (3): 358-80.

_____________, 1959. Some properties of a dynamic Leontief system with a spectrum of techniques. Econometrica, 27 (4): 626-37.

_____________, 1960. Economic expansion and the interest rate in generalized von Neumann models. Econometrica, 28 (2): 352-63.

_____________, 1961. Proof of a turnpike theorem: The "no joint production" case. Review of Economic Studies, 28 (77): 89-97.

MOORE, M. A., 1957. Forest tenures and taxes. Tax Paper 11, Canadian Tax Foundation, Ottawa. 315 pp.

MORROW, R. L., 1946. Time study and motion economy. Ronald Press, New York. 338 pp.

NAFFZIGER, T. R., R. S. MATUSZEWSKI, T. F. CLARK and I. A. WOLFF, 1960. Dissolving pulps from domestic timber: Bamboo Phyllostachys bambusoides. Tappi, 43 (6): 591-6.

NATH, S. K., 1964. Are formal welfare criteria required? Economic Journal, 74 (295): 548-77.

NAUTIYAL, J. C., 1965. A survey of economic implications of fast-growing tree plantations for Uttar Pradesh in India. Unpublished M. F. thesis, Faculty of Forestry, University of British Columbia, 144 pp.

_____________, 1966. Optimum rate of forest harvesting. Forestry Chronicle, 42 (4): 337-45.

_____________ and P. H. PEARSE, 1967. Optimizing the conversion to sustained yield: A programming solution. Forest Science. In press.

NEALE, W. C., 1965. India: The search for unity, democracy, and progress. Van Nostrand, Princeton, N.J. 128 pp.

NEWMAN, G. A., 1965. How India finances development. Foreign Trade. February 1965: 24-6.

NEWNHAM, R. M., 1964. The development of a stand model for Douglas fir. Lithographed Ph.D. thesis. Faculty of Forestry, University of British Columbia. 201 pp.

NICHOLLS, W. A., 1955. Investment in agriculture in under-developed countries. American Economic Review, 45 (2): 58-73.

__________, 1963. An agricultural surplus as a factor in economic development. Journal of Political Economy, 71 (1): 1-29.

NIEBEL, B. W., 1955. Motion and time study: an introduction to methods, time study, and wage payment. Irwin, Homewood, Ill. 433 pp.

NOVACK, D. E. and R. LECKACHMAN (Editors), 1964. Development and society: The dynamics of economic change. St. Martin's Press, New York. 433 pp.

NURKSE, R., 1953. Problems of capital formation in under-developed countries. Blackwell, Oxford. 163 pp.

ORCUTT, G. H., 1960. Simulation of economic systems. American Economic Review, 50 (4): 893-907.

O'REAGAN, W. G., L. ARVANITIS and E. M. GOULD, 1965? Systems, simulation and forest management. Mimeographed. Pacific Southwest Forest and Range Experiment Station. 16 pp.

O.R.R.R.C., 1962. Economic studies of outdoor recreation. Outdoor Recreation Resources Review Commission (ORRRC) Study Report 24. United States Government Printing Office, Washington, D.C. 166 pp.

PATEL, S. J., 1966. The India we want: Its economic transition. Manaktalas, Bombay. 223 pp.

PAZOS, F., 1953. Economic development and financial stability. In International Monetary Fund, Staff Papers, Vol. III (1953-54), Washington, D.C. 441 pp.

PEARSE, P. H. and S. SYDNEYSMITH, 1966. Method for allocating logs among several utilization processes. Forest Products Journal, 16 (9): 87-98.

PETERSON, W. C., 1962. Income, employment and economic growth. Norton, New York. 550 pp.

PHELPS, E. S., 1962. The goal of economic growth: An introduction to a current issue of public policy. Norton, New York. 176 pp.

____________, 1966. Golden rules of economic growth: Studies of efficient and optimal investment. Norton, New York. 189 pp.

PLANNING COMMISSION, 1962. Towards a self-reliant economy. India's Third Plan 1961-66. (First printed 1961). Publications Division Ministry of Information and Broadcasting. Government of India, New Delhi. 320 pp.

POTTER, N. and F. T. CHRISTY, 1962. Trends in natural resource commodities: Statistics of prices, output, consumption, foreign trade and employment in the United States, 1870-1957. Resources for the Future Inc. John Hopkins Press, Baltimore. 568 pp.

PREBISCH, R., 1959. Commercial policy in the underdeveloped countries. American Economic Review, 49 (2): 251-73.

PREST, A. R. and R. TURVEY, 1965. Cost-benefit analysis: A survey. Economic Journal, 75 (300): 683-731.

RADNER, R., 1961. Paths of economic growth that are optimal with regard only to final states: A turnpike theorem. Review of Economic Studies, 28 (77): 98-104.

RAHMAN, M. A., 1963. Regional allocation of investment. Quarterly Journal of Economics, 77 (1): 26-39.

RAMSEY, F. P., 1928. A mathematical theory of saving. Economic Journal, 38 (152): 543-59.

RANIS, G. and J. C. H. FEI, 1961. A theory of economic development. American Economic Review, 51 (4): 533-65.

RAO, V. K. R. V., 1963. Investment, income and the multiplier in an underdeveloped economy. Reprinted from

The Indian Economic Review (February 1952) in AGARWALA, A. N. and S. P. SINGH (Editors), The economics of underdevelopment, Oxford University Press, New York. 510 pp.

REED, F. L. C., 1966. Elasticity of demand for wood products. Paper presented for discussion at a conference of Western Forest Economists at Welches, Ore., April 20-21, 1966. Mimeographed. 16 pp.

REIFSNYDER, W. E. and H. W. LULL, 1965. Radiant energy in relation to forests. Technical Bulletin 1344, United States Department of Agriculture, Forest Service, Washington, D.C. 111 pp.

RENNE, R. R., 1958. Land economics: Principles, problems and policies in utilizing land resources. (First published 1947). Harper, New York. 599 pp.

REYNOLDS, L. G., 1963. Economics: A general introduction. Irwin, Homewood, Ill. 739 pp.

ROBINSON, J., 1956. Accumulation of capital. Macmillan, London, 440 pp.

__________, 1960a. Collected economic papers, Vol 2. Blackwell, Oxford. 281 pp.

__________, 1960b. Exercises in economic analysis. Macmillan, London. 242 pp.

ROSENSTEIN-RODAN, P. N., 1963. Problems of industrialization of eastern and south-eastern Europe. Reprinted from the Economic Journal (June-September 1943) in AGARWALA, A. N. and S. P. SINGH (Editors), The economics of underdevelopment. Oxford University Press, New York. 510 pp.

ROSTOW, W. W., 1960. The stages of economic growth. Cambridge University Press, Cambridge. 179 pp.

__________, 1962. The process of economic growth. (First published 1952). Norton, New York. 372 pp.

SAMMET, L. L. and J. B. HASSLER, 1951. Use of the ratio-delay method in processing plant operations. Agricultural Economics Research, 3 (4): 124-34.

SAMUELSON, P. A., 1954. The pure theory of public expenditure. Review of Economics and Statistics, 36 (4): 387-9.

SAMUELSON, P. A., 1962. Parable and realism in capital theory: The surrogate production function. Review of Economic Studies, 29 (2): 193-206.

__________________, 1964. Economics: An introductory analysis. (First published 1948). McGraw-Hill, New York. 838 pp.

SANTA CRUZ, H., 1966. The forestry sector in processes of economic and social development and forestry institutions. Address at the Third Plenary Session of the Sixth World Forestry Congress, June 1966. The Institutional Framework for Forestry Development. FAO. 11 pp.

SCHULTZ, T. W., 1956. The economic test in Latin America. New York School of Industrial and Labour Relations, Cornell University, Bulletin 35. (Original not seen; quoted from Hirschman 1963).

SCHUMPETER, J. A., 1954. History of Economic Analysis. Edited by Elizabeth B. Schumpeter from manuscript. Oxford University Press. New York. 1260 pp.

__________________, 1962. The theory of economic development. (First published in English 1934 from original in German 1912). Oxford University Press, New York. 255 pp.

__________________, 1964. Business cycles: A theoretical, historical and statistical analysis of the capitalist process. (First published 1939). Abridged edition. McGraw-Hill, New York. 461 pp.

SCITOVSKY, T., 1963. Two concepts of external economies. Reprinted from The Journal of Political Economy (April 1954) in AGARWALA, A. N. and S. P. SINGH (Editors), The economics of underdevelopment. Oxford University Press, New York. 510 pp.

SCOTT, A. D., 1953. Notes on user cost. Economic Journal, 63 (250): 368-84.

______________, 1955. Natural resources: The economics of conservation. University of Toronto Press. 184 pp.

SEN, A. K., 1960. Choice of techniques: An aspect of the theory of planned economic development. Blackwell, Oxford. 122 pp.

SEN, A. K., 1961. On optimizing the rate of saving. Economic Journal, 71 (283): 479-95.

SEWELL, W. R. D., J. DAVIS, A. D. SCOTT and D. W. ROSS, 1961. Guide to benefit cost analysis. Resources for Tomorrow, Queen's Printer, Ottawa. 49 pp.

SHENG, TSE-CHENG and HAN KANG, 1961. Windbreaks in Taiwan. Forestry Series 7. Chinese-American Joint Commission on Rural Reconstruction. Taipei, Taiwan. 49 pp.

SHIRLEY, H. L., 1964. Professional education in forestry. Unasylva, 18 (4): 5-13.

SINGH, V. B., 1954. Keynesian economics in relation to under-developed countries. Science and Society, 18 (3): 222-34.

