REASSESSMENT OF THE INDIAN
HEAVY INDUSTRIALIZATION STRATEGY

A REASSESSMENT OF THE INDIAN HEAVY INDUSTRIALIZATION STRATEGY

by

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ABSTRACT

The industrial strategy which emphasizes heavy industries in the Indian economy has been the subject of a major controversy. This study reassesses the implications of the heavy industries strategy. The study has been conducted within the framework of a five-year plan using a dynamic multisectoral linear programming model.

Several experiments are performed with the model under varied assumptions and restrictions. The results of the various experiments are then compared with the results of the bench mark case and among themselves. The capacity constraint is introduced in the model in order to ensure non-transferability of capital between sectors and periods and to prevent consumption of capital. The land constraint is introduced in order to evaluate the effect of the limited availability of land on economic growth. To assess the impact of the use of modern techniques in agriculture on economic growth, in some experiments of the model Japanese agricultural input/output and capital/output coefficients are used. In order to examine the issues related to the choices between present and future consumption, three different objective functions are used in this study.

The main effect of the capacity constraint is to strengthen the equipment sector. The constraint raises the

deliveries made by the equipment sector for the purpose of investment. The increased investment activity is provided for by increase in domestic production of equipment goods. The burden of the growth in the equipment sector caused by the capacity constraint is generally borne by the services sector. This is especially the case when the agricultural sector uses traditional technology.

The results of our study show that it is mainly the capital goods sectors which benefit from the assumption of limited land availability. Our findings thus provide a justification for the heavy industries strategy in the Indian case where the assumption of limited land availability is very reasonable.

The application of the Japanese agricultural technology in Indian agriculture raises agricultural production, however, its effect on consumption and on other sectors of the economy may not be favourable if the technological transformation is limited to the agricultural sector alone.

The main effect of inclusion of the consumption stream of the post-plan period, or of inclusion of investment, in the objective function is to strengthen the equipment sector. The strengthening of the equipment sector comes mainly at the cost of the agricultural sector.

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The responsibility for any errors or omissions in this study, is fully mine.

TABLE OF CONTENTS

CHAPTERS PAGE

LIST OF TABLES

CHAPTER 1

STRATEGY OF DEVELOPMENT

1.1 INTRODUCTION

India in 1947 emerged out of an era of colonialism, spanning a period of nearly 200 years, during which Britain had systematically deindustrialized India such that, at the time of independence, the Indian economy was primarily an agricultural economy producing and exporting agricultural commodities and raw materials.[1] At this time the economy exemplified all the major symptoms of underdevelopment: low per capita income and consumption, low productivity of labour, and low levels of savings and capital formation. If significant improvements in the living standard of the Indian people were to be achieved, even in the life-span of a generation or two, the pace of economic development would have to be substantially higher than that which was experienced during the first half of the twentieth century.[2] Successful fulfilment of this historical task would have necessarily entailed conscious efforts towards rapid industrialization.

At the time of independence, Indian capitalism was too weak to make major efforts towards large-scale industrialization and greater national economic independence by means of private investment alone. The private industrial sector not only lacked the means but also the will to invest in sectors which required long gestation periods. Only the state had the means to undertake large-scale investment. In 1951, the Government of India initiated a process of planned economic development of the country. The broad objectives of this planning were self-sustained economic growth and progress towards equality and social justice.

The goal of self-sustained economic growth led to an emphasis on investment as a strategic variable. India's Second Five Year Plan was very explicit in calling for a marked shift in favour of investment in capital goods industries. The theoretical basis of this plan was provided by the two-sector growth model developed by Professor P. C. Mahalanobis.

The Mahalanobis formulation identified capital as the scarce factor. The low level of the capital stock of the economy was deemed to be the primary reason why the economy could not produce enough goods and services. In order to increase the economy's output capacity, it was necessary to increase the stock of capital goods in the economy. It was assumed then that the economy's import capacity was very limited. If the economy could not afford to import capital goods in large quantities, then, the major part of them would have to be produced domestically. And given the vast size of the economy, the increasing demand for consumer goods would also have to be met by domestic production. The need for an increase in the tempo of investment and for large-scale import-substitution were clear implications of this reasoning. Mahalanobis' fundamental contribution however lay in his suggestion that a larger proportion of the investment should go to the capital goods sector, hereafter referred to as the Mahalanobis strategy.

This strategy distinguished between two kinds of capital goods: one that produces consumer goods; and a second that produces other capital goods. In other words, investment made in the consumer goods sector was distinguished from investment made in the capital goods sector. His two-sector growth model showed that the effect of a higher proportion of investment going to the capital goods sector would always be an increase in the asymptotic growth rates of both consumption and output (see Chapter 3 for a detailed description of the model).

By maximizing the share of investment going to the capital goods sector, or to the production of "machine producing machines", the economy could achieve high growth rates in the future. In the sense that investments going to the consumer goods sector slow the capital accumulation process, they were seen as a leakage from the system.

Minimization of that leakage would mean a shortage of consumer goods in the short-run. The strategy of emphasis on the capital goods sector (also referred to as heavy industries) thus implies that some sacrifice of present consumption was inevitable if high future consumption levels were to be achieved.

This approach was later extended in Mahalanobis' four-sector model which served as the basis for the Draft Plan formulation of the Second Five Year Plan. (See Chapter 3 for more details).

The basic policy of emphasis on heavy industries continued through successive plans, although the emphasis was somewhat moderated in the later plans.[3]

Evaluation of the performance of the Indian economy during the last three decades shows that the stated objectives of the plans have been attained only partially. On the positive side it should be noted that the economy, starting from a small base, built up a substantial and highly diversified modern industrial sector. India today can boast of a substantive heavy industries sector that is the envy of even some developed countries. The growth in production of intermediate goods was also impressive. A result of this growth was that the economy gained self-sufficiency in basic consumer goods as well as in the manufacture of plant and machinery needed by some of its major industries.

On the other hand, there is evidence that the performance of the Indian economy since the mid-sixties has been unsatisfactory in comparison with the overall economic performance during the first 15 years of planning.[4] The growth of industrial production suffered a setback during the 1965-67 recession. Production of consumer non-durables, which include most commodities of mass consumption, has only increased marginally since then. The growth of production of capital goods also has been relatively slow since that time. The low level of industrial production went hand in hand with a low level of utilization of existing capacity in a number of key industries. Growth has been much slower in agriculture than in the industrial sector. This imbalance has also contributed to the slowing down in the growth of production of some consumer goods.

In any case, in spite of rapid growth, some of India's economic problems remain as critical as ever. The balance of payments situation remains critical, with a tendency of imports to run ahead of exports.[5] The employment in organized industry has increased much less rapidly than output. Very little, if any, success has been achieved in solving the acute and potentially explosive problems of poverty, unemployment, and a highly skewed income distribution.

The strategy of emphasis on heavy industries has been held responsible by many economists for the alleged lack of success in resolving India's economic problems, some of which we have noted briefly just above. The pattern of evolution of the Indian economy during the last three decades, undoubtedly has been affected by the choice of this particular strategy. At this point, it should however be noted that it is not very clear whether these problems are due to this strategy itself, or due to the half-hearted implementation of this strategy. The blame for improper implementation can be placed on administrative shortcomings, or, more seriously, it can be traced to "the Planners" themselves who have been wavering in their faith in this strategy. Some economists on the other hand, have focused their criticism on the economy's continued reliance on foreign capital and technology.

The major criticisms of the heavy industry strategy basically fall under the following three categories.

First, this strategy does not accord adequate importance to the agricultural and/or consumer goods sector. Eradication of poverty in India will entail substantial growth in these sectors. Also from the point of view of employment creation this strategy is deficient because it uses capital-intensive methods.

Second, the import-substitution policies implied by this strategy have been very costly. The economy would have benefitted more by export-oriented policies.

Thirdly, this strategy is not suitable for the "mixed-economies" of developing countries. These economies cannot generate the required savings, and the net result is inflation and balance of payment problems.

This study reconsiders the evidence used to refute the industrial strategy of emphasis on heavy industries. Some of the criticisms of this strategy have their source in objectives different from the one implicit in its formulation. If the economy's output capacity is to be raised through capital formation, then some sacrifice in terms of present consumption would be necessary. If that premise is accepted then the economy's performance should not be judged simply in terms of its consumption level alone. The evaluating criteria must consider the enhancement in the economy's output capacity resulting from the process of industrialization as equally important as that of increasing consumption.

Other criticisms of the heavy industry strategy are based on assumptions which are not tenable, in our opinion, in Indian conditions. The growth of agricultural production is constrained by the limited availability of natural resources, especially of land. A serious assessment of this strategy must therefore take the land constraint into consideration.

Here we are not asserting that it is not possible to achieve an increase in the growth of agricultural production. With the use of modern agricultural technology, it could plausibly be accomplished. The new technology however definitely requires more use of the economy's limited resources by the agricultural sector. Does this put strain on the process of capital formation in other sectors of the economy?

We suspect that inadequate attention to resource limitations or to the implicit trade-offs between present and future consumption streams has caused many to conclude that the industrial strategy of emphasis on heavy industries was an historical error. The purpose of our study is to reconsider the debate about the role of heavy industries in Indian industrial development in light of the suggestions we have made just above.

The subject of our study was motivated in part because some of the models built in the context of Indian planning were also found deficient in these regards. The objective function of these models frequently sought maximization of consumption in the short-run and virtually no explicit attention was given to future consumption or to capital formation in the economy. These models were thus not suitable for studying "trade-offs" between present and future consumption. In some cases, treatment of capital as "putty" made transfer of capital between sectors or between periods unrealistically feasible. Erosion of the economy's capital base could take place in these models because once created capacities were not checked from falling.

These models either totally neglected or paid very little attention to the agricultural sector's growth limits. Similarly, use of modern technology in agriculture was not analyzed in earnest. In this thesis, the answers to the questions raised above are sought within the framework of a dynamic, multisectoral planning model defined over 5 sectors and 5 periods. Our model aims at providing a proper framework within which the implications of an industrial policy with specific emphasis on heavy industries may be comprehended. It attempts to incorporate the above-mentioned aspects which have been hitherto ignored in much of the theoretical and empirical research related to this subject.

The remaining sections of this chapter take up in detail the discussion of Indian industrial policy and its historical record which we touched upon earlier. In the discussion that follows we have, at times, also drawn on experiences of some other developing countries when it was deemed relevant. The Plan of our study is presented at the end of this chapter.

1.2 THE ROLE OF AGRICULTURE

The role of agriculture in economic development has been one major source of controversy. The agricultural sector in India employs about 75 per cent of the labour force and accounts for about 40 per cent of national income. Even though agriculture plays such a significant role in the economy, it is argued that it has not been given a proper place in development strategy.

The growth in agriculture has been rather slow. To what extent has this been the result of the relative lack of emphasis on the agriculture sector in official plans? Does a slow rate of growth of agriculture act as a retarding factor on the pace of growth of the economy? These and other related questions have been vehemently debated since the early days of Indian planning.[6] To quote Minhas

> The most conspicuous failure which has proved extremely harmful, was the failure to develop the agriculture sector to the requisite degree. The operative strategy of development failed to appreciate the crucial role of agriculture. From plan to plan we had to increase our dependence on foreign supplies of food and agricultural raw materials....Rather than growing at home adequate amounts of food, so necessary for securing a stable base for sustained industrial development, we took the easy way out and accepted large amounts of food aid. Our perception of the role of agriculture in our development strategy continues to be just as defective today as it was during the Second and Third Plans.[7]

Bauer, in his criticism of the Second Plan in 1961, warned of the harmful consequences of neglecting agriculture.

Progress in agriculture was essential if there was to be a significant increase in general living standards. He wrote

> It is highly probable, both on general grounds and from Indian experience of the last half-century, that there can be no sustained improvement in general living standards without appreciable advance in the huge agricultural sector, which in its present backwardness is a drag on progress. A substantial increase in agricultural production is necessary to provide an assured surplus for a large industrial population, a market for the output of industry, and an appreciable contribution to government revenues (much larger than at present) for the financing of essential services.
>
> Without (these) advances in agriculture, much of the industrial capacity established under the plan is likely to be liability rather than an asset, to be subsidized by the rest of the economy. Its presence is likely to depress rather than improve general living standards. It is likely to represent an uneconomic use of scarce resources, and therefore aggravate rather than relieve unemployment and also the management of balance of payments problems.[8]

Lipton has argued that agricultural output growth was meagre because a very low share of total resources had been allocated to agriculture. Marginal capital/output ratios are substantially lower in agriculture than elsewhere, so agriculture's share should have been higher relative to industry's. Even though the planners insist on the importance of agriculture and have set high targets, they have provided insufficient input to attain them. There is a real paradox here: high targets, high yields for extra outlay, yet low planned outlay. The explanation of this paradox lies in the "urban bias" of Indian planning. Agriculture's persistently low share of development resources must be traced to urban bias in Indian policy. Rewards and status are higher in urban areas and policies are made under urban pressures.[9] The vast mass of small farmers and landless labourers, being unorganized and illiterate, have no say in decision-making.

The Second Plan contained a clear emphasis on heavy industries. But the Third Plan tried to reverse the Second Plan's emphasis on industries. Achieving self-sufficiency in foodgrains and increasing agricultural production to meet the requirements of industry and exports was one of the principal aims of the Third Plan. The Fourth Plan featured a marked shift of emphasis in favour of agriculture, power, irrigation and rural agro-industries. But the increase in agricultural production was not very high. If the marginal capital/output ratios were relatively low in agriculture, one would have expected better results.