SISAM, J. W. B., 1961. Survey and assessment of forest management practices on public land. Resources for tomorrow. Conference background papers. Vol. 2. Queen's Printer, Ottawa. 669-82.

__________, 1964. Teaching forestry and utilization. Unasylva, 18 (4): 14-21.

SJÖSTEDT, S. I., 1966. Logging in India. Unasylva, 20 (3): 36-42.

SMITH, ADAM, 1784a. An inquiry into the nature and causes of the wealth of nations. Vol. I (First published 1776). Strahan and Cadell, London. 499 pp.

__________, 1784b. An inquiry into the nature and causes of the wealth of nations. Vol. II (First published 1776). Strahan and Cadell, London. 518 pp.

_____, J. H. G., 1962. Sustained yield is not ideal. Forestry Chronicle, 38 (2): 167 and 172.

__________, 1963. Balanced forestry: A new management concept. Forestry Chronicle, 39 (1): 5.

__________, 1964. Report to the National Government of the Republic of China on forests and forest industries. Report 1854. Expanded Program of Technical Assistance. Food and Agriculture Organization of the United Nations. Rome. 60 pp.

SMITH, J. H. G., 1965. Wood supply in British Columbia - present and potential. Proceedings of seminar on British Columbia's future in forest products. Trade in Asia and the Pacific Area, February 19, 1965, University of British Columbia, Vancouver: 9-15.

_____________, R. M. NEWNHAM, and J. HEJJAS, 1965. Importance of distribution and amount of mortality can be defined by simulation studies. Commonwealth Forestry Review, 44 (3): 188-92.

SNIDER, D. A., 1965. Economic myth and reality. Prentice-Hall. Englewood Cliffs, N.J. 149 pp.

SOCIETY OF AMERICAN FORESTERS, 1958. Forestry terminology. Society of American Foresters, Washington, D. C. 97 pp.

SOLOW, R. M. 1956. A contribution to the theory of economic growth. Quarterly Journal of Economics, 70 (1): 65-94.

SOMBERG, S. I., 1962. A program for fostering the economic growth and development of the Republic of Honduras through investments in forestry. Unpublished Ph.D. thesis. School of Forestry, Duke University, Durham, N. C. 251 pp.

SOULE, G. 1962. Introduction to economic science. (First published 1948). New American Library, New York. 127 pp.

SPEARS, J. S., 1966. Forest investments from a government point of view. Paper presented at the Sixth World Forestry Congress, Madrid, June 1966. No. 6 CFM/G/pl.4/1. F.A.O. 12 pp.

SPENGLER, J. J., 1964. Population and economic growth. In FREEDMAN, R. (Editor). Population: The Vital Revolution. Doubleday, Garden City, New York. 274 pp.

STREETEN, P. P., 1961. Unbalanced growth. Reprint from Oxford Economic Papers, Vol. II (June 1959) in STREETEN, P. P., Economic Integration. Sythoff Leyden. 150 pp.

SUNDBERG, U., 1963. A review of research carried out at the Department of Operational Efficiency 1949-62 with a list of publications. Institutionen för skogsteknik, Rapporter och Uppsatser No. 18, 1963. Stockholm. 22 pp.

SUTCLIFFE, R. B., 1964. Balanced and unbalanced growth. Quarterly Journal of Economics, 78 (4): 621-40.

SWAN, T. W., 1956. Economic growth and capital accumulation. Economic Record, 32 (63): 334-61.

TAUBMAN, P., 1965. Permanent and transitory income effects. Review of Economics and Statistics, 47 (1): 38-43.

TAYLOR, C. C., D. ENSMINGER, H. W. JOHNSON and J. JOYCE, 1965. India's roots of democracy. Orient Longmans, Bombay. 604 pp.

THOMAS, G. B., 1966. Calculus and analytical geometry. (First published 1951). Addison-Wesley, Reading, Mass. 1010 pp.

THOMPSON, E. F., 1966. Traditional Forest regulation model: An economic critique. Journal of Forestry, 64 (11): 750-2.

TICOULAT, G. J., 1966. Forestry investment from industry's point of view. Paper presented at the Sixth World Forestry Congress, Madrid, June 1966. No. 6 CFM/G/pl. 4/4. 11 pp.

TINBERGAN, J., 1956. The optimum rate of saving. Economic Journal, 66 (264): 603-9.

__________, 1962. The design of development. Hopkins, Baltimore. 99 pp.

TISSEVERANSINGHE, A. E. K., 1964. The economics of forestry in developing countries. Ceylon Forester, 6 (3-4): 81-94.

TOBIN, J., 1965. Money and economic growth. Econometrica, 33 (4): 671-84.

TURNER, H. D., 1965. Introduction to computation of return on investment. Forest Products Journal, 15 (6): 238-41.

TURVEY, R., 1963. Present value versus internal rate of return: An essay in the theory of the third best. Economic Journal, 73 (289): 93-8.

TWEETEN, L. G., 1966. Socio-economic growth theory. Paper presented at a symposium on "Stimulants to social and economic development." Banff, Alta. September 1966. Department of Agricultural Economics, University of Alberta. 33 pp.

UDALL, S. L., 1963. The quiet crisis. Avon Books, New York. 224 pp.

U.N.E.C.L.A., 1963. Latin American timber trends and prospects. Publication E/CN.12/624. Economic Commission for Latin America and Food and Agriculture Organization of the United Nations. New York. 117 pp.

UNITED NATIONS, 1950. National and per capita incomes, seventy countries - 1949. Statistical papers series E, No. 1, New York. pp 14-16 and p. 29. (Original not seen; quoted from Leibenstein 1963)

______________, 1951. Land reform: Defects in agrarian structure as obstacles to economic development. No. E/2003/Rev. 1, ST/ECA/11. Department of Economic Affairs, Social and Economic Council, United Nations, New York. 101 pp.

UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE, 1965a. Outdoor recreating in the national forests. Agriculture Information Bulletin 301. United States Department of Agriculture, Forest Service, Washington, D.C. 106 pp.

______________, 1965b. Timber trends in the United States. Forest Resource Report 17. United States Department of Agriculture, Forest Service, Washington, D.C. 235 pp.

______________, 1966. A guide for evaluating reforestation and stand improvement projects. Agriculture Handbook 304. United States Department of Agriculture, Forest Service, Washington, D.C. 24 pp.

UNITED STATES GOVERNMENT, 1966. The United States book of facts, statistics and information for 1966. Pocket Books, New York. 1104 pp.

VALG, L. and J. H. G. SMITH, 1966. Simulation of forest stand growth. Proceedings, Third Annual Forest Industries Marketing Conference, University of Oregon, Eugene, Ore. 43-50.

VAN LAAR, A., 1961. Eucalyptus saligna in South Africa: An investigation into the silviculture and economics. Annale Universiteit van Stellenbosch, 36 (A1): 110 pp.

VAUX, H. J., 1949. Some economic goals in forestry. Journal of Forestry, 47 (8): 612-7.

__________ and J. A. ZIVNUSKA, 1952. Forest production goals: A critical analysis. Land Economics, 28 (4): 318-27.

VINER, J., 1963. The economics of development. Reprinted from the original of 1953 in AGARWALA, A. N. and S. P. SINGH (Editors), The economics of underdevelopment, Oxford University Press, New York. 510 pp.

VON DER MEHDEN, F. R., 1964. Politics of the developing nations. Prentice-Hall, Englewood Cliffs, N. J. 140 pp.

VON NEUMANN, J., 1938. Über ein ökonomisches Gleichungssystem und eine Verallgemeinerung des Brouwerschen Fixpunktsatzes, in Ergebuisse eines Mathematischen Seminars (Vienna 1938). Translated by G. MORGENSTERN as "A model of general equilibrium". Review of Economic Studies, 13 (30): 1-18.

WAGGENER, T. R., 1966. The federal land grant endowments: A problem in forest resource management. Unpublished Ph.D. thesis. College of Forestry, University of Washington, 180 pp.

WANAMAKER, T., 1964. American foreign policy today. Bantam Books, New York. 250 pp.

WARIS, K., 1966. A banker's view of financing the development of forestry and the forest industries. Paper presented by the Governor of the Bank of Finland to the Sixth World Forestry Congress, Madrid, June 1966. No. 6 CFM/G/P1. 4/5. 5 pp.

WATSON, D. S., 1963. Price theory and its uses. Houghton Mifflin, Boston. 431 pp.

WESTOBY, J. C., 1962. Forest industries in the attack on economic development. Unasylva, 16 (4): 168-201.

__________, 1965. An international perspective on British Columbia's prospects. Proceedings of seminar on British Columbia's future in forest products trade in Asia and the Pacific Area, February 19, 1965, University of British Columbia, Vancouver: 121-4.

WILSON, R. C., 1965. More on "Forests and economic development in Latin America". Points of View in *Journal of Forestry*, *63* (1): 781-4.

WOODS, F. W., 1960. Energy flow silviculture: A new concept for forestry. *Proceedings*, Society of American Foresters, Washington, D.C., 1960: 25-7.

WORLEY, D. P., 1966. A forest inventory approach to multiple use analysis. Paper presented at the Mensuration Section, 66th Annual Meeting of the Society of American Foresters, September 12-15, 1966. Mimeographed. Seattle, Wash. 20 pp.

WORRELL, A. C., 1959. Economics of American forestry. Wiley, New York. 441 pp.

YUAN, H. C., 1964. JCRR forest products research and development program, 1963. Mimeographed. Joint Commission on Rural Reconstruction Taipei, Taiwan. 11 pp.

ZAREMBA, J., 1958. The trend of lumber prices. *Journal of Forestry*, *56* (2): 179-81.