The agriculture vs. industry debate is far from over. Development strategy for low income countries, suggested by the World Bank's reports on development, lays tremendous emphasis on agriculture and rural productivity. It is recommended that "in low income countries, with their large numbers of rural poor and heavy dependence on agriculture, the main emphasis must be placed on raising productivity in the rural economy, particularly that of small farms."

Besides, programmes such as dairy, poultry, and fisheries, which are particularly important in raising the incomes of small and marginal farmers and the landless, should also be started. The rural sector's importance is also stressed from the point of view of job creation. "Even on optimistic assumptions about the growth of agriculture, unemployment will be a growing problem in low-income Asia, calling for greater emphasis on creating non-farm jobs in rural areas and systematic expansion of large-scale public works programmes."[10]

The middle income countries are advised to promote agricultural development and implement industrial and trade policies that promote a rapid expansion of production and employment in industry. The more advanced, semi-industrialized countries can gradually shift into more capital intensive and skill-intensive lines of production.[11]

The development strategy proposed by the Janata Government's Draft Five Year Plan, 1978-83, was very similar to that suggested by the World Bank, as can be judged from the following excerpt:

> The main thrust of the planning strategy would be to expand the area under irrigation as rapidly as may be possible, and to develop cropping patterns and agricultural practices which optimize the use of land and water resources.....The New Plan would provide for massive investments in expanding the rural infrastructure....After agriculture, household and small-scale industries producing consumer goods for mass consumption

> hold out the greatest potential for employment. This is a sector which has received inadequate attention in earlier plans.[12]

The World Bank's "linear-type" conception of development can be summarized as follows: start from agriculture and light industries and slowly move on to developing intermediate and heavy industries as industrial capability increases. Not all international organizations agree, however, with the World Bank's approach. UNIDO documents advocate an "integrated development approach" emphasizing simultaneously both rapid industrialization and alleviation of poverty through rural development. Accordingly, heavy industries such as steel, metallurgical and petrochemical industries, are considered as basic to industrialization. Technological dependence cannot be overcome without expanding heavy industries and industries which use advanced techniques. It is suggested "that developing countries should devote particular attention to the development of basic industries--thereby consolidating their economic independence, while at the same time assuring an effective form of import substitution and a greater share of world trade."[13] Small and medium-scale and rural industries should also be supported to meet the basic needs of the population. Industrialization strategy should therefore take into account both the competitive and complementary roles of large-scale and small-scale industries. Rural industrial development programmes need to be integrated horizontally with national rural development programmes and vertically with national industrial development programmes.

1.3 THE "BASIC-NEEDS" APPROACH

There is growing support in the recent development economics literature for the "basic-needs" approach which concentrates mainly on the problems of poverty and distribution in developing countries. The debate about this approach resembles closely the earlier agriculture vs. industry debate. Some arguments of the exponents of this approach are presented at length below even at the cost of some repetition.

The past quarter century has witnessed some economic growth in developing countries, and in some cases, the growth has been remarkable. But the benefits of growth have not been shared equally by all people. In countries which have been unable to achieve high growth, a vast number of people, sometimes even the majority, still live at the very level of subsistence, without even such basic necessities of life as adequate food and shelter.[14] Even in the countries which had rapid industrial growth, e.g., Brazil, Mexico, and South Korea, very large sections of the population remain poor, if not destitute. In reference to Asian countries, Griffin writes

> ...most disturbing of all, is the evidence that even in countries where average incomes have risen, the standard of living of the poorest groups has fallen. A considerable amount of research has been done in Asia and hence the picture there is particularly clear. In the rural areas the proportion of the population below the "poverty line" either has been rising (as in Philippines) or has remained roughly constant (as in Pakistan). Even in regions which have enjoyed exceptionally rapid growth--as in Punjab/Haryana, India--there has been no perceptible decline in the incidence of rural poverty....In other parts of India the situation was much worse.[15]

Until now, the planners' main concern has generally been to ensure a steady rise in GNP with little or no attention being paid to equitable distribution of the income so generated. Development strategies have attempted to solve the problems of mass poverty and surplus population by giving priority to economic growth in the hope that the very process that promoted growth would take care of the distributional aspect as well; much reliance has been placed upon the so-called "trickle-down effect". Empirical evidence from a number of developing countries shows, to the contrary, that growth has generally led to concentration of incomes in the hands of a small segment of the population. Clearly, the assumption of growth automatically leading to a just social order is not tenable. Economic growth is a necessary condition for the removal of poverty, but not sufficient. Without growth there is not much to redistribute except poverty. On the other hand, average national growth rates would have to be much higher than achieved until now if the needs of the poorest groups are to be met through trickle-down effects only.

The views of some Indian economists[16] who emphasize the "wage-goods"[17] constraints as one major cause responsible for the lack of progress in eradication of poverty in India are very similar to those stated just above. They hold that an increase in the real consumption of the poor in India requires a sustained increase in the production of wage-goods. Indian economic policy failed precisely in that respect as it did not give adequate attention to the allocation of resources to increase the production of wage-goods.

Choudhuri for instance asserts that slow growth in the supply of wage-goods also explains why the Mahalanobis strategy did not succeed. For a heavy industry strategy to be successful, it was essential to maintain a high rate of growth of overall demand in the economy. The degree of utilization of capacity and the rate of profit in capital-intensive heavy industries is dependent on overall demand in the economy. However, it was not possible to maintain a high rate of growth of overall demand in the economy without a concomitant increase in the demand and supply of wage-goods.[18]

Mathur, on the other hand, argues that the major shortcoming of Indian economic strategy lies not in its emphasis on heavy industries but rather in the lack of it.

He thinks that there has been too much leakage of heavy industry goods to the consumption goods sector. This has resulted in an unduly high degree of mechanization in the consumption goods sector which seems to be reproducing approximately the capital structure as found in rather advanced countries.

He criticizes those economists who argue that heavy industry should provide the mechanical equipment for the production of consumption goods for the present generation. This policy will ultimately result in production of consumption goods for urban and rural upper classes. He suggests that the heavy industry goods which presently "leak" to the consumption goods sector should be ploughed back into the heavy industry sector. The consumption goods sector should use techniques with a low content of heavy industry goods. This will result in a low degree of mechanization and generate larger employment. The income distribution will be less unequal in the consumption-goods sector at the source of production itself. It will be anti-inflationary in character, as it leads to a larger supply of the necessities of consumption.

> The growth potential of the economy instead of being dwarfed is increased through the rapid growth of high-order investments which is made possible only with this strategy of low leakage of its products towards the consumption sector. It thus holds the balance between present and future consumption.[19]

1.4 "APPROPRIATE TECHNOLOGY" FOR A LABOUR-SURPLUS ECONOMY

The Mahalanobis strategy has also been reproved for promotion of capital-intensive technologies in the labour-surplus Indian economy. As capital-intensive technologies are necessary in the heavy industry sector, this sector cannot be counted upon to provide jobs in large numbers. Without providing gainful jobs to millions of jobless, it is contended, poverty cannot be eradicated. Redistribution of income could plausibly be achieved through an efficient fiscal system. In practice, however, fiscal policies may not be relied on fully to produce desired distributional effects in most developing countries. Thus employment creation may be the only mechanism by which income can be redistributed.[20]

But it has been argued by some that more employment creation could have an adverse effect on production. The use of more labour when its marginal product is negative will result in an inefficient production process where more labour and capital produce less output. Many times it has been found that capital intensive methods (more up-to-date methods) resulted in a lower capital cost per unit of output due to superior technology. Thus, increasing employment by using labour intensive technology may reduce output and use more capital. The situation of conflict between output and employment could only be visualized if it is not possible to increase production and employment simultaneously.

The lack of appropriate technology to suit developing countries with abundant labour supplies is judged to be one of the major causes of the output-employment conflict. The complementarity between output and employment can be increased if research and development efforts are directed to making labour-intensive methods efficient as compared with capital-intensive methods. In many industries, it has been shown that more labour-intensive methods can use less capital per unit of output.[21]

While capital-intensive technologies are necessary in heavy industries, other light and rural industries should use labour-intensive technologies. The argument that labour-intensive technologies are necessarily inefficient is not always true. "In several sectors, particularly those designed to meet rural consumption and production needs, small-scale production using techniques significantly different and less capital-intensive than those in industrialized countries may prove fully effective, with the resulting products available at competitive international prices."[22] In these circumstances the adoption of labour-intensive technologies will also reduce the average capital/output ratio and ensure utilization of domestic equipment and resources to a greater extent.

1.5 USE OF MODERN TECHNOLOGY IN AGRICULTURE

Since the mid-sixties, there has been increasing use of modern technology in Indian agriculture, a phenomenon which is commonly described as the "green revolution." The new technology requires proper irrigation facilities, and involves use of "new" inputs such as hybrid-seeds, chemical fertilizers and machinery. It has potential to substantially increase agricultural output in a short period.

Agricultural output can be increased either by increasing the land area under cultivation or by raising land productivity. The first option does not provide much hope (in the case of India) as the proportion of cultivated area to total area is already high (about one-half of the total geographical area) and cannot be increased a great deal. Furthermore, without replacing traditional methods in agriculture, it is not possible to raise productivity significantly. This argument explains the attractiveness of land-augmenting modern technology (e.g., hybrid seeds and fertilizers) to a land scarce nation.

For several reasons (see Chapter 2) the spread of the "green revolution" in terms of area as well as crops has been rather limited. The "new type" of inputs needed for the "green revolution" are of industrial origin, either to be supplied by the domestic industrial sector or imported from outside. Thus, the "green revolution" puts a heavy demand on industrial goods which could, alternatively, be invested in the industrial sector itself. This is an interesting reversal of the situation where, as generally believed in theories of economic development, industrial development depends upon the surplus provided by the agricultural sector. Now it is agriculture that depends upon industry for agricultural inputs.

The new technology which is generally associated with increased use of machinery could, though not necessarily, reduce employment by displacing labour.[23] The adoption of this technology also has distributional implications, regional as well as inter-personal. As the new technology requires both an adequate and controllable supply of water, it is no surprise that the "green revolution" has spread easily in the well-irrigated regions such as Punjab and Haryana. At the inter-personal level, it has been argued that the gap between the rich and the poor peasants has widened as a result of the "green revolution." The rich farmers, because of their privileged social and economic position, have been able to channel an undue share of the available resources to their benefit.

Finally in this section, we discuss some issues related to the suitability of imported agricultural technology in Indian agriculture. The experience of other developing Asian countries is very similar in this respect, so the following discussion is carried in general terms to include these countries as well.

The new agricultural technologies being applied in Asian countries have been borrowed, to a large extent, from Western countries (Europe and North America). Though it is true that indigenous agricultural research in these countries has been very successful especially in the field of developing some new high-yield varieties of rice. In most Asian countries, including India, the problem of economic growth is sometimes posed as a problem of transfer of Western technologies. But the uncritical borrowing of technologies has had distorting effects on their economies. Some distortions in the agricultural sector have arisen mainly because non-transferable lessons from the European experience were mechanically imposed on the Asian environment.

Agriculture has a region-bound character because of its inherent dependence on soil and climate. Thus, agricultural technology, as compared to industrial technology, is far less transferable from one region to another. That explains why the imitative approach of Asian countries has not succeeded in solving their problems.

The European (and American) "models" of contemporary agricultural success cannot be mechanically adopted in the Asian context for several reasons. First, having their roots in temperate climates and land-surplus economies (as in the case of North America), they are not very relevant for tropical and sub-tropical climate zones and for land scarce agrarian economies. Secondly, unlike European countries, Asian countries are predominantly rice-growing. Thirdly, the European technology which is suited to the needs of large farms, is not suited to the predominance of small holdings. For all these reasons, the Japanese model of agricultural growth, with appropriate modifications, could have more relevance for developing, peasant-dominated Asian countries than do the models of Europe and America.[24]

1.6 IMPORT-SUBSTITUTION OR EXPORT PROMOTION

The import-substitution policies implied by the Mahalanobis strategy have been the target of much of the neo-classical criticism of this strategy. It is alleged that these policies have proved costly to the country. According to Patel, at any set of international prices facing the economy, the economy might well have gained by obtaining a given amount of heavy machinery at a smaller resource cost through trade rather than domestic production.[25]

Bhagwati and Chakravarti have argued that the Mahalanobis strategy was ill-founded because it unjustifiably presupposed constraints on domestic and foreign transformation, i.e., it assumed a closed economy and total non-shiftability of capital stock from the consumption goods sector to the investment goods sector. The prospects of Indian exports were never examined properly. According to them, "the Second Plan's examination of exports earnings through the Plan is so cursory that it is difficult to believe that the 'stagnant world demand for Indian exports' assumption, by virtue of which the shift to heavy industries was later sought to be justified, was seriously made: such a crucial assumption, if made, would surely have been examined more intensely."[26]

Bhagwati supports the view that an export-oriented strategy is superior to that of import-substitution for the country where industrialization has been initiated. He does admit, however, that "for primitive agricultural and extractive economies, it is admittedly true that the choice between export promotion and import substitution implies, in turn, a choice between specialization in primary products and industrialization."[27] In our view, this choice is not only faced by "primitive agricultural and extractive" economies, but by almost all developing countries. This was precisely the choice India faced at the time of independence; and even today, her choice can be phrased in more or less the same terms.

The historical experience of all major developed countries shows that all these countries followed import-substitution and protectionist policies in their early stages of industrialization. Even now, these countries resort to protectionist policies whenever they are perceived beneficial. Developing countries, especially the large ones, will have to have a long-run view of industrialization if they desire to achieve living standards for their people comparable to developed countries. It is not suggested here that this transformation will be easy. In fact, developing countries face far more obstacles--which may even prove insurmountable--than those that were faced by today's developed countries at comparable stages of their development. These questions, however, lie outside the purview of our inquiry. The question of comparative advantage should also be seen in similar perspective. Heavy investments in steel in India, for example, are justified because India has a long-run comparative advantage in steel.

The argument that India should have or should import capital goods is flawed in many respects. First, capital goods are required by almost all sectors of the economy. Given the vast size of the economy, import of capital goods will have to be on a large scale. By overestimating the demand for India's exports, this argument underestimates the problem of foreign exchange required to ensure a continuous flow of capital goods at such a scale. Second, the technology embodied in capital goods is normally suited to the market conditions and factor proportions of the producing country and thus may not be appropriate for India. Third, India will not be able to acquire industrial maturity without the first-hand experience of producing capital goods at home. And fourthly, too much dependence on imports for the supply of some inputs vital to the economy can prove dangerous.

The neo-classical criticism is based on standard assumptions of liberal international trade: there is a smooth transformation function for all tradeable goods; and though often not stated explicitly, developing countries such as India face no structural problems in transforming their domestic resources into foreign resources. The advocacy of export-oriented policies which can make use of short-run (comparative advantage) opportunities is in conformity with this view of the world.

The World Bank has been a very active proponent of export-promotion. The Bank's second report on development asserts that, despite recent protectionist tendencies and other difficulties in the international trade environment, there exist important export opportunities for countries that are willing to risk investment in export industries. The performance of countries which have pursued export oriented policies, says the report, has been better than those who followed "inward looking" policies:

> Almost all developing countries have, to varying degrees, followed import-substituting policies in their early stages of industrialization. While in

> many instances policies of tariff protection and import quotas have undoubtedly assisted the establishment of industrial activities, prolonged recourses to such measures has all too often hampered the continued expansion of industrial production and employment. By and large, countries that have shifted their industrial policies to reward exports with incentives comparable to those for domestic sales, have achieved faster growth in industrial production and employment than those whose policies have remained inward looking.[28]

Some countries, e.g., South Korea, Taiwan, Hong Kong and Singapore have successfully used export oriented policies and have registered sustained rates of growth over the past two decades. But it is widely realized that the demand for exports from "cheap-labour" economies by developed nations is limited. In today's circumstances of shrinking world markets due to stagnation in developed countries and their protectionist policies, an export-oriented development strategy hardly serves as a panacea for other developing countries.

Bhagwati and Desai contend that the policies followed by the Indian Government were protectionist, and an artificially high exchange rate for the rupee was maintained through excessive tariffs. In their joint study they show that much of Indian industry is subject to high degrees of "effective protection" (for the years 1961 and 1962, the protection levels are shown to be in the range of 80-100 per cent).[29]

It is assumed in their analysis that the international demand for Indian exportables is price elastic over the relevant range. The devaluation of the rupee in 1966 however provides evidence to the contrary. There was no significant increase in India's exports during the second half of the sixties.[30] In fact, devaluation led to a fall in the dollar value of exports.

1.7 THE SAVING CONSTRAINT

Can a heavy industry strategy be effectively applied in a developing country such as India? The answer to this question depends, in part, on the country's ability to raise the rate of saving in the economy, because this strategy requires substantial mobilization of resources for the purpose of investment in the capital goods sector, or away from consumption.

This strategy has been successfully applied in the Soviet Union in the past for setting up heavy industries in that country. But a mixed-economy system such as that of India is very different from the Soviet socialist system. In a socialist system there is no (significant) place for the private sector. Central planning authorities in these countries can directly allocate investment between different sectors in proportions which conform to the strategy of development. But in India, there is a large area of privately-owned economic activities covering all sectors of the economy. The private sector plays an enormous role both in mobilization and disposition of resources. Direct planning is only possible for the public sector. In the case of the private sector, planning has to operate through persuasion, incentives and acceptance.[31]

The heavy industry strategy implicitly assumed that a given investment plan would finance itself by generating its own savings. Bhagwati and Chakravarti have pointed out that this assumption involved a fallacy--because capital goods were not themselves available for consumption purposes does not mean that a given level of output of these goods would automatically generate their own savings. Actually unless the ex-ante rate of savings is equal to the planned rate of investment, the outcome might simply generate excess demand and put pressure on the price level and the balance of payments.[32]

The problem of saving in India, in retrospect, has been less serious than expected (see Chapter 2). The rate of saving in the Indian economy has increased considerably during the last three decades. However, the concomitant increase in the overall capital/output ratio has partially offset the effects of increased saving on output increases.

1.8 FOREIGN AID AND CAPITAL

Some other economists[33] have focused their criticism on the Indian economy's continued reliance on foreign capital and technology. The issues raised by their criticism, although very important, are discussed below only briefly because as such they do not relate directly to the Mahalanobis strategy.

India has received foreign resources in the form of official aid as well as private foreign capital. In addition, she has acquired foreign technology, either embodied in capital goods or through the acquisition of licences or through foreign collaboration agreements.

Foreign aid has enabled the economy to maintain a higher level of investment than it would have otherwise achieved by financing the import content of such investment. But it does not appear to have had a significant effect on domestic savings or on public savings.[34] The actual amount of foreign aid has also been much smaller than the nominal amount. The various reasons accounting for this include: the difference between utilized and authorized aid, the difference between net and gross aid, the composition of aid as between grants and loans, the practice of "aid-tying," and the reduced purchasing power of aid due to inflation in donor countries.

It is argued that private foreign investment has had harmful effects on Indian development and that the costs of this investment to the economy have been relatively large in relation to the benefits. The average inflow of private foreign capital has been a very small percentage of net national product and therefore has had limited impact on the overall economy. However, in the industrial sector the relative importance of private foreign capital has been much larger. It is the strategic importance of the industrial sector that gives relevance to the issue of foreign capital in India.

The questions related to inappropriateness of imported technology have been discussed above. An industrialization strategy which is dependent on technology imports cannot but be exceedingly costly. The level and orientation of industrial production remain dependent on the commercial policies of transnational firms, who have a virtual monopoly over modern technology, and not on the potentialities and needs of the host countries.

The lengthy debate above reflects the complex and multi-dimensional nature of the problem of industrial development in India or in any large developing country. No single study can investigate this issue in its entirety and capture encompassingly all the relevant dimensions whether they are historical, socio-economic, political, international, etc.--and maintain a focus. For this reason our study focuses only on certain aspects of the process of industrialization. Our study has been conducted within the framework of five-year plans. The scope of the study therefore is limited by the sphere of influence of planning in India.

1.9 PLAN OF THE STUDY

A detailed look at the performance of the Indian economy during the last three decades and at the economic issues in the Indian context is necessary because they provide the background for assessment of the role of heavy industries in Indian industrial development. Chapter 2 of this thesis is therefore devoted in its entirety to a lengthy survey of the economy's performance and of the relevant issues.

This study has been conducted within the framework of a planning model. Many planning models have been built in the context of Indian planning, some of which are quite elaborate and sophisticated. A summary account of these planning models is also felt necessary before we describe our model. Chapter 3 of this thesis presents that summary.

In Chapter 4, the structure of our model is outlined. The data used in the model are also presented in this chapter. To ensure non-transferability of capital between sectors and periods, a capacity constraint is introduced in the model. A land constraint is entered in the model to capture the effects of the limited land availability on industrial development. To assess the impact of the use of modern techniques in agriculture on industrial development, the model allows substitution between the modern and traditional techniques in the production of agricultural goods. The input/output and capital/output coefficients related to the modern agricultural technology are taken from Japanese input/output and capital/output tables, since no separate coefficients for modern agriculture are available for India. Finally, in order to examine the issues related to the choices between present and future consumption, three different objective functions are used in this study.

Several experiments are performed with the model to reassess the implications of the heavy industries strategy. The results of the experiments are reported and analyzed in Chapters 5, 6, and 7. Comparisons of the results of different experiments with each other show how the various assumptions and restrictions affect the pattern of industrialization. In Chapter 5, the objective function is the present discounted value of consumption over the plan-period. In this chapter, the results are analyzed both in terms of the quantities and shadow prices emerging from the solutions of the linear programming models; the emphasis is, however, on the quantities. In Chapter 6 some simulations of the model are performed with two alternative objective functions. The role and behaviour of the shadow prices generated by the solutions are examined in Chapter 7.

Finally, in Chapter 8, the conclusions drawn from the study are reported.

FOOTNOTES

CHAPTER 1

1. For economic history of British rule in India, see R. C. Dutt (1906/56), R. P. Dutt (1947), Hobsbawm (1971), and Mukherjee (1958).

2. The economy grew at a rate of about one per cent per annum during the period 1900-1947. In per capita terms, there was no growth, see Chandra (1982).

3. For a short period of two years, the Janata Government in 1978 shifted the emphasis to agriculture and development of the rural and infrastructure sectors. The revised Sixth Plan by the Gandhi Government, while not altering the basic structure of the Janata Government's Plan, has reduced somewhat the allocations to agriculture and the rural sectors. See Draft Five Year Plan 1978-83, Planning Commission, 1978.

4. Shetty (1978), p. 14.

5. In the late seventies, the foreign exchange problem temporarily eased thanks to the foreign currency remittance by Indians abroad.

6. See Bauer (1961), Shenoy (1963), and Rudra (1967).

7. Minhas, B. S. Whither Indian Planning, 1974. p. 4, quoted in Das Gupta and Sengupta (1978), p. 374.

8. Bauer (1961), pp. 56-57.

9. Lipton, M. "Strategy for Agriculture: Urban Bias and Rural Planning," in Streeten and Lipton (1978), pp. 145-146. Also see Mellor (1976), p. 105.

10. World Bank (1978), p. 65.

11. World Bank (1979), p. 95.

12. Draft Five Year Plan 1978-83, Planning Commission, 1978, p. 4.

13. Secretariat of UNIDO (1979), p. 3.

14. The magnitude of the problem is assessed by the World Bank in the following terms: "About 800 million people still live in absolute poverty. There are people living at the very margin of existence with inadequate food, shelter, education and health care. For many of them, there has been little improvement in the standard of living and for some there may have been a deterioration." World Bank (1978), p. 1.

15. Griffin (1980), published in World Development, March, 1981, p. 222.

16. See Brahmanand and Vakil (1956), and Chaudhuri (1979).

17. The term wage-goods is used to mean the goods that are consumed by the poorer parts of the country's population.

18. Chaudhuri (1979), p. 252.

19. Mathur (1978), published in Indian Economic Journal, April-June 1979, No. 4-5, p. 21.

20. Stewart and Streeten (1973), p. 8.

21. See Sen(1960).

22. Secretariat of UNIDO (1979), p. 4.

23. See Ladejinsky (June 1969, and September 1969).

24. Joshi (1979), p. A-53.

25. See Patel (1969).

26. Bhagwati and Chakravarty (1969), p. 7.

27. Bhagwati (1979), p. 45.

28. World Bank (1979), p. 111.

29. Bhagwati and Desai (1970), p. 363.

30. Nayyar (1976), p. 293.

31. Bagchi (1970), p. 171.

32. Bhagwati and Chakravarty (1969), p. 26.

33. See Bagchi (1970), and Chattopadhyay (1973).

34. See Chaudhuri (1979), pp. 95-109.

CHAPTER 2

ISSUES IN THE INDIAN CONTEXT

2.1 INTRODUCTION

In India more than three decades of development, since independence in 1947, have brought paradoxial results.

India is a large country with about 700 million people[1] whose per capita income is only about 200 US dollars. Distribution of that low income is highly unequal. About 300 million people live below "the poverty line"--which is Rs.20 a month in 1960-61 prices.[2]

The agriculture sector dominates the economy, employing 74 per cent of the labour force in 1978, the same percentage as in 1911, and contributing about 40 per cent of value added. Millions of farmers still use traditional technology. The incidence of poverty is highest among the households of agricultural labourers and small cultivators. 79 per cent of the population and 82 per cent of the labour force still live and work in villages.[3]

This is only one aspect of India's development. A paper, presented by the Government of India at the Commonwealth Industries Ministers' meeting in 1979, describes India's situation as follows:

> Today India is among the major industrial countries of the world. It is the world's 10th most industrialized country,[4] the world's 4th largest food grain producer. And Indian exports include a whole spectrum of products--from hides and skins to power generation units.[5]

India is richly endowed with many natural resources--coal, iron ore, maganese ore, bauxite, lime-stone, gypsum, mica and other deposits. India has a large labour force and enormously rich land--some of the most consistently fertile land anywhere in the world.

The presence of high technology and well developed infrastructure provides her with potential to grow and develop at a more rapid pace than has been achieved thus far.

2.2 PLANNED ECONOMIC DEVELOPMENT

India, with the launching of the First Five Year Plan in 1951, embarked on a course of planned economic development. She has completed five Five-Year Plans, and the Sixth Plan started in 1980.

Planning in India covers almost all sectors of the economy, unlike many developed and underdeveloped countries where planning was adopted to remove certain imbalances in the capitalist structure. Planning in India is also different from socialist planning. The development of the public sector in India has not been at the cost of the private sector. The private sector still has a substantial role to play in the economy.