__________, 1961. Family income and wood consumption. *Journal of Forestry*, *59* (6): 443-8.

ZINKIN, T., 1964. India. Oxford University Press, London. 126 pp.

ZIVNUSKA, J. A., 1949a. Commercial forestry in an unstable economy. *Journal of Forestry*, *47*(1): 4-13.

__________, 1949b. Some aspects of the economic theory of forestry. *Land Economics*, *25* (2): 165-72.

__________, 1961. The multiple problems of multiple use. *Journal of Forestry*, *59* (8): 555-60.

__________, 1963. The future for wood in a competitive market. Paper presented at the joint meeting of the Columbia River-Puget Sound Sections. Society of American Foresters. Mimeographed. Longview, Wash., May 4, 1963. 14 pp.

__________, 1965. The forest resources of the United States in a world economy: A problem analysis. Lithographed. A report to Resources for the Future, Inc., Washington, D.C. School of Forestry, University of California, Berkeley, Calif. 121 pp.

ZIVNUSKA, J. A., 1966a. The integration of forest development plans and national development plans: How to make the forestry case at the national level. Paper presented at the Sixth World Forestry Congress, Madrid, June 1966. No. 6 CFM/G/P1.2/3 F.A.O. 15 pp.

________________, 1966b. Points of view. The forester: Prophet, policy-maker, or professional. Journal of Forestry, 64 (12): 816-9.

APPENDIX I

A LIST OF THE MORE IMPORTANT VARIABLES IN THE PROGRAMMES WITH THEIR MEANINGS AND THE TERMS USED TO DENOTE THEM IN THE TEXT IN CHAPTER THREE.

AOCR	Average output-capital ratio	β
ALPHA	Marginal output-capital ratio	α
DEP	Depreciation expressed as a proportional rate	d
DIG.	Total domestic investment	S.P.
DM	That component of SM which comes from domestic savings	
F	The rate of decrease of the speed of adjustment of per capita consumption level	f
FPCI	Foreign investment per capita	F
IY(I)	The year (I-1). When used as subscript, it denotes the value of the variable (of which it is subscript) corresponding to that year. IY(1) means year 0. IY(2) means year 1 and so on. PCI(7) means per capita income in year 6. PCI(n) means per capita income in year (n-1)	n
M	Year of take-off	T
PCC	Per capita capital	k
PCCK	Level below which per capita consumption can not fall	
PCCN	Per capita consumption	C
PCI	Per capita income	Y
PCS	Per capita savings	S
PMU	The proportion of per capita income that is consumed in the fully adjusted state	μ

RIA	Rate of interest at which foreign loans are repaid	i'
RIB	Rate of time preference	i
SM	The total (domestic plus foreign) minimum per capita investment that must be made so that per capita income five years hence is maintained at its level.	
SS_1	Present worth of foreign capital borrowed during take-off as seen from time period zero	SS_1
SS_2	Present worth of income increases due to development during take-off as seen from time period zero.	SS_2
$SS_2 - SS_1$	Net benefit during take-off	SS_2-SS_1
TINV	Total investment i.e., all per capita investment multiplied by the population	$(S+F) \cdot P$
XPOP	Population	P

The following initial values are assumed in the model

PCC(1)	=	$78.12
PCI(1)	=	$50.00
XPOP(1)	=	1.00
PCS(1)	=	$ 2.50
DIG (1)	=	$ 2.50
AOCR(1)	=	0.64

The parameters are given the following values

PMU	=	0.85
F	=	8.00
RIA	=	0.02
RIB	=	0.06
PECK	=	$47.50
BETA	=	0.33

APPENDIX II

DESCRIPTION OF THE FORTRAN PROGRAMME FOR THE GROWTH OF AN ECONOMY

1. Programme in Fortran IV for the growth of the economy described in the model of Chapter Three if new investments have a marginal output-capital ratio of 0.33 and following per capita foreign investments are made.

FPCI(1) = $5.00

FPCI(2) = $5.00

FPCI(3) = $5.00

FPCI(4) = $5.00

FPCI(5) = $3.00

FPCI(6) = $2.15

FPCI(7) = $1.35

FPCI(8) = $0.61

FPCI(9) = $0.46

```
FROESE                                   FORTRAN SOURCE LIST                05/04/67      PAGE  1
       ISN        SOURCE STATEMENT

         0 * $IBFTC
         1 *           DIMENSION FPCI(100),X(50),Y(50),PCC(100),PCI(100),XPOP(100),PCS(10
           *          1C),DIG(100),AOCR(100),DM(100)
         2 *           DIMENSION IY(100),TC(100),TI(100),PCCN(100),TCN(100),TINV(100),PO(
           *          1100),TCIM1(100),FM(100),SM(100),PCCK(100),P(100)
         3 *           DEP=.03
         4 *           ALPHA= .33
         5 *           READ (5,4) PCC(1),PCI(1),XPOP(1),PCS(1),DIG(1),AOCR(1),DM(1),PMU,F
           *          1,RIA,RIB
         6 * 4         FORMAT (11F6.0)
         7 *           READ (5,6) JU,(FPCI(I),I=1,JU)
        15 * 6         FORMAT (I6,(12F6.0))
        16 *           N=0
           * C         -- PO(5)=1.001895**4 --  BECAUSE RATE OF GROWTH OF POPULATION IN
           * C YEARS ZERO TO FOUR IS CONSTANT AT 1.001895.  THIS FIGURE HAS BEEN OB-
           * C TAINED AS THE VALUE OF POW CORRESPONDING TO PCI VALUE OF 50 FROM
           * C STATEMENT 71 AND ALSO HAS BEEN USED IN STATEMENT 27.
        17 *           PO(5)=1.001895**4
        20 * 1         CCNTINCE
        21 *           N=N+1
        22 *           I=N
        23 *           IY(I)=I-1
        24 *           IF (I.GE.6) GO TO 70
        27 *           XPOP(I)=XPOP(1)*1.001895**IY(I)
        30 *           PCC(1)=PCC(1)
        31 *           PCI(I)=PCI(1)
        32 *           TC(I)=XPOP(I)*PCC(I)
        33 *           TI(I)=XPOP(I)*PCI(I)
        34 *           IF (I.NE.1) GO TO 7
        37 *           PCCN(I)=PMU*PCI(I)
        40 *           GO TO 8
        41 * 7         C=PMU*PCI(I)
        42 *           D=PCCN(I-1)
        43 *           Q=C-D
        44 *           IF(Q.LE.0.) PCCN(I)=PCCN(I-1)-SQRT(2.*F*(PCCN(I-1)-PMU*PCI(I)))+.5
           *          1*F
        47 *           IF(Q.LE.0.) GO TO 8
        52 *           PCCN(I)=PCCN(I-1)+SQRT(2.*F*(PMU*PCI(I)-PCCN(I-1)))-0.5*F
        53 * 8         IF(PCCN(I).LT.47.5) PCCK(I)=47.5
        56 *           IF (PCCN(I).GE.47.5) PCCK(I)=PCCN(I)
        61 *           TCN(I)=XPOP(I)*PCCK(I)
        62 *           PCS(I)=PCS(1)
        63 *           DIG(I)=DIG(1)
        64 *           TINV(I)=(DIG(I)+FPCI(I))*XPOP(I)
        65 *           AOCR(I)=AOCR(1)
        66 *           DM(I)=DM(1)
        67 *           GO TO 1
        70 * 70        CONTINUE
        71 *           IF(PCI(I-1).LE.150.) POW=3.3-(PCI(I-1)-150.)**2/3214.85
        74 *           IF(PCI(I-1).GT.150.) POW=1.0+23000./((PCI(I-1)-150.)**2+10000.)
        77 *           POW=1.+POW/100.
       100 *           PO(I)=PO(I-1)*POW
       101 *           XPOP(I)=PO(I)*XPOP(1)
           * C         SUBSCRIPT  -- (I-5) --  IS USED IN FOLLOWING STATEMENTS WHENEVER
           * C NEEDED BECAUSE PERIOD OF GESTATION HAS BEEN ASSUMED AS 5 YEARS.
```

```
FROESE                                   FORTRAN SOURCE LIST                05/04/67      PAGE  2
       ISN        SOURCE STATEMENT

       102 *           TCIM1(I)=(1.-DEP)*TC(I-1)
       103 *           TC(I)=TCIM1(I)+TINV(I-5)
       104 *           PCC(I)=TC(I)/XPOP(I)
       105 *           TI(I)=TCIM1(I)*AOCR(I-1)+TINV(I-5)*ALPHA
       106 *           PCI(I)=TI(I)/XPOP(I)
       107 *           C=PMU*PCI(I)
       110 *           D=PCCN(I-1)
       111 *           Q=C-D
       112 *           IF(Q.LE.0.) PCCN(I)=PCCN(I-1)-SQRT(2.*F*(PCCN(I-1)-PMU*PCI(I)))+.5
           *          1*F
       115 *           IF(Q.LE.0.) GO TO 5753
       120 *           PCCN(I)=PCCN(I-1)+SQRT(2.*F*(PMU*PCI(I)-PCCN(I-1)))-0.5*F
       121 * 5753      IF (PCCN(I).LT.47.5) PCCK(I)=47.5
       124 *           IF (PCCN(I).GE.47.5) PCCK(I)=PCCN(I)
       127 *           TCN(I)=PCCK(I)*XPOP(I)
       130 *           PCS(I)=PCI(I)-PCCK(I)
       131 *           DIG(I)=PCS(I)
       132 *           TINV(I)=(DIG(I)+FPCI(I))*XPOP(I)
       133 *           AOCR(I)=PCI(I)/PCC(I)
       134 *           A=PCI(I-1)*XPOP(I)
       135 *           B=TC(I-1)*(1.-DEP)*ACCR(I-1)
       136 *           SM(I-5)=((A-B)/XPOP(I-5))/ALPHA
       137 *           IF (SM(I-5).GT.DIG(I-5)) FM(I-5)=SM(I-5)-DIG(I-5)
       142 *           IF (SM(I-5).GT.DIG(I-5)) DM(I-5)=DIG(I-5)
       145 *           IF (SM(I-5).LE.DIG(I-5)) FM(I-5)=0.
       150 *           IF (SM(I-5).LE.DIG(I-5)) DM(I-5)=SM(I-5)
       153 *           CHECK=(SM(I-5)/PCI(I-5)*100.)
       154 *           P(I-5)=CHECK
       155 *           IF(N.LT.100) GO TO 1
       160 *           KK=95
       161 *           WRITE (6,10)
       162 * 10        FORMAT (86X,10HPER CAPITA)
       163 *           WRITE (6,20)
       164 * 20       0FORMAT (29X,10HPER CAPITA,8X,10HPER CAPITA,8X,10HPER CAPITA,11X,10
           *          1HSAVINGS   +,8X,10HPER CAPITA,9X,7HAVERAGE)
       165 *           WRITE (6,30)
       166 * 30        FORMAT (87X,8HDOMESTIC,11X,7HFOREIGN,11X,7HOUT/CAP)
       167 *           WRITE (6,40)
       170 * 40       0FORMAT (2X,4HYEAR,5X,10HPOPULATION,10X,7HCAPITAL,11X,6HINCOME,10X,
           *          111HCONSUMPTION,10X,10HINVESTMENT,8X,10HINVESTMENT,11X,5HRATIO//)
       171 *           DO 5 I=1,KK
       172 *           WRITE (6,50) IY(I),XPOP(I),PCC(I),PCI(I),PCCK(I),PCS(I),FPCI(I),AO
           *          1CR(I)
       173 * 50        FORMAT (3X,I2,F16.5,6(2X,F16.3))
       174 * 5         CONTINUE
       176 *           STCP
       177 *           END

          NO MESSAGES FOR ABOVE ASSEMBLY
 TIME 18HRS 34MIN 19.7SEC
```