The different plans have provided for a large sum of public investments, as a result of which the Government's direct investment in industry has increased very rapidly. The public sector now occupies a pivotal position in the Indian economy. The public sector produced about 20 per cent of the total NDP and accounted for about 44 per cent of capital formation in 1977-78. In some key industries the public sector accounts for a large part of production. The public sector enterprizes produced 77 per cent of the steel, about 42 per cent of the nitrogenous fertilizers, and 32 per cent of the phosphatic fertilizers in 1977-78.[6]

Many of the public sector enterprizes rank among the top Indian industrial corporations. 52 government-owned companies were among India's top 101 industrial corporations accounting for 79.3 per cent of the aggregate assets of these corporations and 74.4 per cent of sales in 1977-78. Three of the public sector enterprizes, India Oil Corporation, Steel Authority of India Limited, and Bharat Heavy Electricals figure in the list of major industrial corporations outside of the United States.[7]

The objectives of planning put forward by the Government can be classified in two categories: self-sustained economic growth, and a reduction in inequality. The First Plan was a modest one, basically an integration of the social overhead projects already initiated by the

Union and State Governments. The Second Plan was much bigger and more ambitious than the First Plan. It significantly increased the relative share of heavy industries in total plan outlay. The strategy of sizeable investment in heavy industries continued through successive plans.

Table 2.1 shows the sectoral distribution of total Public Sector Plan Outlays (for five plans). As is clearly evident from the table, plan outlays earmarked for industry and minerals have been higher than those for agriculture and allied activities after the Second Plan.

2.3 ECONOMIC GROWTH AND STRUCTURAL CHANGES IN THE ECONOMY

There has been consistent but slow economic growth during the last three decades, which exceeded the corresponding population growth rate and resulted in modest increases in per capita income. Table 2.2 shows GNP, NNP at factor cost, and per capita income from 1950-51 to 1978-79.

During the last three decades, real national income increased by about 180 per cent, which works out to 3.5 per cent per annum. Per capita real income grew at a rate of 1.4 per cent per annum which is about one-half of the Plan target.

Per capita growth rate of 1.4 per cent is only an average figure. In fact, the pace of progress has varied over time. Average annual growth rates of GNP, NNP and per

TABLE 2.1

SECTORAL DISTRIBUTION OF TOTAL PUBLIC SECTOR PLAN OUTLAYS
(Percentage)

SECTORS	FIRST PLAN (1951-52 to 1955-56) ACTUALS	SECOND PLAN (1956-57 to 1960-61) ACTUALS	THIRD PLAN (1961-62 to 1965-66) ACTUALS	THREE ANNUAL PLANS (1966-67 to 1968-69) ACTUALS	FOURTH PLAN (1969-70 to 1973-74) ACTUALS	FIFTH PLAN (1974-75 to 1978-79) OUTLAYS
Agriculture and Allied Activities	14.8	11.7	12.7	16.7	14.7	13.0
Irrigation and Flood Control	22.1	9.2	7.8	7.1	8.6	8.7
Power	7.6	9.7	14.6	18.3	18.6	17.8
Village and Small Industries	2.1	4.0	2.8	1.9	1.5	1.3
Industry and Minerals	2.8	20.1	20.1	22.8	18.2	24.6
Transport and Communications	26.4	27.0	24.6	18.5	19.5	17.6
Others	24.1	18.3	17.4	14.7	18.9	16.9
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: Government of India, Planning Commission, Respective Plan Documents.

TABLE 2.2

GNP, NNP AND PER CAPITA INCOME
(Rs. Crores)

YEAR	GNP at Factor Cost (at 1970-71 prices)	NNP at Factor Cost (at 1970-71 prices)	Per Capita Income (at 1970-71 prices)
1950-51	17469	16731	466.0
1951-52	17841	17086	468.1
1952-53	18483	17699	475.8
1953-54	19660	18854	497.5
1954-55	20190	19328	500.7
1955-56	20854	19953	507.7
1956-57	21988	21056	524.8
1957-58	21593	20587	503.3
1958-59	23413	22329	534.2
1959-60	23802	22676	532.3
1960-61	25424	24250	558.8
1961-62	26293	25039	563.9
1962-63	26834	25414	559.8
1963-64	28210	26746	576.4
1964-65	30399	28808	607.8
1965-66	28791	27103	558.8
1966-67	29081	27298	551.5
1967-68	31590	29715	587.3
1968-69	32460	30513	589.1
1969-70	34518	32408	612.6
1970-71	36452	34235	632.8
1971-72	37000	34715	626.6
1972-73	36599	34191	604.1
1973-74	38410	35967	621.2
1974-75	38794	36411	616.1
1975-76	42542	40011	662.4
1976-77	43163	40534	658.0
1977-78	46644	43857	697.2
1978-79*	48607	45637	712.0

SOURCE: Government of India, Economic Survey, 1980, p. 75

*Quick estimates

capita income for different plan periods are given in Table 2.3. There was a sharp decline in real national income in 1979-80. But the year 1980-81, according to estimates, saw a growth in real NNP of 7.0 per cent.[8]

National income growth was relatively high during the first two Plans. During the Third Plan, there was no growth in per capita income largely because of the severe drought in its last year (1965-66). Another drought occurred in 1966-67. The growth of the economy suffered a setback during the 1966-67 recession from which it has not yet recovered.

The grave fact of declining growth of per capita real income stands out clearly if we take a decade-wise look at the performance of the economy. In the first decade (1950-51 to 1960-61), the real per capital income increased at the rate of 1.8 per cent per annum. In the second decade (1960-61 to 1970-71), it increased at 1.2 per cent per annum. This came down sharply to 0.9 per cent per annum in the last decade (1970-71 to 1980-81).[9]

The transformation of the structure of the Indian economy over the period of the last three decades, even though not so pronounced as was hoped for, was still significant. Table 2.4 shows the relative shares of the primary, secondary and tertiary sectors in net domestic product. The share of the primary sector was reduced from 57.0 per

TABLE 2.3

ANNUAL GROWTH RATES

(Percentage)

	GNP (at 1970-71 prices)	NNP (at 1970-71 prices)	Per Capita Income (at 1970-71 prices)
First Plan Period	3.6	3.6	1.7
Second Plan Period	4.0	4.0	2.0
Third Plan Period	2.5	2.2	0
Three Annual Plan Period (1966-67 to 1968-69)	4.1	4.0	1.8
Fourth Plan Period	3.4	3.4	1.1
Fifth Plan Period (1974-75 to 1978-79)	4.9	4.9	2.8
1979-80	-4.5	-4.9	-6.8
1980-81	N.A.	7.0	2.4

SOURCES: (1) Government of India, Economic Survey, 1980

(2) Indian Economy, January-March, 1981, No. 4, Volume III for 1979-80 figures.

(3) The Economist Intelligence Unit, Quarterly Economic Report of India, Nepal, Annual Supplement, 1982, p. 8 for 1980-81 figures.

NA = not available

TABLE 2.4

NET DOMESTIC PRODUCT AT FACTOR COST BY INDUSTRY OF ORIGIN
(Percentage Distribution at Current Prices)

Year \ Industry	PRIMARY SECTOR	SECONDARY SECTOR				TERTIARY SECTOR	
		Total	Manufacturing	Electricity, Gas and Water Supply	Construction	Total	Transport, Communications, Trade, Finance and Real Estate
1950-51	57.0	16.4	N.A.	N.A.	N.A.	26.4	N.A
1956-57	54.9	18.0	N.A.	N.A.	N.A.	27.1	N.A
1960-61	52.2	19.1	13.9	0.5	4.7	28.7	18.2
1961-62	51.1	19.6	14.4	0.6	4.6	29.3	18.6
1962-63	49.4	20.2	15.0	0.6	4.6	30.5	19.4
1963-64	50.0	20.4	15.2	0.6	4.6	29.6	18.9
1964-65	51.7	19.3	14.1	0.6	4.6	29.0	18.7
1965-66	49.0	20.3	14.4	0.7	5.1	30.7	19.7
1966-67	50.5	19.5	13.6	0.7	5.2	30.0	19.4
1967-68	53.1	18.1	12.2	0.7	5.2	28.8	18.7
1968-69	51.0	19.0	12.8	0.8	5.4	30.0	19.3
1969-70	50.7	19.8	13.5	0.9	5.4	29.5	19.0
1970-71	50.0	19.8	13.6	0.9	5.3	30.2	20.7
1971-72	48.5	20.4	14.0	0.9	5.5	31.1	21.3
1972-73	48.5	20.4	14.2	0.9	5.3	31.1	21.4
1973-74	52.1	18.8	13.6	0.8	4.4	29.2	20.4
1974-75	48.5	20.6	15.4	0.9	4.3	30.9	21.5
1975-76	44.4	21.9	15.6	1.1	5.2	33.7	23.6
1976-77	42.4	23.2	16.1	1.3	5.8	34.4	24.3

NOTES: (1) N.A. = Not available
(2) Figures for 1950-51 and 1956-57 are expressed in 1960-61 prices.

SOURCE: Central Statistical Organization, National Accounts Statistics, February 1976, January 1979 and other issues.

cent in 1950-51 to 42.4 per cent in 1976-77. During the same period, the share of the secondary sector increased from 16.4 per cent to 23.2 per cent. The tertiary sector has also registered an increase in its share.

The shift towards industry and the tertiary sector is not visible when we look at employment statistics related to different sectors of the economy as presented in Table 2.5. On the contrary, during the last three decades, the ratio of the labour force employed in agriculture has actually increased marginally. The agriculture sector continues to absorb much of the population increase, even though its share in net domestic product is declining.

TABLE 2.5

DISTRIBUTION OF THE LABOUR FORCE
(Percentage)

Year	Agriculture	Mining and Manufacturing	Others
1951	72.8	9.3	17.9
1961	73.0	10.4	16.6
1971	73.8	9.8	16.4

Source: Government of India, Planning Commission, Draft Five Year Plan, 1978-83, 1978.

Employment in the industrial sector increased much less rapidly than output. Between 1960 and 1965 output of organized industry increased roughly by 9 per cent per annum, whereas employment rose by about 6 per cent. Between 1965 and 1970 the increase in output over the period was of the order of 18.4 per cent, whereas employment increased by about 5.4 per cent [10] (The figures for the two sub-periods, before and after 1965, are not strictly comparable).

2.4 THE AGRICULTURE SECTOR

The agriculture sector has important significance in the Indian economy. The performance of the agriculture sector is a major determinant of the overall progress of the economy. As noted above, this sector employs 74 per cent of the labour force and accounts for about 40 per cent of national income. During the last thirty years, agriculture production has increased at the average rate of 2.7 per cent per annum (see Table 2.6). Although this growth rate has kept food production, as well as agricultural output as a whole, ahead of population growth (India is now self-sufficient in foodgrains), it has been behind the targeted growth of about 4 per cent per annum.

There have been widespread structural changes in Indian agriculture. Indian agriculture has increasingly acquired a scientific character. Hybrid seeds for wheat and some other crops were introduced in the mid-sixties. These high-yielding varieties have immense potential to raise agricultural output in a very short period. A visible

TABLE 2.6

TRENDS IN AGRICULTURE

YEAR	Index Number of Agricultural Production 1967-70 = 100	Foodgrain Production (Million Tonnes)
1955-56	71.9	69.34
1960-61	86.7	82.33
1965-66	80.8	72.74
1970-71	111.5	108.42
1971-72	111.2	105.17
1972-73	102.3	97.03
1973-74	112.4	104.67
1974-75	108.8	99.83
1975-76	125.3	121.03
1976-77	116.5	111.17
1977-78	133.4	126.41
1978-79	138.0	131.34

SOURCES: (1) Central Statistical Organization, Basic Statistics Relating to the Indian Economy, 1950-51 to 1976-77, 1979.

(2) Government of India, Economic Survey, 1980.

acceleration in the pace of technical progress is indicated by the increasing use of chemical fertilisers (5.26 million tonnes in terms of nutrients in 1979-80 as against 69 thousand tonnes in 1950-51) and pesticides. There has been a rapid expansion of the area under irrigation from about 21 million hectares in 1959-51 to over 52 million hectares (about 30 per cent of cultivated area) in 1979-80. Table 2.7 provides figures for total cropped area and gross area irrigated for some selected years.

But high expectations, based on the (positive) factors mentioned above, have not materialized fully. A careful analysis of sources of growth in agriculture reveals a deceleration in the agricultural growth rate.

Two major factors are responsible for the growth of agricultural production: (a) an increase in the area under cultivation and (b) an increase in land productivity in terms of yield per hectare.

For this analysis, the last thirty years are divided into two nearly equal periods: period I from 1951-52 to 1964-65, and period II from 1964-65 to 1980-81. According to Narrotam Shah, the annual rate of increase in cultivated area dropped from 1.7 per cent in period I to 0.6 per cent in period II.[11]

At the same time, the pace of improvement in productivity (i.e., yield per hectare) improved marginally from

TABLE 2.7

CROPPED AREA AND IRRIGATED AREA

Year	Total Cropped Area (Million Hectares)	Gross Area Irrigated (Million Hectares)	Gross Irrigated as % of Cropped Area
1960-61	152.8	28.0	18.3
1965-66	155.3	30.9	19.9
1970-71	165.8	38.2	23.0
1973-74	169.9	40.3	23.7
1974-75	163.9	41.7	25.5
1975-76	171.0	43.2	25.3
1976-77	167.1	43.1	25.8

SOURCE: Tata Services Limited, Statistical Outline of India, 1980.

1.4 per cent per annum in period I to 1.5 per cent per annum in period II. As a combined result of these two factors, the rate of increase of agricultural production declined from 3.2 per cent per annum recorded in period I to 2.2 per cent per annum in period II.[12]

The scope for extending the area under cultivation will become less and less in the future because about half of the country's geographical area is already being cultivated. The figures show that improvement in productivity in period II (the period of the "green revolution") was not much different from that in period I. There are several reasons for that.