2. Output of the programme described above.

N.B. In heading of Col. 6 the plus sign (+) should be read as "and".

YEAR	POPULATION	PER CAPITA CAPITAL	PER CAPITA INCOME	PER CAPITA CONSUMPTION	PER CAPITA SAVINGS + DOMESTIC INVESTMENT	PER CAPITA FOREIGN INVESTMENT	AVERAGE OUT/CAP RATIO
0	1.00000	78.120	50.000	47.500	2.500	5.000	0.640
1	1.00189	78.120	50.000	47.500	2.500	5.000	0.640
2	1.00379	78.120	50.000	47.500	2.500	5.000	0.640
3	1.00570	78.120	50.000	47.500	2.500	5.000	0.640
4	1.00760	78.120	50.000	47.500	2.500	3.000	0.640
5	1.00951	83.062	50.857	47.500	3.357	2.150	0.612
6	1.01196	87.801	51.662	47.500	4.162	1.350	0.588
7	1.01491	92.337	52.414	47.500	4.914	0.610	0.568
8	1.01834	96.672	53.115	47.500	5.615	0.460	0.549
9	1.02221	98.838	53.115	47.500	5.615	0.000	0.537
10	1.02610	100.928	53.115	47.500	5.615	0.000	0.526
11	1.03000	102.945	53.113	47.500	5.613	0.000	0.516
12	1.03392	104.901	53.114	47.500	5.614	0.000	0.506
13	1.03785	107.330	53.293	47.500	5.793	0.000	0.497
14	1.04190	109.214	53.311	47.500	5.811	0.000	0.488
15	1.04599	111.031	53.327	47.500	5.827	0.000	0.480
16	1.05010	112.785	53.342	47.500	5.842	0.000	0.473
17	1.05423	114.478	53.356	47.500	5.856	0.000	0.466
18	1.05840	116.288	53.426	47.500	5.926	0.000	0.459
19	1.06262	118.048	53.498	47.500	5.998	0.000	0.453
20	1.06690	119.760	53.570	47.500	6.070	0.000	0.447
21	1.07125	121.422	53.641	47.500	6.141	0.000	0.442
22	1.07566	123.036	53.713	47.500	6.213	0.000	0.437
23	1.08014	124.657	53.801	47.500	6.301	0.000	0.432
24	1.08469	126.285	53.907	47.500	6.407	0.000	0.427
25	1.08933	127.919	54.029	47.500	6.529	0.000	0.422
26	1.09407	129.558	54.166	47.500	6.666	0.000	0.418
27	1.09892	131.197	54.316	47.500	6.816	0.000	0.414
28	1.10389	132.855	54.484	47.500	6.984	0.000	0.410
29	1.10899	134.543	54.674	47.500	7.174	0.000	0.406
30	1.11424	136.275	54.891	47.500	7.391	0.000	0.403
31	1.11966	138.061	55.136	47.500	7.636	0.000	0.399
32	1.12526	139.908	55.412	47.500	7.912	0.000	0.396
33	1.13108	141.828	55.722	47.500	8.222	0.000	0.393
34	1.13713	143.838	56.071	47.500	8.571	0.000	0.390
35	1.14365	145.953	56.465	47.500	8.965	0.000	0.387
36	1.15007	148.194	56.909	47.633	9.277	0.000	0.384
37	1.15702	150.579	57.410	47.951	9.459	0.000	0.381
38	1.16435	153.129	57.972	48.557	9.416	0.000	0.379
39	1.17210	155.869	58.606	49.043	9.562	0.000	0.376
40	1.18032	158.824	59.317	49.736	9.581	0.000	0.373
41	1.18908	161.897	60.075	50.345	9.730	0.000	0.371
42	1.19841	164.949	60.833	51.014	9.818	0.000	0.369
43	1.20832	167.762	61.518	51.532	9.985	0.000	0.367
44	1.21877	170.530	62.195	52.152	10.044	0.000	0.365
45	1.22976	173.132	62.825	52.623	10.202	0.000	0.363
46	1.24127	175.701	63.451	53.202	10.249	0.000	0.361
47	1.25331	178.181	64.054	53.664	10.391	0.000	0.359
48	1.26588	180.652	64.661	54.222	10.440	0.000	0.358
49	1.27897	183.009	65.238	54.658	10.579	0.000	0.356
50	1.29260	185.354	65.817	55.194	10.623	0.000	0.355
51	1.30676	187.580	66.363	55.602	10.761	0.000	0.354
52	1.32145	189.785	66.909	56.110	10.798	0.000	0.353
53	1.33668	191.881	67.425	56.493	10.931	0.000	0.351
54	1.35244	193.960	67.941	56.978	10.964	0.000	0.350
55	1.36874	195.932	68.428	57.335	11.094	0.000	0.349
56	1.38558	197.893	68.918	57.799	11.119	0.000	0.348
57	1.40297	199.748	69.378	58.131	11.248	0.000	0.347
58	1.42090	201.594	69.841	58.575	11.266	0.000	0.346
59	1.43919	203.335	70.275	58.881	11.394	0.000	0.346
60	1.45843	205.071	70.713	59.307	11.405	0.000	0.345
61	1.47804	206.704	71.121	59.588	11.533	0.000	0.344
62	1.49821	208.336	71.534	59.999	11.535	0.000	0.343
63	1.51896	209.865	71.918	60.254	11.664	0.000	0.343
64	1.54028	211.398	72.309	60.651	11.658	0.000	0.342
65	1.56219	212.828	72.670	60.881	11.789	0.000	0.341
66	1.58468	214.269	73.039	61.267	11.772	0.000	0.341
67	1.60778	215.605	73.377	61.469	11.908	0.000	0.340
68	1.63148	216.959	73.726	61.847	11.879	0.000	0.340
69	1.65579	218.204	74.042	62.021	12.021	0.000	0.339
70	1.68072	219.477	74.372	62.394	11.978	0.000	0.339
71	1.70628	220.636	74.668	62.539	12.129	0.000	0.338
72	1.73247	221.833	74.980	62.909	12.071	0.000	0.338
73	1.75931	222.911	75.256	63.024	12.232	0.000	0.338
74	1.78679	224.037	75.552	63.396	12.155	0.000	0.337
75	1.81495	225.037	75.809	63.478	12.331	0.000	0.337
76	1.84377	226.098	76.089	63.856	12.233	0.000	0.337
77	1.87328	227.023	76.327	63.900	12.427	0.000	0.336
78	1.90348	228.025	76.594	64.290	12.304	0.000	0.336
79	1.93439	228.878	76.814	64.294	12.520	0.000	0.336
80	1.96599	229.826	77.068	64.702	12.367	0.000	0.335
81	1.59834	230.609	77.271	64.658	12.612	0.000	0.335
82	2.03141	231.509	77.514	65.093	12.422	0.000	0.335
83	2.06524	232.225	77.699	64.995	12.704	0.000	0.335
84	2.09982	233.083	77.934	65.465	12.469	0.000	0.334
85	2.13519	233.732	78.101	65.304	12.797	0.000	0.334
86	2.17131	234.556	78.328	65.820	12.508	0.000	0.334
87	2.20827	235.138	78.477	65.584	12.893	0.000	0.334
88	2.24601	235.934	78.699	66.162	12.537	0.000	0.334
89	2.28461	236.449	78.830	65.836	12.995	0.000	0.333
90	2.32401	237.225	79.049	66.494	12.555	0.000	0.333
91	2.36431	237.673	79.161	66.056	13.105	0.000	0.333
92	2.40542	238.438	79.380	66.817	12.563	0.000	0.333
93	2.44749	238.815	79.472	66.244	13.228	0.000	0.333
94	2.49039	239.581	79.693	67.136	12.558	0.000	0.333