One reason is that successful hybrid seeds could be developed only for a few crops, such as wheat, jowar, maize, bajra and cotton which together account for only one-fifth of total agricultural production. In the case of rice (which is the most important crop) and other crops, success was limited.

Benefits of hybrid seeds could not be fully realized because their application has been limited only to parts of the country. High-yielding varieties necessarily need other inputs such as availability of water, fertilisers, and credit. A large plurality of peasants are unable to supply these complementary inputs.

2.5 THE INDUSTRIAL SECTOR

In a number of industrial products India is among the world's top producers. It is the largest producer of cotton yarn in the world, it stands fifth in the production of coal, and sixth in lignite and sugar.[13] But the overall industrial growth rate in India is far below what has been achieved by most other industrialized countries in the world. As a result, India has been losing its rank among major industrial powers of the world.

During the last thirty years, industrial production in India has increased at an average rate of 6.1 per cent per annum. This growth rate has been less than the target rates of 8 per cent to 10 per cent set under the various plans.

Industrial production suffered a severe setback during the 1965-67 recession. But, more than that, there has been a steady deterioration in the growth rate of industrial production. This fact can be illustrated by referring to the growth of industrial production in the organised sector.[14] The growth rate declined from 7.4 per cent per annum in the 1950s to 6.3 per cent per annum in the 1960s and further down to 4.6 per cent per annum in the 1970s.[15]

This deceleration in the growth of industrial production has been caused, to some extent, by deceleration in the growth of agricultural production. The poor performance of the transport and energy sector, viz., coal, power, railway transport and ports is another explanatory factor. For instance, the rate of increase in electricity generation came down from 12.7 per cent per annum during the 1950s and 1960s to 7.3 per cent per annum in the 1970s.[16]

On the other hand, there were many achievements which cannot be overlooked. At the time of independence, India had hardly any worthwhile capital goods industry. Today, the country is self-sufficient not only in basic consumer goods, but also in the manufacture of plant and machinery needed by some of its major industries, such as cotton textile, steel, jute, sugar, chemicals, cement, and a whole range of consumer goods.

In the past thirty years, many technological transformations have taken place which have contributed to the growing diversification of the country's industrial base. India today produces sophisticated machinery and equipment for hydro and thermal power stations, steel plants, fertiliser and petro-chemical plants. Major electrical items for domestic and industrial use are now produced in the country. Small beginnings have been made in the field of computer systems and other electronic equipment. India can produce a wide range of equipment required for nuclear power reactors. She is fast emerging as a space power. Impressive achievements have been reported recently in the field of satellite communications.

The last two decades have seen some structural changes in the industrial sector. The composition of industrial output has changed in favour of capital goods. Basic and capital goods[17] industries accounted for 40.3 per cent of total value added in the factory sector[18] in 1978-79, intermediate goods industries accounted for 28.8 per cent and consumers goods industries (durable and non-durables) accounted for 30.9 per cent.[19] This can also be seen from Table 2.8 which shows the components of manufacturing value added (registered) from 1960-61 to 1976-77 in percentage terms. In 1960-61, light industries accounted for 51.0 per cent of the total value added while intermediate goods and heavy industries accounted for 29.2 per cent and 19.8 per cent, respectively. By 1976-77, the respective shares of light industries, intermediate, and heavy industries had changed to 36.2 per cent, 38.3 per cent,, and 25.5 per cent.

Since the mid-sixties the growth of basic and capital goods industries has been slower than in the past and slower than even the meagre average growth in industrial output. Consumer durable goods industries which generally produce goods for elite consumption, on the other hand, have registered moderately high growth rate. The output of consumer non-durable goods industries, which cater to the requirements

TABLE 2.8

MANUFACTURING VALUE ADDED-REGISTERED

(Percentage Distribution at Current Prices)

Year	INDUSTRY GROUP		
	Light Industries	Intermediaries	Heavy Industries
1960-61	51.0	29.2	19.8
1961-62	49.2	30.8	20.0
1962-63	48.4	31.2	20.4
1963-64	45.1	31.9	23.0
1964-65	44.1	32.3	23.6
1965-66	43.1	32.9	24.0
1966-67	43.5	32.4	24.1
1967-68	43.0	32.1	24.9
1968-69	42.1	34.3	23.6
1969-70	43.5	33.4	23.1
1970-71	40.6	35.2	24.1
1971-72	38.3	35.4	26.1
1972-73	38.6	35.1	26.3
1973-74	41.2	34.0	24.8
1974-75	38.0	37.8	24.3
1975-76	36.0	38.8	25.2
1976-77	36.2	38.3	25.5

SOURCES: (1) Central Statistical Organization, National Accounts Statistics, February 1976, for 1960-61 to 1969-70 figures.

(2) Central Statistical Organization, National Accounts Statistics, January 1979 for 1970-71 to 1976-77 figures.

of mass consumption, has increased only marginally.[20] The data presented in Table 2.9 clearly indicate the structural retardation within the industrial sector since the mid-sixties.

Other disappointing aspects of the performance of the industrial sector relate to the vast under-utilization of capacity in many key industries and the very meagre increase in employment in organised industry (see Table 2.5). Share of manufacturing in the industrial sector has stayed almost the same at about 70 per cent during the last twenty years (see Table 2.4).

2.6 SAVING AND CAPITAL FORMATION

India has been remarkably successful in increasing its saving rate. In fact, this has been the most satisfactory achievement of the last three decades.

Table 2.10 shows that the saving rate has increased from an average of only 6.7 per cent during the First Plan to 19.3 per cent in 1978-79. Thus, over the whole period, the saving rate almost tripled. Over the period of 1955-73, the saving rate showed large fluctuations without any definite pattern or trend. But after 1974, there has been a steady upward trend in the saving rate.

As is evident from Table 2.10, the rate of investment had also increased considerably from an average of

TABLE 2.9

ANNUAL COMPOUND GROWTH RATES IN INDEX NUMBERS OF INDUSTRIAL PRODUCTION

Industry	1951-55 4 years	1955-60 5 years	1960-65 5 years	1965-70 5 years	1970-76 6 years
Basic industries	4.7	12.1	10.4	6.2	6.8
Capital goods industries	9.8	13.1	19.6	-1.4	6.0
Intermediate goods industries	7.8	6.3	6.9	2.6	3.3
Consumer goods industries	4.8	4.4	4.9	4.1	2.9
a) Consumer durable goods	-	-	11.0	8.5	4.3
b) Consumer non-durable goods	-	-	-	2.8	-
General Index	5.7	7.2	9.0	3.3	4.7

SOURCE: Shetty (1978), p. 9.

TABLE 2.10

SAVING AND INVESTMENT RATES

Period/Year	Saving Rate	Investment Rate	Net Inflow of Foreign Capital as % of NDP
First Plan Period	6.7	7.0	0.3
Second Plan Period	8.2	9.6	1.4
1961-62	8.4	10.7	2.3
1962-63	9.6	12.3	2.7
1963-64	9.8	12.1	2.3
1964-65	9.2	12.0	2.8
1965-66	11.2	13.8	2.6
1966-67	11.8	15.4	3.6
1967-68	9.6	12.3	2.7
1968-69	9.5	10.8	1.3
1969-70	11.8	12.5	0.7
1970-71	12.0	13.0	1.0
1971-72	12.4	13.6	1.2
1972-73	11.3	11.9	0.6
1973-74	15.0	15.7	0.7
1974-75	14.6	15.6	1.0
1975-76	16.0	15.8	-0.2
1976-77	18.4	16.6	-1.8
1977-78	18.3	17.7	-0.6
1978-79*	19.3	19.4	0.1

* Quick estimates

NOTES: (1) Saving Rate is the ratio of saving to net domestic product.

(2) Investment Rate is the ratio of net domestic capital formation to net domestic product.

SOURCES: (1) CSO, National Accounts Statistics, January 1978 for the First and Second Plan figures.

(2) Government of India, Economic Survey, 1980.

7.0 per cent during the First Plan to 19.4 per cent in 1978-79.

The high saving rate has meant less dependence on foreign capital. The gap between investment and saving was quite large during the period covered by the Second Plan, the Third Plan and the Three Annual Plans. But after that there has been a drastic reduction in the investment-saving gap.

As depicted in Table 2.11, the pattern of saving of the instutitional sectors of households, private corporate, and public has undergone noticeable changes over the period considered above. Table 2.12 shows the shares of these three sectors in net domestic saving in percentage terms.

The household sector (including unincorporated unorganized enterprises), which provides most of the aggregate saving, increased its share to more than 80 per cent during 1966-70, and in recent years its share has been about three-fourths of the total. The level, however, has fluctuated over the past few years.

The share of the public sector was quite high during the first three plans; later, it declined. Since 1974-75, however, it has risen again. The private corporate sector's share in total saving has been relatively small, and has declined over the period. In 1976-77, it was only 2.2 per cent, well below the 10.6 per cent in 1961-62.

TABLE 2.11

DOMESTIC SAVING
(Rs. Crores)
(At Current Prices)

Period/Year	Household Sector	Private Corporate Sector	Public Sector	Total Net Domestic Saving
First Plan Period	2368	244	588	3200
Second Plan Period	3859	344	957	5160
1961-62	783	135	363	1281
1962-63	995	141	408	1544
1963-64	1137	149	539	1825
1964-65	1307	105	611	2023
1965-66	1871	99	592	2562
1966-67	2604	107	407	3118
1967-68	2602	70	355	3027
1968-69	2535	77	522	3134
1969-70	3230	147	645	4022
1970-71	3557	223	804	4584
1971-72	4011	286	762	5059
1972-73	4072	252	740	5064
1973-74	6190	481	1082	7753
1974-75	6451	771	2442	9664
1975-76	7986	350	2829	11165
1976-77	10550	306	3196	14052

SOURCE: Central Statistical Organization, National Accounts Statistics, February 1976, January 1978, and January 1979 issues.

TABLE 2.12

COMPOSITION OF SAVING
(Percentage)
(At Current Prices)

Period/Year	Household	Private Corporate	Public	Total
First Plan Period	74.0	7.6	18.4	100.0
Second Plan Period	74.7	6.7	18.6	100.0
1961-62	61.1	10.6	28.3	100.0
1962-63	64.5	9.1	26.4	100.0
1963-64	62.3	8.2	29.5	100.0
1964-65	64.6	5.2	30.2	100.0
1965-66	73.0	3.9	23.1	100.0
1966-67	83.5	3.4	13.1	100.0
1967-68	86.0	2.3	11.7	100.0
1968-69	80.9	2.5	16.6	100.0
1969-70	80.3	3.7	16.0	100.0
1970-71	77.6	4.9	17.5	100.0
1971-72	79.3	5.6	15.1	100.0
1972-73	80.4	5.0	14.6	100.0
1973-74	79.8	6.2	14.0	100.0
1974-75	66.7	8.0	25.3	100.0
1975-76	71.5	3.1	25.4	100.0
1976-77	75.1	2.2	22.7	100.0

SOURCE: Central Statistical Organization, National Accounts Statistics, February 1976, January 1978 and January 1979 issues.

The composition of total gross domestic capital formation has also fluctuated over the period. Between 1961-62 and 1976-77, construction on average formed more than half of the total; machinery and equipment accounted for about 35 to 40 per cent, while change in stocks accounted for the rest.[21]

The distribution of capital formation by industry of use between 1960-61 and 1976-77 shows that the secondary sector, comprising manufacturing, construction, electricity and gas and water supply, contributed the major share to capital formation--varying from 35 to 47 per cent. The contribution of the primary sector, comprising agriculture and allied activities (including mining), has been about half that of the secondary sector, while the tertiary sector accounted for the rest.[22]

Before we move to the next section, we must take note of the fact that the capital/output ratio in the Indian economy has steeply risen during the last three decades. Compared to 2.32 in 1950-51, it reached 3.28 in 1974-75.[23] This has worked, unfortunately, to partially neutralize the impact of the higher investment and saving rates.

2.7 FOREIGN TRADE AND BALANCE OF PAYMENTS

Foreign exchange has acted as one of the dominant constraints on the overall growth of the economy. The severe shortage of foreign exchange, at times, was reflected in a low level of capacity utilization and has affected the realized rates of saving and investment. The import policy followed by the Indian Government has been rather restrictive. It has involved total control and licensing of foreign exchange for all uses in the economy. A comprehensive system of import regulations covering a wide range of commodities was devised in accordance with the priority areas in various plans.

During the 50s and 60s, emphasis was more on import substitution, and as a result, exports remained almost stagnant. Some initiatives to promote exports were taken during the Third Plan. The Indian rupee was devalued by 57.5 per cent aginst the U.S. dollar in 1966. There was no significant increase in India's exports during the second half of the 60s. In fact, devaluation led to a fall in the dollar value of exports. Exports valued in Indian rupees, however, performed remarkably well during the mid-seventies. During the 1973-74 to 1976-77 period, exports grew at the unprecedented average rate of 27 per cent per annum. But since then growth has been sluggish. Exports in 1978-79 rose by only 5.9 per cent.[24] Table 2.13 shows export levels for some selected years.

There have been some significant changes in the export structure since the early 1960s. The role of

TABLE 2.13

INDIA's FOREIGN TRADE (MERCHANDISE)
(Rs. Crores)

Year	Imports	Exports	Balance of Trade
1950-51	650	647	-3
1955-56	773	640	-133
1960-61	1105	630	-475
1965-66	1367	784	-583
1970-71	1634	1535	-99
1973-74	2955	2523	-432
1974-75	4519	3329	-1190
1975-76	5265	4043	-1222
1976-77	5074	5146	+72
1977-78	6025	5404	-621
1978-79*	6755	5691	-1064

* Provisional

SOURCE: (1) Reserve Bank of India, Report on Currency and Finance, 1978-79.

(2) Central Statistical Organization, Basic Statistics Relating to Indian Economy, 1979.

traditional items, e.g., tea, jute and cotton, has declined markedly while some "non-traditional" items, e.g., engineering goods, pearls and precious stones, and chemicals, have emerged as major export items reflecting the greater diversification of exports and increase in export promotion measures. The data in Table 2.14 shows that engineering goods accounted for 12.2 per cent of total exports in 1978-79. The combined share of tea, jute and cotton fabrics dropped from 47.9 per cent in 1960-61 to only 12.3 per cent in 1978-79. These new export items, being the most dynamic elements in world trade, promise better future prospects.

India's share in world exports has shrunk considerably during the last three decades. It has declined from 1.8 per cent in 1952 to 0.44 per cent in 1980.[25] One reason for this decline is that primary products still weigh heavily in Indian exports whose share in world trade is rapidly declining. The growth of protectionism in developed countries in recent years directed at manufactured exports from developing countries has also had adverse effects on India's exports.

Table 2.13 reveals the problem of recurring balance of trade deficits during the last three decades. Imports have increased at a faster rate than exports. One reason has been the deterioration in India's terms of trade caused by a many-fold increase in the price of imported oil. Imports

TABLE 2.14

EXPORTS OF SELECTED COMMODITIES

(Percentage Shares)

Commodities	1960-61	1970-71	1978-79*
Tea	18.7	9.7	5.9
Jute	20.5	12.4	2.9
Cotton Yarn and Fabrics	8.7	4.9	3.5
Engineering Goods	1.0	8.5	12.2
Pearls and Stones	Neg.	2.7	12.4

*Provisional

NOTE: Neg. = negligible (less than 1%)

SOURCES: (1) Central Statistical Organization, Basic Statistics Relating to the Indian Economy, 1979.

(2) Government of India, Economic Survey, 1980.

of oil now figure as the largest single item on the list of imported commodities. In 1978-79, India imported Rs.1676.8 crores worth of petroleum oil and lubricants, accounting for 24.6 per cent of total imports.[26] In recent years the balance of payments of India has been favourable due to increased foreign exchange remittance by Indian residents abroad. But this may be a purely temporary phenomenon which is not likely to last long. India's foreign exchange reserves (excluding gold and SDRs) stood at a comfortable sum of Rs.5163.7 crores in 1979-80.

As discussed above, import trade has been directly controlled through the policy of import licensing. Imports of capital goods, raw materials and intermediate goods have been given priority over imports of consumer goods excepting food. In 1977-78, imports of raw materials and intermediate manufactures accounted for 73 per cent of total imports, capital goods for 19 per cent, and consumer good for 8 per cent.

2.8 CHANGES IN DISTRIBUTIONAL PATTERN

There has been a heightening of economic and social disparities between rich and poor, between urban and rural sectors and between different states during the past three decades. One of the main causes of inequalities is the skewed distribution of ownership of assets and means of production. The skewed distribution of asset ownership leads to a skewed distribution of income which in turn determines the pattern of production, incomes and investment, thus maintaining or even worsening inequality.

The "distribution" problem has been studied from various angles with varying emphasis on asset distribution, and income distribution.

2.8.1 Asset Distribution

Two survey reports by the Reserve Bank of India (RBI), the All-India Rural Debt Survey 1961-62 and All-India Debt and Investment Survey 1971-72, provide some useful data with regard to asset distribution in rural India.

Table 2.15 provides a comparison of the findings of the two surveys of the RBI. It presents the decile group values obtained by fitting a lognormal distribution to the asset-group-wise distribution of assets.

This table shows that the lowest 10 per cent of the rural households held only 0.21 per cent of the total assets, whereas the top 10 per cent held 61.79 per cent in 1971-72. The share of the bottom forty percent of rural households in total assets is only 3.36 per cent. This table also reveals that there has been a decline in the share of assets accounted for by each of the first nine decline groups over the decade.

TABLE 2.15

THE PATTERN OF ASSET HOLDINGS OF RURAL HOUSEHOLDS

1961-62 to 1971-72

Decile Group	1961-62 Share in Total Assets (percent)	1971-72 Share in Total Assets (percent)	
0-10	0.26	0.21	(-19.23)
10-20	0.68	0.56	(-17.65)
20-30	1.18	1.01	(-14.41)
30-40	1.80	1.58	(-12.22)
40-50	2.76	2.34	(-15.22)
50-60	3.88	3.47	(-10.57)
60-70	5.79	5.51	(-4.84)
70-80	9.11	8.28	(-9.11)
80-90	15.83	15.24	(-3.73)
90-100	58.71	61.79	(+5.25)

Figures in brackets indicate variations in share of assets.

SOURCE: Pathak, Ganpathy, and Sarma (1977), p. 507.

The concentration of corporate property has also increased in past decades. According to the Draft Sixth Plan, the assets of the top 20 business houses increased from about Rs.2500 crores to RS.4500 crores between 1969 to 1975.

> It has also been shown in recent studies that four firms control more than half of the total sales in nine industries including steel, petroleum, transport equipment, cement, synthetic fibres, paper, food products, cigarettes and rubber products. In the first two of these industries, production is concentrated mainly in the public sector. But in the last seven private houses control the bulk of production.[27]

2.8.2 Income Distribution

In the absence of data on the size distribution of national income, different studies have relied mainly on consumption data available in National Sample Surveys for studying income differentials. One such study by Ojha and Bhatt shows that, during the period 1953-55 to 1961-64, personal income disparity increased. Table 2.16 presents their findings on size distribution of income for that period. As is clear from the table, the distribution of income was more uneven in the urban sector than in the rural. During the period covered, the inequality increased in the urban sector and declined in the rural sector. Overall income distribution became more uneven, the share of the bottom 20 per cent and 40 per cent declined while those of the top 10 per cent and 20 per cent increased.

TABLE 2.16

PATTERN OF PERSONAL INCOME DISTRIBUTION AMONG INDIVIDUALS

(Percentage)

	Income Share of bottom 20%		Income Share of bottom 40%		Income Share of top 10%		Income Share of top 20%	
	1953-55	1961-64	1953-55	1961-64	1953-55	1961-64	1953-55	1961-64
Overall	7	6	17	14	35	40	49	54
Urban Sector	5	6	14	15	39	45	55	57
Rural Sector	8	7	18	20	30	25	45	53

SOURCE: Ojha, Bhatt (1971), quoted in Mahajan (1977), p. 19.

Most of the studies covering the first decade of planning agree that income inequality increased during that period. There is no conclusive evidence regarding the trend in income inequality during the second decade of planning. Dandekar and Rath have argued that small gains of development over the years have not been equitably distributed among all groups of the population.[28] They showed that during the period 1960-61 to 1967-68 the condition of the bottom 20 per cent urban poor deteriorated and for the second 20 per cent of the urban population it remained more or less unchanged. Even if there has been some improvement in income distribution, it has been very marginal.

The Indian development experience of the last three decades as delineated in this chapter provides the context for our inquiry. But, before we describe our model and report the results of our study, a survey of Indian planning models is undertaken in the next chapter.

FOOTNOTES

CHAPTER 2

1. Population grew by 2.1 per cent a year in the 1970s leading to a total of 684 mn in 1981.

2. This concept of the poverty line is primarily based on minimum nutritional requirements for the sustenance of a healthy human being. The people below the poverty line are those who cannot afford the minimum nutrition level. There have been several studies to measure the number of peopole below the poverty line in India, see Bardhan (1970), Minhas (1970), Dandekar and Rath (1971), and Ojha (1970).

3. Krisna (1979), p. 15.

4. India ranked as the 10th largest industrial power in 1971 in terms of value added by industry. She had become the 16th largest industrial power by 1977-78.

5. Government of India (1979), p. 37.

6. Bahuguna(1979), pp. 13-14.

7. Government of India (1979), p. 36.

8. Economic Survey 1981/82, Government of India, 1982, reported in Quarterly Economic Report of India, Nepal, The Economist Intelligence Unit, Annual Supplement, 1982, p. 8.

9. Shah (1981), p. 11.

10. Chaudhury (1979), p. 152.

11. Shah (1981), p. 7.

12. Ibid.

13. Government of India (1979), p. 37.

14. The organised sector includes mines and factories covered by the Factory Act, powerhouses, etc. Adequate information is not available for the unorganized sector (smaller workshops, cottage industries, etc.), even though this sector is large in size.

15. Shah (1981), p. 9.

16. Shah (1981), p. 10.

17. Basic industries include mining and quarrying, heavy inorganic chemicals, fertilizers, cement, iron and steel industries, aluminum manufacturing, and electricity. Capital goods industries include prime movers, boilers and steam generating plants, industrial machinery, machinery components and accessories, electrical cables and insulated wires, railroad equipment, motor vehicles.

18. The factory sector includes units registered under the Factories Act (1948), employing 10 or more workers and using power and 20 or more workers and not using power.

19. Government of India (1979), p. 37.

20. Shetty (1978), p. 14.

21. See Government of India, Central Statistical Organization, National Accounts Statistics, Feb. 1976, and Jan. 1979 issues.

22. See Government of India, Central Statistical Organization, National Accounts Statistics, Feb. 1976, Jan. 1978, and Jan. 1979 issues.

23. Brahmanand (1978).

24. Government of India, Economic Survey, 1980, p. 58.

25. Bhagwati and Srinivasan (1975), p. 19, and International Monetary Fund (1983), International Financial Statistics, No. 7, July 1983.

26. Government of India, Economic Survey, 1980.

27. Government of India, Planning Commission, Draft Five Year Plan, 1978-79, 1978, p. 12.

28. Dandekar and Rath (1971).

CHAPTER 3

INDIAN PLAN MODELS

As mentioned in earlier chapters, planning in India started with the First Five Year Plan in 1951. The history of plan models in India also dates back to the same period.[1] In this area of economic research, India, since then, has kept pace with that of the rest of the world. The subject matter of these plan models has been very vast, covering many important aspects of economic development.[2] The Indian planning process has benefited from the expertise of many well-known economists, Indian as well as foreign.

The natural place to start any discussion of plan models in India is with the First Five Year Plan. The planning model[3] used by the Indian Planning Commission was based primarily on the Harrod-Domar growth model with one modification that pertained to the distinction between the average and the marginal propensities to save. The basic logic of the model is stated by the following equation:

$$\Delta I/s = Iv$$

where I represents the rate of investment in a given period, s the marginal propensity to save and v the potential social average productivity of investment.

The First Plan considered several alternatives by attaching different values which were considered feasible to s and v. The rate of investment in the base year (Io) was taken as given. The actual First Five Year Plan, however, was basically an integration of social overhead projects most of which were already in execution when the plan was finalized. The Harrod-Domar model of growth was provided more as a mathematical appendix to the plan.

The Second Plan was very much more advanced than the First Plan. The Second Plan shifted the emphasis in favour of building up a capital goods base, the rationale for which was provided by the two-sector growth model developed by Mahalanobis. The model showed that a strategy of more investment in capital goods industries would, in the long run, result in growth rates of income and aggregate consumption that are higher than that achieved by a different strategy emphasizing faster development of consumption goods' industries.

The general strategy suggested by the Mahalanobis model has deeply influenced Indian planning. The model is described below.

Mahalanobis Two Sector Model[4]

The economy consists of two sectors, the investment-goods and the consumption-goods sectors. Current investment

I_t is divided into two parts $r_k I_t$ and $r_c I_t$, where r_k and r_c indicate the proportions going to the investment-goods and consumption-goods sectors, respectively. If b_k and b_c are the output/capital ratios, and s_o, the initial rate of investment, then

$$I_t - I_{t-1} = b_k r_k \; I_{t-1} \quad (3.1)$$

$$C_t - C_{t-1} = b_c r_c \; I_{t-1} \quad (3.2)$$

and $$I_o/Y_o = s_o \quad (3.3)$$

Equation (3.1) has the solution

$$I_t = I_o \; (1+r_k b_k)^t \quad (3.4)$$

Substituting this in equation (3.2) we get the difference equation

$$C_t = C_{t-1} + I_o b_c r_c (1 + r_k b_k)^{t-1} \quad (3.5)$$

which has the solution

$$C_t = C_o + I_o r_c b_c \{(1+r_k b_k)^t - 1\}/r_k b_k \quad (3.6)$$

adding equation (3.4) and (3.6) we get

$$Y_t = Y_o + I_o (r_k b_k + r_c b_c) \{(1+r_k b_k)^t - 1\}/r_k b_k \quad (3.7)$$

where $Y_t = C_t + I_t$

From equation (3.3) and 3.7) we get the growth path of the economy

$$Y_t=Y_o\{1+s_o(r_kb_k+r_cb_c)[(1+r_kb_k)^t-1]/r_kb_k\} \qquad (3.8)$$

Equation (3.8) shows that the rate of growth of national income depends on s_o, r_k, b_k, b_c, and t. Now s_o is an initial condition, and b_k and b_c are determined by technological factors and conditions of production, hence r_k becomes the decision variable in the growth process of the model. If $b_c>b_k$, then it can be shown that a higher value of r_k would result in a lower increment in consumption (or income) in the short run but, in the long run, it would result in a higher rate of growth of consumption (or income). Thus a higher r_k would always have a favourable effect on the asymptotic growth rate of the system. The choice of r_k, thus, implies an implicit choice of different consumption streams. If the aim is to achieve a high rate of growth of consumption in the future then priority must be given to the development of investment goods' industries over consumer goods industries.