APPENDIX III

DESCRIPTION OF THE FORTRAN PROGRAMME FOR THE SEARCH FOR TAKE-OFF

1. Programme in Fortran IV for the search for take-off, and calculations of the net benefits therefrom, when one to eight equal initial foreign investments within the ranges specified in the programme are made by turns.

```
KCZAK                              FORTRAN SCURCE LIST                    05/04/67      PAGE  2
      ISN        SCURCE STATEMENT

         0 * $IBFTC MAIN                                                        *
         1 *         CIMENSICN FPCI(100),AK(11),X(1CO)                          *
         2 *         READ 5,AK                                                  *
         3 * 5       FORMAT (11F6.0)                                            *
           * C       -- JU -- NUMBER OF EQUAL FPCI MADE INITIALLY.              *
           * C       -- N1 -- FOR A GIVEN JU, N1 IS THE FIRST VALUE OF THE INITIAL  *
           * C INVESTMENTS THAT ARE MACE BY TURN                                *
           * C       -- N2 -- FOR A GIVEN JU, N2 IS THE LAST VALUE OF THE INITIAL   *
           * C INVESTMENTS THAT ARE MADE DY TURN                                *
           * C       -- T -- RECIPROCAL OF THE INTERVAL BY WHICH INITIAL VALUES OF  *
           * C FPCI INCREASE.  (SEE DATA FORMAT AT THE END OF THE PROGRAM.)     *
         4 *         JU=1                                                       *
         5 * 1       READ 2,N1,N2,T                                             *
        10 * 2       FORMAT (3I6)                                               *
        11 *         CO 3 I=N1,N2                                               *
        12 *         CO 4 J=1,JU                                                *
        13 *         Z=I                                                        *
        14 * 4       FPCI(J)=Z/T                                                *
        16 *         CALL CCS (FPCI,SS1,SS2,CCST,JU,MARIA,L,AK,X,TAX)           *
        17 *         PRINT 6,JU,(FPCI(K),K=1,L)                                 *
        24 * 6       FORMAT(20H-NC. OF INVESTMENTS=,I3,24H  AMOUNT OF INVESTMENTS=,(5F1 *
           *        1C.2)/)                                                     *
        25 *         IF (L.EQ.0) PRINT 7                                        *
        30 * 7       FCRMAT (12H-NO TAKE OFF/)                                  *
        31 *         IF (L.EQ.0) GO TO3                                         *
        34 *         L1=L-1                                                     *
        35 *         PRINT 8,L1,TAX                                             *
        36 * 8       FORMAT (18H-YEAR OF TAKE CFF=,I3,31H PER CAPITA INCOME MAINTAINED= *
           *        1,F10.2/)                                                   *
        37 *         PRINT 9, (X(K),K=1,L)                                      *
        44 * 9       FORMAT (12H MAINTENANCE,(12F10.2)/)                        *
        45 *         PRINT 11,SS1,SS2,CCST                                      *
        46 * 11      FORMAT (35H-PRESENT WORTH CF FOREIGN CAPITAL= ,F10.2/      *
           *        135H PRESENT WORTH CF INCOME INCREASES=,F10.2/              *
           *        235H NET BENEFIT DURING TAKE-OFF       =,F10.2/)            *
        47 * 3       CCNTINUE                                                   *
        51 *         JU=JU+1                                                    *
        52 *         GO TO 1                                                    *
        53 *         END
```

```
KCZAK                              FCRTRAN SCURCE LIST                    05/04/67      PAGE  3
      ISN        SOURCE STATEMENT

         0 * $IBFTC                                                             *
         1 *         SUBROUTINE CCS (FPCI,SS1,SS2,CCST,JU,MARIA,L,AK,FM,TAX)    *
         2 *         CIMENSICN FPCI(100),X(50),Y(50),PCC(100),PCI(100),XPOP(100),PCS(10 *
           *        1C),DIG(1CO),ADCR(1CC),DM(100)                              *
         3 *         CIMENSION IY(1CC),TC(100),TI(100),PCCN(100),TCN(100),TINV(100),PO( *
           *        11CC),TCIM1(1CO),FM(10C),SM(100),PCCK(100),P(100)           *
         4 *         CIMENSION AK(11)                                           *
         5 *         ALPHA= .33                                                 *
         6 *         CEP=.03                                                    *
         7 *         PCC(1)=AK(1)                                               *
        10 *         PCI(1)=AK(2)                                               *
        11 *         XPCP(1)=AK(3)                                              *
        12 *         PCS(1)=AK(4)                                               *
        13 *         CIG(1)=AK(5)                                               *
        14 *         ADCR(1)=AK(6)                                              *
        15 *         CM(1)=AK(7)                                                *
        16 *         PMU=AK(8)                                                  *
        17 *         F=AK(9)                                                    *
        20 *         RIA=AK(10)                                                 *
        21 *         RIB=AK(11)                                                 *
        22 *         KUK=6                                                      *
        23 *         KUM=1                                                      *
        24 *         N=C                                                        *
        25 *         MUK=0                                                      *
        26 *         JU1=JU+1                                                   *
        27 *         JU2=JU+2                                                   *
           * C       -- PO(5)=1.001895**4 --  BECAUSE RATE CF GROWTH CF POPULATION IN  *
           * C YEARS ZERO TO FOUR IS CCNSTANT AT 0.001895.  THIS FIGURE HAS BEEN OB-  *
           * C TAINED AS THE VALUE OF POW CORRESPONDING TO PCI VALUE OF 50 FROM   *
           * C STATEMENT 116.  IT HAS ALSO BEEN USED IN STATEMENT 54 AND 270.    *
        30 *         PO(5)=1.001895**4                                          *
        31 *         CC 28 I=2,83                                               *
        32 * 28      FPCI(I)=C.                                                 *
        34 * 5       N=N+1                                                      *
        35 *         I=N                                                        *
        36 *         IF(N.GT.83) GO TO 9301                                     *
        41 *         IY(I)=N-1                                                  *
        42 *         N5=N+4                                                     *
        43 *         N1=N-3                                                     *
        44 *         IF(N1.LT.1) N1=1                                           *
        47 *         DO 1981 IZ=N1,N5                                           *
        50 *         I=IZ                                                       *
        51 *         IF (I.GE.6) GC TO 70                                       *
        54 *         XPOP(I)=XPOP(1)*1.001895**IY(I)                            *
        55 *         PCC(I)=PCC(1)                                              *
        56 *         PCI(I)=PCI(1)                                              *
        57 *         TC(I)=XPOP(I)*PCC(I)                                       *
        60 *         TI(I)=XPOP(I)*PCI(I)                                       *
        61 *         IF (I.NE.1) GO TO 7                                        *
        64 *         PCCN(I)=PMU*PCI(I)                                         *
        65 *         GO TO 8                                                    *
        66 * 7       C=PMU*PCI(I)                                               *
        67 *         D=PCCN(I-1)                                                *
        70 *         Q=C-D                                                      *
        71 *         IF(Q.LE.0.) PCCN(I)=PCCN(I-1)-SQRT(2.*F*(PCCN(I-1)-PMU*PCI(I)))+.5 *
```

```
KCZAK                                  FORTRAN SCURCE LIST                         05/04/67       PAGE  4
         ISN        SOURCE STATEMENT

             *        1*F                                                                *
        74   *         IF(Q.LE.C.) GO TO 8                                                *
        77   *         PCCN(I)=PCCN(I-1)+SQRT(2.*F*(PMU*PCI(I)-PCCN(I-1)))-0.5*F          *
       1C0   * 8       IF(PCCN(I).LT.47.5) PCCK(I)=47.5                                   *
       1C3   *         IF (PCCN(I).GE.47.5) PCCK(I)=PCCN(I)                               *
       1C6   *         TCN(I)=XPOP(I)*PCCK(I)                                             *
       1C7   *         PCS(I)=PCS(1)                                                      *
       110   *         CIG(I)=DIG(1)                                                      *
       111   *         TINV(I)=(DIG(I)+FPCI(I))*XPOP(I)                                   *
       112   *         AOCR(I)=AOCR(1)                                                    *
       113   *         CM(I)=CM(1)                                                        *
       114   *         GO TO 1881                                                         *
       115   * 70      CONTINLE                                                           *
       116   *         IF(PCI(I-1).LE.150.) POW=3.3-(PCI(I-1)-150.)**2/3214.85            *
       121   *         IF(PCI(I-1).GT.150.) POW=1.0+23000./((PCI(I-1)-150.)**2+10000.)    *
       124   *         POW=1.+PCW/1CO.                                                    *
       125   *         PO(I)=PO(I-1)*PCW                                                  *
       126   *         XPOP(I)=PO(I)*XPOP(1)                                              *
             * C       SUBSCRIPT  -- (I-5) --  IS USED IN FOLLOWING STATEMENTS WHENEVER   *
             * C NEEDED BECAUSE PERIOD OF GESTATION HAS BEEN ASSUMED AS 5 YEARS.          *
       127   *         TCIM1(I)=(1.-DEP)*TC(I-1)                                          *
       130   *         TC(I)=TCIM1(I)+TINV(I-5)                                           *
       131   *         PCC(I)=TC(I)/XPOP(I)                                               *
       132   *         TI(I)=TCIM1(I)*AOCR(I-1)+TINV(I-5)*ALPHA                           *
       133   *         PCI(I)=TI(I)/XPOP(I)                                               *
       134   *         C=PMU*PCI(I)                                                       *
       135   *         D=PCCN(I-1)                                                        *
       136   *         Q=C-D                                                              *
       137   *         IF(Q.LE.C.) PCCN(I)=PCCN(I-1)-SQRT(2.*F*(PCCN(I-1)-PMU*PCI(I)))+.5 *
             *        1*F                                                                *
       142   *         IF(Q.LE.0.) GO TO 5753                                             *
       145   *         PCCN(I)=PCCN(I-1)+SQRT(2.*F*(PMU*PCI(I)-PCCN(I-1)))-0.5*F          *
       146   * 5753    IF (PCCN(I).LT.47.5) PCCK(I)=47.5                                  *
       151   *         IF (PCCN(I).GE.47.5) PCCK(I)=PCCN(I)                               *
       154   *         TCN(I)=PCCK(I)*XPOP(I)                                             *
       155   *         PCS(I)=PCI(I)-PCCK(I)                                              *
       156   *         CIG(I)=PCS(I)                                                      *
       157   *         AOCR(I)=PCI(I)/PCC(I)                                              *
       160   *         IF(I.GT.KUK) GO TO 1777                                            *
       163   *         A=PCI(I-1)*XPOP(I)                                                 *
       164   *         GO TO 1778                                                         *
       165   * 1777    A=PCI(KUK)*XPOP(I)                                                 *
       166   * 1778    B=TC(I-1)*(1.-DEP)*AOCR(I-1)                                       *
       167   *         SM(I-5)=((A-B)/XPOP(I-5))/ALPHA                                    *
       170   *         IF (SM(I-5).GT.DIG(I-5)) FM(I-5)=SM(I-5)-DIG(I-5)                  *
       173   *         IF (SM(I-5).GT.DIG(I-5)) DM(I-5)=DIG(I-5)                          *
       176   *         IF (SM(I-5).LE.DIG(I-5)) FM(I-5)=0.                                *
       2C1   *         IF (SM(I-5).LE.DIG(I-5)) DM(I-5)=SM(I-5)                           *
       2C4   *         TINV(I)=(DIG(I)+FPCI(I))*XPOP(I)                                   *
       205   * 1881    CONTINUE                                                           *
       207   *         I=N5-1                                                             *
       21C   *         IF(I.LE.KUK) GO TO 5                                               *
       213   *         IF (FM(I-5).GT.0.) FPCI(I-5)=FM(I-5)                               *
       216   *         IF (FM(I-5).EQ.0.) MUK=MUK+1                                       *
       221   *         IF (FM(I-5).GT.0..AND.MUK.NE.0) MUK=0                              *
```

```
KCZAK                                  FORTRAN SCURCE LIST                         05/04/67       PAGE  5
         ISN        SOURCE STATEMENT

       224   *         IF (MUK.EC.15) GO TO 151                                           *
       227   *         GO TO 5                                                            *
       230   * 9301    KUK=KUK+1                                                          *
       231   *         KUM=KUM+1                                                          *
       232   *         IF(KUK.GT.65) GO TO 929                                            *
       235   *         IF(KUM.GE.JU) KUM=JU                                               *
       240   *         IF(JU.EQ.1) GO TO 22                                               *
       243   *         CO 15 J=2,KUM                                                      *
       244   * 15      FPCI(J)=FPCI(1)                                                    *
       246   * 22      MUK=0                                                              *
       247   *         N=C                                                                *
       250   *         GO TO 5                                                            *
       251   * 151     CONTINUE                                                           *
       252   *         L=N-19                                                             *
       253   *         TAX=PCI(KUK)                                                       *
       254   *         IF (L.LT.KUK) L=KUK                                                *
       257   *         SS2=0.                                                             *
       260   *         SS1=0.                                                             *
       261   *         J=L                                                                *
       262   *         CO 253 I=1,L                                                       *
       263   *         M=I-1                                                              *
       264   *         SS1=SS1+FPCI(I)*XPOP(I)/(1.+RIA)**M                                *
       265   *         SS2=SS2+ (PCI(I)*XPOP(1)/(1.+RIB)**M)                              *
       266   * 253     CONTINUE                                                           *
       270   *         SS2=SS2-(PCI(1)*XPOP(1))*((1.001895/(1.+RIB))**J-1.)/(1.001895/(1. *
             *        1+RIB)-1.)                                                          *
       271   *         COST=SS2-SS1                                                       *
       272   *         GO TO 930                                                          *
       273   * 929     L=C                                                                *
       274   * 930     RETURN                                                             *
       275   *         ENC                                                                *

          NO MESSAGES FOR ABOVE ASSEMBLY
```

```
DATA FORMAT---

78.12   50.    1.   2.5   2.5   .54   2.5   .85    8.   .02   .06

  N1    N2     T

   1    12     1       FPCI - FROM $1.00 TO $12.00 INCREASING BY $1.00
   1    10     1       FPCI - FROM $1.00 TO $10.00 INCREASING BY $1.00
   1    10     1       FPCI - FROM $1.00 TO $10.00 INCREASING BY $1.00
   1    10     1       FPCI - FROM $1.00 TO $10.00 INCREASING BY $1.00
  10    50    10       FPCI - FROM $1.00 TO $ 5.00 INCREASING BY $0.10
 100   500   100       FPCI - FROM $1.00 TO $ 5.00 INCREASING BY $0.01
 100   500   100       FPCI - FROM $1.00 TO $ 5.00 INCREASING BY $0.01
 100   500   100       FPCI - FROM $1.00 TO $ 5.00 INCREASING BY $0.01

END-OF-DATA ENCOUNTERED ON SYSTEM INPUT FILE.
```