The model is based on the assumption of closed economy (see Chapter 1). It also ignores the demand side of the economy and its two-sector classification of the economy involves a very high degree of aggregation which renders it unusable for computational purposes. Despite all the limitations, the model provided some powerful insights.

The resource allocation of the official Second Plan were very much in accordance with the allocation pattern of the Mahalanobis four-sector model.[5] The Second Plan had set certain overall income and employment targets to be achieved during the plan period. The four-sector model broke down total investment among four sectors in such a way as to achieve the Plan targets.

The three further sectors of Mahalanobis, in addition to the capital goods sector (k), are:

Sector 1. Factory production of consumer goods

Sector 2. Household production of consumer goods (including agriculture)

Sector 3. Services

He assumed that all four sectors had constant incremental output/capital ratios and constant incremental labour/capital ratios, symbolized by b_k, b_1, b_2, b_3, l_k, l_1, l_2, and l_3, respectively. The problem then becomes: how to allocate the total given investment (I) in four sectors if the the specified increases in income (ΔY) and in employment (ΔN) are to be achieved. The policy variables are the shares of investment going to each sector, symbolized by r_k, r_1, r_2, and r_3.

The problem can be presented by the following system of equations:

$$r_k b_k I + r_1 b_1 I + r_2 b_2 I + r_3 b_3 I = \Delta Y \qquad (3.9)$$

$$r_k l_k I + r_1 l_1 I + r_2 l_2 I + r_3 l_3 I = \Delta N \qquad (3.10)$$

$$r_k I + r_1 I + r_2 I + r_3 I = I \qquad (3.11)$$

The above system has three equations and four unknowns, r's. The equations could have a unique solution only if the value of one of the r's is given exogenously. With the value of r_k taken from the solution of the two-sector model, the system was solved to allocate investments among the three remaining sectors.

The Mahalanobis solution to the problem is sub-optimal in the sense that solution could be improved if choice was introduced in the model. The above system provides no element of choice as it has zero degree of freedom. Komiya[6] transformed the problem into a linear programming one and showed that greater employment and output could have been obtained by mere reallocation of the given investments among the sectors. But in his solution, investments allocated to factory production of consumer goods and services are zero.

The Mahalanobis four-sector model also neglects, like his two-sector model, the demand side of the economy.

The "Experimental Plan Frame" of Frisch[7] and the

"Demonstration Model" of Sandee[8] were two earlier attempts to build computable multisector plan models which have played a useful part in the development of planning methodology in India. Frisch did not present any final results even though he had performed considerable numerical work with the help of the model. One interesting aspect of his model is that it has an objective function as the summation of three diverse measures of social welfare with different numerical weights attached to them.

The objective function is:

$$Q = 16u + 4v + w$$

Where u = new jobs created in millions

v = annual rate of investment as percentage of national income

w = net annual increase in India's net foreign assets as percentage of national income

The numerical weights were arrived at through subjective reasoning.

During his visit to the Indian Statistical Institute during 1957-58, Sandee constructed the first full-scale planning model combining input/output techniques with linear programming. A terminal year linear optimisational model was used by him to maximize aggregate household consumption in 1970 as an excess of consumption over a base year 1960.

In his model, C stands for the increase in total consumption where C' is the starting value in 1960. Then, C/C' is the relative rise in consumption. If p is the relative rise in population, then the per capita increase in consumption is given by C/C'-p.

The per capita increase in consumption of a particular commodity j is

$$n_j(C/C'-p)$$

where n_j is the expenditure elasticity and the total increase is

$$c_j/c'_j = n_j(C/C'-p)+p$$

or

$$c_j = n_j\ c'_j C/C'-n_j pc'_j+pc'_j$$

He, thus, defines incremental consumption in terms of initial consumption, population increase, increase in total consumption and sectoral expenditure elasticities.

Sandee's model has one other notable feature which relates to his treatment of investment in the terminal year. He assumes that investment flows should increase linearly every year in each sector. If Io is the investment in 1960 and y is the increment of investment each year, then total investment in the 10 intermediate years is given by

$$10(Io+5y)$$

This must be equal to rx where r is the capital/ output ratio and x is the increase in output of that particular sector during the period 1960-70.

Thus,

$$10(Io+5y) = rx$$

The increase in the investment will be

$$10y = .2rx - 2Io$$

Inventory is related to output in a similar way.

The model has many other constraints, some of which are introduced with the aim of avoiding unacceptable results. Imports are assumed to be equal to exports and lower and upper bounds are put to the individual net export quantities. Non-competitive imports are not allowed. One set of constraints ensures non-negative investment in each sector.

In the model it is assumed that both investment and consumption go together, maximising the one means maximising the other. The model, thus, fails to consider the trade-off between consumption and investment, which is one of the most crucial policy decisions. The model also does not distinguish between output and capacity. Nevertheless, the model's historical importance cannot be disputed.

The Third Plan, despite its lack of coherence, can be regarded as an improvement over earlier plans in the sense that it, for the first time, involved an examination of consistency at the intersectoral level. Reddaway[9] undertook a systematic demand/supply balance exercise for many industries to test for consistency for the terminal year of the Plan, 1965-66. The terminal year targets of output for 67 commodities were supplied by the Perspective Planning Division in a paper entitled "Certain Dimensional Hypothesis Concerning the Third Plan." Reddaway developed his model in nonmathematical terms. Padma Desai attempted to put Reddaway's exercise in formal mathematical frame; she found the system to be underdetermined.[10]

During the Third Plan period, four models were constructed in connection with the Fourth and Fifth Plans, then scheduled to start in 1966-67 and 1971-72 respectively; three of those are consistency models and one is an optimization model.

The consistency model by Manne, Rudra and others[11] is a 30 sector conventional Leontief inter-industry model with "a few embellishments for the endogenous treatment of capital formation." The base year for the model is 1960 and the terminal year 1970. Independent estimates were made of input/output coefficients, capital/output ratios and demand projections expressly for the purpose of the model.

Some very interesting insights regarding the structure of the Indian economy were obtained from the numerical exercises involved in the model. The discovery of an "acutely block angular structure of the input/output linkage pattern" in the Indian economy was one of the principal findings of the exercise. To quote the authors

> ...within the Indian economy, it appears that there is an almost block-angular structure of current account transactions. The bulk of such transactions takes place within two virtually independent complexes: one based upon agriculture and the other upon mining, metals, machinery and forestry products. The first of these sectors is the predominant source of consumption goods. The second is the source of investment goods, and appears to be the strategic point for import substitution. A third and smaller complex produces items that may be described as "universal intermediates"--fuel, power, transport and chemicals--items that are consumed within virtually all sectors of the economy.[12]

This suggested the possibility of going ahead with a rapid industrialisation program without caring too much about what happens to agriculture.

One of the notable features of the model is its treatment of investment activity in the terminal year. It is assumed that investment grows exponentially at the rate of r per annum. Then, the proportion of investment in the terminal year is given by

$$n = \frac{e^{10r}}{\int_{-s}^{10-s} e^{rt}dt}$$

$$n = re^{rs}/(1-e^{-10r})$$

where s is the assumed time lag between investment and capacity creation. If s is two years and r around 8 per cent then the stock-flow conversion factor n is equal to 0.17.

The consumption vector is taken to be given--derived from aggregated household consumption, an exogenous variable, using Engel curves. The demand projection for consumer item i is written as

$$F_i = p^{70}\int_{-\infty}^{\infty} g^{70}(c)\,D_i^u(c)\,dc$$

where p^{70} stands for population in year 1970, $g^{70}(c)$ represents the log-normal density function for the frequency distribution of consumers over c in year 1970, and $D_i^u(c)$ the cross-section demand function (Engel curve).

Knowing the investment requirements in the terminal year and the consumption vector, the gross production vector can be found as follows. Let X stand for the vector of production levels in 1970, then

$$X_i+M_i = \Sigma a_{ij}X_j+F_i+nb_{ij}(X_j-X_j^o)$$

where X^o stands for the vector of production levels in 1960, M for imports and a_{ij} and b_{ij} are the input/output and capital/output coefficients, respectively.

The model was primarily meant to make numerical projections. Some exercises in parametric variations were also carried out with the help of the model.

The second consistency model "Structure of the Indian Economy: 1975-76" by T. N. Srinivasan, M. R. Saluja and J. C. Sabherwal was an extension up to 1975-76 of the consistency model of Manne and Rudra which had its terminal year 1970.[13] Even the data base is the same except for some changes in the estimates of coefficients. The model in addition to its primary purpose of making numerical projections was also used for the purpose of sensitivity analyses.

Manne with Bergsman produced one more model "An Almost Consistent Inter-temporal Model for India's Fourth and Fifth Plans" shortly after his consistency model with Ashok Rudra and others.[14] The primary purpose of the model was "to explore balance-of-trade time paths under alternative growth and imports substitution strategies." The authors regard the model as a "requirements analysis."

The model is a thirty sector inter-temporal model, the sector classification being the same as in the model by Manne and Rudra. The model has 1966-67 as its base year, and 1970-71 and 1975-76 as its two terminal years. The model first computes a consistent set of output levels, imports, and induced investment for each of the two target years. "After calculating these output levels for the target years, the output levels, the input/output coefficients, and the exogenous final demand for the intermediate years were interpolated log-linearly. Interindustry demands were then calculated by the input/output method." The gap between demand and supply was to be met by "shock absorbers"--by imports in the case of producers' goods, by consumption shortfalls in the case of food and fibers, or by increases in domestic output in the case of services. Since the domestic service sectors, notably construction, turned out to be too severe a bottleneck during the initial years, the model is called almost consistent rather than fully consistent.

The numerical calculations are based upon two alternative time paths of aggregate domestic expenditure, and, for each time path, there are three alternative assumptions concerning import substitution targets.

The results with respect to import substitution show that a rapid import substitution strategy pays off in terms of foreign exchange costs. "The most ambitious import substitution strategy has the highest deficit in the early years but achieves the greatest reduction in future deficits." One other set of results shows that if enough foreign financing is available to cover the trade deficit, the domestic savings ratios (whether marginal or average) do not differ significantly when the growth rates vary but differ when import substitution programs vary. "The more rapid the import substitution program, the less foreign financing becomes available and the greater the reliance upon domestic savings." Finally, the output projections show an interesting trend: the growth rates for producers' goods are much higher during the Fourth than during the Fifth Plan while the output of consumers' goods grows more rapidly during the Fifth Plan.

The India centre of MIT sponsored an ambitious project to build a multisector optimisation model for Indian Planning. The model and results of research were published under the following titles: "An Optimising Planning Model," by S. Chakravarty and L. Lefeber, 1965; "Planning in India" by R. S. Eckaus, 1966; and "Planning for Growth: Multisectoral, Inter-temporal Models Applied to India" by Eckaus and Parikh, 1968.

The model is one of the most detailed and sophisticated planning models developed in the context of Indian Planning. The book by Eckaus and Parikh presents many variants of the original model; the data and numerical results are also reported in great detail. We have borrowed substantially from this exercise both in terms of data and model-frame. The model along with some crucial results are described below.

The model in its core form is a finite horizon, 11 sector, linear optimisation model involving explicit intersectoral and intertemporal relationships. The time horizon of the model coincides with the five years of the Third Five Year Plan.

The Basic Model[15]

1. Objective Function

The objective function is the present discounted value of aggregate private consumption W over the planning period t = 1,---,T;

$$W = \sum_{t=1}^{T} C(t)/(1+w)^{t-1} \qquad (3.12)$$

where C(t) is aggregate consumption in period t and w is the social discount rate.

2. Consumption Growth Constraints

$$C(t+1) \geq C(t)\ [1+g] \qquad (3.13)$$

$$C(o) = \overline{C(o)} \qquad (3.14)$$

where g is the prescribed minimum growth rate for aggregate private consumption and $\overline{C(o)}$ is the aggregate private consumption in the preplan period.

3. Production Accounting Relationships

$$J(t)+H(t)+N(t)+Q(t)+F(t)+G(t)+E(t) \leq M(t)+X(t) \qquad (3.15)$$

where J(t) represents intermeidate inputs, H(t) deliveries for inventory accumulation, N(t) deliveries of investment goods for new fixed capital, Q(t) deliveries of investment goods for restoring depreciated fixed capital, F(t) private consumption, G(t) government consumption, E(t) exports, M(t) imports and X(t) domestic production.

Intermediate Products:

The intermediate requirements for output in each period are determined by Leontief-type matrix of input/output coefficients a(t);

$$J(t) = a(t)X(t) \tag{3.16}$$

Inventory Accumulation:

$$H(t) = s(t)\{X(t+1)-X(t)\} \tag{3.17}$$

$$H(1) = s(1)\{X(2)-(1+lo)\overline{X(o)}\} \tag{3.18}$$

where s(t) is an inventory coefficients matrix and lo is a diagonal matrix of anticipated sectoral growth rates.

Private Consumption:

$$F(t) = c(t)\ C(t) \tag{3.19}$$

where c(t) is a column vector, each term of which indicates the proportion of the sector's output in total consumption.

Government Consumption:

$$G(t) = \overline{G(t)} \qquad (3.20)$$

where $\overline{G(t)}$ is specified exogenously.