2. **Output of that part of the programme described above where five equal investments between $4.00 and $5.00 are made.**

```
NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.00

NO TAKE OFF

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.10

NO TAKE OFF

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.20

NO TAKE OFF

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.30

NO TAKE OFF

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.40

NO TAKE OFF

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.50     4.50     4.50     4.50     4.50
      2.30     1.65     1.05     0.48     0.37

YEAR OF TAKE OFF=  9 PER CAPITA INCOME MAINTAINED=,     53.05
MAINTENANCE     2.36     2.50     2.63     2.76     2.88     2.30     1.65     1.05     0.48     0.00

PRESENT WORTH OF FOREIGN CAPITAL=       26.97
PRESENT WORTH OF INCOME INCREASES=       6.52
NET BENEFIT DURING TAKE-OFF      =     -20.45

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.60     4.60     4.60     4.60     4.60
      2.30     1.62     0.99     0.40     0.28

YEAR OF TAKE OFF=  9 PER CAPITA INCOME MAINTAINED=,     53.20

MAINTENANCE     2.35     2.51     2.65     2.78     2.90     2.30     1.62     0.99     0.40     0.00

PRESENT WORTH OF FOREIGN CAPITAL=       27.21
PRESENT WORTH OF INCOME INCREASES=       6.82
NET BENEFIT DURING TAKE-OFF      =     -20.39

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.70     4.70     4.70     4.70     4.70
      2.29     1.59     0.93     0.31     0.19

YEAR OF TAKE OFF=  9 PER CAPITA INCOME MAINTAINED=,     53.34
MAINTENANCE     2.38     2.52     2.66     2.79     2.93     2.29     1.59     0.93     0.31     0.00

PRESENT WORTH OF FOREIGN CAPITAL=       27.45
PRESENT WORTH OF INCOME INCREASES=       7.13
NET BENEFIT DURING TAKE-OFF      =     -20.32

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.80     4.80     4.80     4.80     4.80
      2.29     1.55     0.87     0.22     0.09

YEAR OF TAKE OFF=  9 PER CAPITA INCOME MAINTAINED=,     53.48
MAINTENANCE     2.36     2.52     2.67     2.81     2.95     2.29     1.55     0.87     0.22     0.00

PRESENT WORTH OF FOREIGN CAPITAL=       27.69
PRESENT WORTH OF INCOME INCREASES=       7.43
NET BENEFIT DURING TAKE-OFF      =     -20.26

NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=     4.90     4.90     4.90     4.90     4.90
      2.29     1.52     0.80     0.14     0.00

YEAR OF TAKE OFF=  9 PER CAPITA INCOME MAINTAINED=,     53.62
MAINTENANCE     2.38     2.53     2.68     2.83     2.97     2.29     1.52     0.80     0.14     0.00

PRESENT WORTH OF FOREIGN CAPITAL=       27.93
PRESENT WORTH OF INCOME INCREASES=       7.74
NET BENEFIT DURING TAKE-OFF      =     -20.19
```

```
NO. OF INVESTMENTS=  5  AMOUNT OF INVESTMENTS=      5.00      5.00      5.00      5.00      3.00
     2.15      1.35      0.61      0.46

YEAR OF TAKE OFF=  8 PER CAPITA INCOME MAINTAINED=,      53.11
MAINTENANCE      2.38      2.54      2.70      2.85      3.00      2.15      1.35      0.61      0.00

PRESENT WORTH OF FOREIGN CAPITAL=        26.39
PRESENT WORTH OF INCOME INCREASES=        5.62
NET BENEFIT DURING TAKE-OFF       =     -20.77

END-OF-DATA ENCOUNTERED ON SYSTEM INPUT FILE.

TIME 20HRS 34MIN 40.4SEC

$$                                                              10542
```

APPENDIX IV

DESCRIPTION OF A STAGNANT ECONOMY

N.B. In heading of Co. 6 the plus sign (+) should be read as "and".

YEAR	POPULATION	PER CAPITA CAPITAL	PER CAPITA INCOME	PER CAPITA CONSUMPTION	PER CAPITA SAVINGS + DOMESTIC INVESTMENT	PER CAPITA FOREIGN INVESTMENT	AVERAGE OUT/CAP RATIO
0	1.00000	78.120	50.000	47.500	2.500	0.000	0.640
1	1.00189	78.120	50.000	47.500	2.500	0.003	0.640
2	1.00379	78.120	50.000	47.500	2.500	0.009	0.640
3	1.00570	78.120	50.000	47.500	2.500	0.009	0.640
4	1.00760	78.120	50.000	47.500	2.500	0.009	0.640
5	1.00951	78.110	49.990	47.500	2.490	0.019	0.640
6	1.01142	78.100	49.984	47.500	2.484	0.025	0.640
7	1.01332	78.100	49.984	47.500	2.484	0.025	0.640
8	1.01523	78.100	49.984	47.500	2.484	0.025	0.640
9	1.01714	78.100	49.984	47.500	2.484	0.025	0.640
10	1.01906	78.100	49.984	47.500	2.484	0.025	0.640
11	1.02098	78.100	49.984	47.500	2.484	0.025	0.640
12	1.02291	78.100	49.984	47.500	2.484	0.025	0.640
13	1.02483	78.100	49.984	47.500	2.484	0.025	0.640
14	1.02676	78.100	49.984	47.500	2.484	0.025	0.640
15	1.02870	78.100	49.984	47.500	2.484	0.025	0.640
16	1.03064	78.100	49.984	47.500	2.484	0.025	0.640
17	1.03258	78.100	49.984	47.500	2.484	0.025	0.640
18	1.03453	78.100	49.984	47.500	2.484	0.025	0.640
19	1.03647	78.100	49.984	47.500	2.484	0.025	0.640
20	1.03843	78.100	49.984	47.500	2.484	0.025	0.640
21	1.04038	78.100	49.984	47.500	2.484	0.025	0.640
22	1.04235	78.100	49.984	47.500	2.484	0.025	0.640
23	1.04431	78.100	49.984	47.500	2.484	0.025	0.640
24	1.04628	78.100	49.984	47.500	2.484	0.025	0.640
25	1.04825	78.100	49.984	47.500	2.484	0.025	0.640
26	1.05022	78.100	49.984	47.500	2.484	0.025	0.640
27	1.05220	78.100	49.984	47.500	2.484	0.025	0.640
28	1.05419	78.100	49.984	47.500	2.484	0.025	0.640
29	1.05617	78.100	49.984	47.500	2.484	0.025	0.640
30	1.05816	78.100	49.984	47.500	2.484	0.025	0.640
31	1.06016	78.100	49.984	47.500	2.484	0.025	0.640
32	1.06215	78.100	49.984	47.500	2.484	0.025	0.640
33	1.06416	78.100	49.984	47.500	2.484	0.025	0.640
34	1.06616	78.100	49.984	47.500	2.484	0.025	0.640
35	1.06817	78.100	49.984	47.500	2.484	0.025	0.640
36	1.07018	78.100	49.984	47.500	2.484	0.025	0.640
37	1.07220	78.100	49.984	47.500	2.484	0.025	0.640
38	1.07422	78.100	49.984	47.500	2.484	0.025	0.640
39	1.07624	78.100	49.984	47.500	2.484	0.025	0.640
40	1.07827	78.100	49.984	47.500	2.484	0.025	0.640
41	1.08030	78.100	49.984	47.500	2.484	0.025	0.640
42	1.08234	78.100	49.984	47.500	2.484	0.025	0.640
43	1.08438	78.100	49.984	47.500	2.484	0.025	0.640
44	1.08642	78.100	49.984	47.500	2.484	0.025	0.640
45	1.08847	78.100	49.984	47.500	2.484	0.025	0.640
46	1.09052	78.100	49.984	47.500	2.484	0.025	0.640
47	1.09258	78.100	49.984	47.500	2.484	0.025	0.640
48	1.09463	78.100	49.984	47.500	2.484	0.025	0.640
49	1.09670	78.100	49.984	47.500	2.484	0.025	0.640
50	1.09876	78.100	49.984	47.500	2.484	0.025	0.640
51	1.10083	78.100	49.984	47.500	2.484	0.025	0.640
52	1.10291	78.100	49.984	47.500	2.484	0.025	0.640
53	1.10499	78.100	49.984	47.500	2.484	0.025	0.640
54	1.10707	78.100	49.984	47.500	2.484	0.025	0.640
55	1.10915	78.100	49.984	47.500	2.484	0.025	0.640
56	1.11124	78.100	49.984	47.500	2.484	0.025	0.640
57	1.11334	78.100	49.984	47.500	2.484	0.025	0.640
58	1.11544	78.100	49.984	47.500	2.484	0.025	0.640
59	1.11754	78.100	49.984	47.500	2.484	0.025	0.640
60	1.11964	78.100	49.984	47.500	2.484	0.025	0.640
61	1.12175	78.100	49.984	47.500	2.484	0.025	0.640
62	1.12387	78.100	49.984	47.500	2.484	0.025	0.640
63	1.12599	78.100	49.984	47.500	2.484	0.025	0.640
64	1.12811	78.100	49.984	47.500	2.484	0.025	0.640
65	1.13023	78.100	49.984	47.500	2.484	0.025	0.640
66	1.13236	78.100	49.984	47.500	2.484	0.025	0.640
67	1.13450	78.100	49.984	47.500	2.484	0.025	0.640
68	1.13663	78.100	49.984	47.500	2.484	0.025	0.640
69	1.13878	78.100	49.984	47.500	2.484	0.025	0.640
70	1.14092	78.100	49.984	47.500	2.484	0.025	0.640
71	1.14307	78.100	49.984	47.500	2.484	0.025	0.640
72	1.14523	78.100	49.984	47.500	2.484	0.025	0.640
73	1.14738	78.100	49.984	47.500	2.484	0.025	0.640
74	1.14955	78.100	49.984	47.500	2.484	0.025	0.640
75	1.15171	78.100	49.984	47.500	2.484	0.025	0.640
76	1.15388	78.100	49.984	47.500	2.484	0.025	0.640
77	1.15606	78.100	49.984	47.500	2.484	0.025	0.640
78	1.15823	78.100	49.984	47.500	2.484	0.025	0.640

GLOSSARY

Allowable cut - "Prescribed yield" of the Indian terminology. The prescribed annual or periodic cut which if practiced will result in formation of a normal forest.

Average output-capital ratio - The ratio between the total output produced and the total capital used (with appropriate amount of labour) to produce it; both measured in the same units.

Building cycles - A relatively longer cycle (cf. Business cycle) of business in the building industry. See also "Business cycles".

Business cycles - A cycle of general business activity. The tendency of business activity to fluctuate regularly between boom and depression. The term refers to "short" cycles of such fluctuations usually varying from one to ten years.

Capital - Goods which are produced not for direct use by consumers, but as aids in the production of things which eventually will be used by the consumers.

Capital-intensity - The degree to which a unit of labour is combined with capital for producing final goods and services. Capital-intensity is higher in a production process where one unit of labour is combined with more capital than in the other process.

Capital-intensive - A production process which has relatively higher capital intensity than the other processes.

Consumption function - A schedule showing the amounts that will be spent for consumer goods and services at different income levels.

Conversion period - The span of time during which an abnormal forest is converted or planned to be converted into a normal forest.

Decision theory - A branch of knowledge developed to deal with problems of choice or decision making under risk and under uncertainty, where the probability figures required for the utility calculus are not available.

Depreciation - Physical wearing out of the capital.

Dynamic consumption function - A consumption function that takes into account the interaction of various changes occurring in variables affecting the consumption as time goes by.

External economies - When output of an individual producer depends not only on his inputs but also on the activities of other firms, external economies or diseconomies are said to occur.

Gross national product - Total monetary or real value of output of all production units in the economy during one income period.

Investment - The act or process of construction or acquisition of a capital good.

Labour-saving - Refers to a production process, or innovation, which makes it possible to use less labour in production.

Liquidity preference - The extent to which investors prefer to keep their assets liquid, i.e., in the form of money or gold rather than in some form of investment.

Long-run - A situation where nothing is assumed as fixed. May also refer to long-run in the chronological sense.

Lumber - "Sawn timber" of Indian terminology.

Marginal - Refers to "a little more" or "a little less" than what is already under discussion. Can be interpreted as "additional".

Marginal output-capital ratio - The output-capital ratio of the additional amount of capital as contrasted with the average output-capital ratio of the already existing stock of capital.

Marginal propensity to consume - The proportion of "marginal" change in income that is consumed.

Marginal propensity to save - The proportion of "marginal" change in income that is saved.

Marginal rate of substitution - The ratio between the marginal quantities of two goods between which a consumer is indifferent.

Marginal rate of transformation - The ratio between the marginal quantities of two goods which can be produced by the same amount of inputs.

Multiplier - The factor by which any autonomous change in spending must be multiplied to get the total change in income over the course of time.

Net national product - The gross national product after deducting from it the depreciation for the income period concerned.

Normal forest - A forest which for a given site and given objects of management, is ideally constituted as regards growing stock, age class distribution and increment and from which the annual or periodic removal of produce equal to the increment can be continued indefinitely without endangering future yields.

Output-capital ratio - The output produced by a unit of capital when used with appropriate amount of capital.

Pareto-efficiency - If situation A produces more of each product than situation B, then A is more efficient than B in the Paretian sense. It will not be so if the quantity of even one product is slightly less than in B, irrespective of the fact that more of all other goods may be produced at A.

Present worth - The value of future happenings as seen today.

Propensity to consume, marginal - See "Marginal propensity to consume".

Propensity to save, marginal - See "Marginal propensity to save".

Public good externalities - Refers to the situation where consumption of a service by one individual does not reduce the amount available to the others. For example watching of TV by A does not affect the watching of TV by B. Producers of TV programmes have difficulty determining, how much of each programme to give to the consumers.

Per capita income - Used in the sense of per capita gross national product in this thesis.

Saving - The act of non-consumption.

Shadow prices - Accounting prices as different from the market prices.

Short-run - A situation where one or more restrictions are placed on the outcome. May also be used in the chronological sense.

Social time preference rate - The rate at which society as a whole discounts the future.

State preference function - The schedule of preferences of a society as a whole, expressed through its government, in contrast to the sum of preferences of individuals in it.

Subsistence level - A level of living which is the barest minimum for survival either in the physical sense or normally accepted social sense.

Sustained yield - Continuous production of more or less equal or increasing annual or periodic yields of forest products from a given area of land.

Take-off - Refers to the stage in the process of economic development after which continued increases in per capita income are ensured.

Time preference - A theory of interest based on the idea that some people prefer to have money to spend at present and are prepared to pay for this privilege, while others if paid interest for doing so, are prepared to postpone their spending to a future date.

Trend - Direction of change in the cyclical fluctuations in the business world. Business or building cycles fluctuate around the trend.

User cost - The present worth of future profits foregone due to a certain action in the present.

Utility - The satisfaction obtained by a consumer.

DEFINITIONS OF TERMS USED IN EQUATIONS

Page	Equation No.	Equation	Definitions
31	(1)	$Y=f(K,L,N)$	Y=Output in the economy
			K=Amount of the economy's capital stock employed
			L=Amount of the economy's labour supply employed
			N=Rate of use of land or natural resources
35	(2)	$Y=f(K,L,N,S,)$	Y,K,L, and N as in Equation 1
			S=Level of technology employed in the economy.
50	(3)	$Y=F(K,L)$	Y,K and L are the same as in Equation 1
51	(4)	$\dot{K}=sY$	$\dot{K}$=Rate of change in capital stock with respect to time.
			s=Proportion of total output saved in the economy
			Y=Output of the economy
51	(5)	$L=L_oe^{nt}$	L=Labour force employed in the economy after passage of t units of time since the reckoning of time
			L_o=Labour force employed at the reckoning of time.
			n=Rate of growth of employed labour force.

Page	Equation No.	Equation	Definitions
76	(6)	$\frac{d^2s}{dt^2} = f$	t=Time s=Change in level of per capita consumption as defined on p. 74 and 75. f=The constant rate at which the rate of change of the level of per capita consumption changes.
76	(7)	$\frac{ds}{dt} = u+ft$	t,s and f as in Equation 6. u=The initial "speed" with which per capita consumption level starts moving towards fully adjusted state.
77	(8)	$T=-\frac{u}{f}$	f and u as in Equations 6 and 7. T=Time taken for reaching a per capita consumption level that is fully adjusted to a new per capita income level.
77	(9)	$u= \sqrt{-2f(\mu Y_1-C_o)}$	f,u as in Equations 6 and 7. μ=Proportion of per capita income that is consumed when consumption is fully adjusted to any income level. C_o=Per capita consumption in time period 0. Y_1=Per capita income in time period 1.
78	(10)	$C_n-C_{n-1}=\sqrt{2f(\mu Y_n-C_{n-1})}\ -\frac{1}{2}f$	μ and f as in Equations 9 and 6. C_{n-1} and C_n=Per capita consumption in time period (n-1) and time period n respectively. Y_{n-1} and Y_n=Per capita income in time period (n-1) and time period n respectively.

Page	Equation No.	Equation	Definitions
78	(11)	$\frac{A}{A-s} = e^{gt}$	s and t are as in Equation 6. A=Difference between the fully adjusted per capita consumption and consumption that is not adjusted at all to an income level. g=A constant which is the ratio between the "speed" of adjustment of per capita consumption level and the difference between the fully adjusted and existing levels.
79	(12)	$C_n = \frac{\mu Y_n (e^g - 1) + C_{n-1}}{e^g}$	C_n, C_{n-1} and Y_n as in Equation 10. μ as in Equation 9. g as in Equation 11
83	(13)	$\pi = \begin{cases} p - \frac{p(Y-\varepsilon)^2}{(\gamma-\varepsilon)^2} \text{ for } 0 \leqq Y \leqq \varepsilon \\ c + \frac{(p-e)(r-\varepsilon)^2}{(\gamma-\varepsilon)^2 - (\gamma-\varepsilon)^2} \text{ for } \varepsilon \leqq Y \end{cases}$	π=Rate of population growth per annum. Y=per capita income. p=Highest possible rate of population growth. ε=Per capita income at which p, highest possible rate of population growth, occurs. γ=Per capita income at which there is no population growth. c=Figure to which the rate of population growth approaches

Page	Equation No.	Equation	Definitions
			when per capita incomes grow beyond ε.
			r=Per capita income at which rate of population growth is the mean of p and c.
84	(14)	$\pi = \begin{cases} 3.30 - \dfrac{(Y-150)^2}{3214.85} & \text{for } 0 \leqq Y \leqq 150 \\ 1.00 - \dfrac{23000}{(Y-150)^2-10000} & \text{for } 150 \leqq Y \end{cases}$	
			π and Y as in Equation 13.
90	(15)	$y' = N_H \cdot e^{(g_H - i)t}$	y'=Value of the total output of an economy in time t discounted to time zero.
			N_H=Total output in time period zero if a technique with higher capital-intensity is chosen.
			g_H=Expected rate of growth of output if the technique with higher capital-intensity is chosen.
			i=Rate at which future is discounted.
90	(16)	$y' = N_L \cdot e^{(g_L - i)t}$	y' and i as in Equation 15.
			N_L=Total output in time period zero if a technique with lower capital-intensity is chosen.
			g_L=Expected rate of growth of output if the technique with lower capital-intensity is chosen.

Page	Equation No.	Equation	Definitions
98	(17)	$SS_1 = \sum_{I=0}^{\infty} F_I . P_I ./(1+i')^I$	SS_1=Worth in time period zero of all foreign investments in the economy. F_I=Per capita foreign investment in time period I. P_I=Population in time period I. i'=Rate of interest at which foreign loans have to be repaid.
99	(18)	$SS_2 = \sum_{I=0}^{T} Y_I . P_I /(1+i)^I - Y_o . P_o . \frac{\left[\frac{1+\pi_o}{1+i}\right]^{T+1} -1}{\left[\frac{1-\pi_o}{1+i}\right] -1}$	SS_2=Worth in time period zero of all increased per capita incomes from period zero to the take-off stage. T=Time taken to reach take-off stage from period zero. Y_I=Per capita income in time period I on the way to take-off. P_I=Population in time period I on way to take-off. i=Social rate of time preference. Y_o, P_o, π_o=Per capita income, population and rate of population growth in time period zero when economy is in stagnation.

Page	Equation No.	Equation	Definitions
106	(19)	$\frac{dc}{dt} = \sqrt{2f(\mu Y_t - C_t)} - ft$	C_t=Per capita consumption in time period t. Y_t=Per capita consumption in time period t. f and μ as in Equations 6 and 9 respectively.
106	(20)	$\frac{dK}{dt} = a[Y_{t-m}+F_{t-m}-C_{t-m}].P_{t-m}-\delta K_t$	K_t=Stock of capital in the economy in time period t. Y_{t-m}, F_{t-m}, C_{t-m} and P_{t-m}=Per capita income, per capita foreign investment, per capita consumption and population in time period (t-m). m=Period of gestation of the capital. δ=Rate of depreciation of capital. a=Factor with which investment must be multiplied to convert it into capital.
106	(21)	$\pi_t = f_1(Y_t)$	π_t and Y_t=Rate of population growth and per capita income in time period t.
106	(22)	$\pi_t = \frac{1}{P_t} \cdot \frac{dP}{dt}$	π_t=Rate of population growth in time period t. P_t=Population level in time period t.

Page	Equation No.	Equation	Definitions
107	(23)	$\beta_t = \frac{Y_t . P_t}{K_t}$	β_t=Average output-capital ratio in time period t. P_t, Y_t as in Equations 22 and 21. K_t as in Equation 20.
107	(24)	$\beta_t = \frac{a . P_{t-m}[Y_{t-m}+F_{t-m}-C_{t-m}] . \alpha_{t-m}}{\delta . K_t}$	α_{t-m}=Marginal output-capital ratio in time period (t-m). β_t as in Equation 23. K_t, Y_{t-m}, F_{t-m}, C_{t-m}, P_{t-m}, m, and a as in Equation 20.
203	(25)	U.C.=F(x,y)	U.C.=User cost. x=Present worth of investments. y=Rate of exploitation of forests.
205	(26)	Total cost=$f_1(x,y)$	x and y as in Equation 25.
207	(27)	Total revenue=$f_2(y)$	y as in Equation 25.
207	(28)	$z=f_2(y)-f_1(x,y)$	z=Present profit. x and y as in Equation 25.
208	(29)	$z-U.C.=f_2(y)-f_1(x,y)-F(x,y)$	All terms as in Equations 25 and 28.
208	(30)	$\frac{\partial f_1}{\partial x} + \frac{\partial F}{\partial x} = 0$	f_1=Total cost (Equation 26) F=User cost (Equation 25) x as in Equation 25.
208	(31)	$\frac{\partial f_2}{\partial y} - \frac{\partial f_1}{\partial y} - \frac{\partial F}{\partial y} = 0$	f_2=Total revenue (Equation 27). f_1 and F as in Equation 30. y as in Equation 25.