Exports:

$$E(t) = \overline{E(t)} \qquad (3.21)$$

where $\overline{E(t)}$ is also specified exogenously.

4. Capacity Constraints

The output in each sector in each period does not exceed the amount producible with the fixed capital in that sector.

$$b(t)\ X(t) \leq K(t) \qquad (3.22)$$

where b(t) is the diagonal matrix of capital/output ratios and K(t) the vector of fixed capital available at the beginning period t.

5. Capital Accounting Relationships

$$K(t+1) \leq K(t)+Z(t+1)+R(t+1)-V(t+1) \qquad (3.23)$$

where Z(t) is the column vector of new additions to fixed-capital capacity in each sector, R(t) vector of depreciated capital capacities that are restored and V(t) column vector of capacities lost in each sector due to depreciation which is treated as exogenous.

Investment Requirements:

$$N(t) = p'Z(t+1)+p''Z(t+2)+p'''Z(t+3) \qquad (3.24)$$

where p', p'', and p''' are investment lag proportions matrices for capital.

Restoration Requirements:

Q(t) and R(t) are related by a formula similar to the one in equation 3.24.

6. Restoration Ceilings

$$R(t) \leq V(t) \qquad (3.25)$$

7. Balance of Payments Constraints

$$uM(t) \leq \overline{A(t)}+uE(t) \qquad (3.26)$$

where u is a unit row vector and $\overline{A(t)}$ is net foreign capital inflow in period t.

8. Imports

Import Composition:

$$M(t) = M'(t)+M''(t) \qquad (3.27)$$

where M'(t) represents non-competitive imports and M''(t) competitive imports.

Non-competitive Imports:

$$M'(t) = m'x(t) \qquad (3.28)$$

where m' is the diagonal matrix of fixed imports coefficients.

Competitive Import Ceilings:

$$M''(t) \leq m''[A(t)+uE(t)-uM'(t)] \qquad (3.29)$$

where m'' is a column vector of (exogenously prescribed) coefficients indicating in each sector maximum use of the foreign exchange available after non-competitive import requirements have been satisfied.

9. Initial Capital-in-progress Restraints

$$K(1) = b(1)(1+lo)\overline{X(o)} \qquad (3.30)$$

$$Z(2)+R(2) \leq b(2)lo(1+lo)\ \overline{X(o)}+V(2) \qquad (3.31)$$

$$Z(3)+R(3) \leq b(3)lo(1+lo)(1+lo)^{2}\overline{X(o)}+V(3) \qquad (3.32)$$

where lo is a diagonal matrix of expected sectoral growth rates.

10. Terminal Requirements

The terminal requirements state the desired minimum levels of the final capital stocks:

$$K(t+1) \geq \overline{K(t+1)} \qquad (3.33)$$

$$K(t+2) \geq \overline{K(t+2)} \qquad (3.34)$$

$$K(t+3) \geq \overline{K(t+3)} \tag{3.35}$$

and

$$s(t)\ X(T+1) \geq \overline{Xs(T+1)} \tag{3.36}$$

where $\overline{Xs(T+1)}$ is the vector of stocks of inventories at the end of the plan.

Equations (3.12 to 3.36) describe the Basic Model. By adding different sets of additional conditions to the Basic Model, many other variants of the Basic Model were built. A Target Model is made by stating the terminal requirements by the following inequalities:

$$K(T+1) \geq b(T)(1+1_r)\overline{X(T)} \tag{3.37}$$

$$K(T+2) \geq b(T)(1+1_r)^2\overline{X(T)} \tag{3.38}$$

$$K(T+3) \geq b(T)(1+1_r)^3\overline{X(T)} \tag{3.39}$$

and

$$s(T)X(T+1) \geq s(T)(1+1_r)\overline{X(T)} \tag{3.40}$$

The assumption made here is that each sector grows post-terminally at the annual sectoral growth rate, 1_{ri}, which is implied between $\overline{X(T)}$ and $\overline{X(o)}$ where $\overline{X(T)}$ are the levels of output for the terminal year that are set as targets. A similar Target Model for the Fourth Plan is also built for the period 1966-67 to 1970-71.

Two other models covering the periods of the Third Plan and the Fourth Plan are made in which the targets are determined as part of the solution, these models are called the Transit Model for the Third Plan and the Transit Model for the Fourth Plan. The models specify the following post-terminal conditions for the components of final demand:

$$F(t) = F(T)(1+g_1)^{t-T} \qquad (3.41)$$

$$G(t) = \overline{G(T)}(1+g_2)^{t-T} \qquad (3.42)$$

$$E(t) = \overline{E(T)}(1+g_3)^{t-T} \qquad (3.43)$$

$$D(t) = \overline{D(T)}(1+g_4)^{t-T} \qquad (3.44)$$

$$M(t) = \overline{M(T)}(1+g_5)^{t-T} \qquad (3.45)$$

for $t > T$

In order to investigate long-term planning issues, the authors have also built two long-term models called the Guidepath Models. The time span of the Guidepath Models is between 18 and 30 years; the unit of time is taken to be 3 years rather than 1 year. The models embody techniques for endogenously changing consumption proportions and for shifting resources from traditional agriculture to modern agriculture. In one of the models, an explicit savings constraint is introduced. The terminal conditions in the model are determined as in the Transit model.

Extensive numerical results were worked out with the help of the model from which some important debatable policy questions have emerged. One startling finding was that the official Plan targets were infeasible. Solutions to the Target Model could be obtained only by changing parameters or by reducing the targets. The Third Plan was also shown to be sub-optimal in the sense that given exactly the same parametric specifications, the model showed that the total discounted sum of consumption would increase if the terminal targets were to be endogenously determined, in other words, value of the objective function was higher in the Transit Model than in the Target Model. But these conclusions have been challenged by Srinivasan.[16] He argues that such "optimality comparisons" are invalid because the official plan might have had a different implicit objective function. The other factors which could be responsible for different results are the crucial assumptions of the model such as lag-structure of investment, fixed commodity pattern of consumption, ceilings on competitive imports, etc.

We now turn to three policy models which were constructed during the late sixties. The main purpose of these models was to make clear the quantitative relations between policy instruments and macro-variables and thus provide valuable help in making policy decisions.

An import substitution model for India was designed by T. E. Weisskopf[17] in 1967. The model is used to generate alternative patterns of domestic production and imports which satisfy a set of predetermined goals of final demand in the terminal year 1975. The growth process is constrained by the lack of savings as well as by the lack of foreign exchange. "When exports are limited exogenously (for example, by inelastic world demand), and when non-competitive imports are required in fixed proportions for domestic production or investment or both, there is always a point beyond which potential domestic savings cannot be increased, for lack of foreign exchange to purchase specific complementary imports. At this point, a higher growth rate can be attained only by working directly on the foreign exchange constraint--by increasing exports, reducing non-competitive imports, or receiving additional foreign aid (net capital inflow)." The import substitution model explores the comparative roles played by the two independent constraints.

The most distinguishing feature of this model is its high degree of sectoral disaggregation. The economy is divided into two parts. The industrial part of the economy is disaggregated into 147 sectors whose level of output and imports are determined endogenously by the model. The remainder of the economy--consisting primarily of the agriculture and services sectors--is divided into three sectors and is strictly exogenous to the model and can affect it only as a source of demand for industrial sector products.

Disaggregation is highly important in the context of choice among alternative production, importing and exporting activities in a linear programming framework. "There is little sense in asking a model to choose between the alternatives of producing or importing the combined output of a 'chemicals' sector, or in asking it to determine whether the export of 'textiles' is profitable."

The core model is a single period terminal year linear programming model with time horizon of 1965 to 1975.

The objective function W is a weighted sum of the domestic (L) and foreign (M) primary resource costs. The domestic resources recognised by the model are primarily labour resources which are required by each of the domestic production activities of the model. These labour requirements are measured in terms of their total wage cost in rupees. The foreign resource cost M is the total c.i.f. dollar value of endogenous imports in the economy. There are four types of endogenous imports in the model: competitive imports of endogenous sector products, imports of non-competitive imports of endogenous sector products, imports of non-competitive agricultural raw materials, and imports of engineering parts and components. The objective function is written as

$$W = Q^L L + Q^M M$$

where the weights Q^L and Q^M are preassigned for each run of the model. The weight ratio Q^M/Q^L can be interpreted as the shadow rate of exchange between rupees and dollars.

Treatment of investment activity in the terminal year is the same as in the consistency model of Manne and Rudra. However, the stock-flow conversion factor n is calculated differently. n is estimated by the following complicated formula:

$$n = \{r^T (1+r^T)^{s-1/2}\}/\{1-(1+r^o)^{-T}\}$$

where r^T is the assumed rate of growth of capital stock after the target year, r^o, between the base and target year, and s is the assumed average gestation lag.

Given the basic structural coefficients, and the initial conditions of the economy, the model is made to provide a wide range of alternative (optimal) solutions for 1975 by changing parametric values. The key parameters include: the rate of growth of exports; the noncompetitive imports; the target rate of growth of aggregate consumption; and the ratio of weights (Q^M/Q^L).

Some interesting results are as follows. When the weight ratio Q^M/Q^L was set equal to 4.75, i.e., equal to the official exchange rate before the devaluation of the Indian rupee in 1966, there were--in addition to essential non-competitive imports--also competitive imports in approximately 30 of the endogenous sectors. "These sectors consisted mainly of modern engineering industries but included also some of the base metals and heavy chemicals."

"For the remaining 100 odd producing sectors--of which about 80 faced competitive imports--domestic production was cheaper than importing at the predevaluation exchange rate, and was hence preferred for every run of the model. As the weight ratio was raised to reflect an increasing premium on foreign exchange, there was a progressive substitution of domestic production activities for competitive imports."

The model also computes the different combination of S and F--as the measures of internal and external resources respectively--required to sustain a given targetted rate of growth of aggregate consumption. The same exercise is repeated under the alternative sets of basic assumptions. A comparison of the results shows that "for a wide range of combinations there is a more or less constant trade-off between domestic and foreign effort which equates one rupee of net foreign capital inflow with roughly two rupees of gross domestic savings."

Weisskopf's model is unconstrained by the availability of domestic resources as it only takes into consideration the foreign exchange constraint. Tendulkar argues that domestic savings are not always capable of being optimally adjusted to the investment requirements, more often than not, because of institutional and behavioural limitations, they pose a binding constraint on the growth of developing economies. He built a model "Interaction Between Domestic and Foreign Resources in Economic Growth: Some Experiments for India" which incorporates both domestic savings and foreign exchange constraints.[18] "For a given availability of foreign assistance and specified institutional limits on savings rates, the model permits an empirical determination of whether the savings constraint is binding or nonbinding."

The basic model is a single-period terminal year linear programming model with a 15-year planning horizon starting from 1960-61 and ending with 1975-76. Two variants of the basic model are considered. The first variant, called Open-Loop variant, is considered where the domestic financing of consumption and investment is regarded exogenous to the system and the optimization process is carried out without domestic savings constraint and subject only to foreign exchange constraint. The second variant, called the Closed-Loop variant, is considered where the domestic financing is made endogenous to the system and the optimization process is carried out subject to both domestic savings and foreign exchange constraints.

The two variants of the model were run under identical assumptions and some very interesting policy conclusions were drawn by comparing the results.

The main impact of savings limitation is reflected in a decline in the average rates of growth of private consumption and gross national product. "This immediately indicates that if the target year growth rate is regarded as fixed, the closed-loop system would reveal higher foreign aid requirements than the open-loop variant."

"In analyzing the effects of variations in net capital inflow, it is observed that a marginal dollar releases only the trade bottleneck in the open-loop system, whereas it directly and simultaneously breaks the savings and trade bottlenecks in the closed-loop system." This results in higher marginal productivity of foreign assistance in the closed-loop system than in the open-loop system.

"The additional foreign aid with unchanged domestic savings specification has been shown to make possible for the closed-loop system, in addition to higher growth rates, inter alia, (1) a higher level of aggregate personal savings; (2) a declining marginal savings ratio; and a downward sloping savings ratio in the target year despite a rising target year ratio of gross investment to GNP. This reveals the savings supplementing role of foreign assistance in all its aspects."

A multiperiod model "A Dynamic Multisectoral Model for India, 1967-75" by Manne and Weisskopf attempts to quantify the implications--both at a macroeconomic and at a sectoral level--of alternative time patterns for the inflow of external assistance.[19]

The model claims to differ from other models in three important respects: the scheme of aggregation reduces the original 30-sector interindustry model to 17 sectors that enter into the linear programming optimization; the "gradualist" consumption path; and the terminal year sectoral allocations of investment are made to conform to turnpike proportions.

The core model is an intertemporal linear programming model with plan horizon of 8 years, stretching from 1967-68 to 1975-76. The model generates, sector by sector, internally consistent paths for domestic production, imports, exports, consumption and investment.

Let C_t denote aggregate consumption expenditures during year t. The values of C_t are constrained to follow "gradualist" consumption paths. In other words, C_t rises monotonically from its given initial values C_o.

$$C_t = C_o + \Delta\{(1+g)^t - 1\}/g$$

where Δ represents the initial period's consumption increment

$$\Delta = C_1 - C_o$$

and g represents the asymtotic rate of consumption growth

$$g = \lim_{t \to \infty} (C_{t+1} - C_t)/C_t$$

g is treated in the model as a policy parameter and Δ is taken as the maximand. When Δ is maximized, consumption is being maximized at each point of time.

In the single-period import substitution model of Weisskopf there were 147 endogenous sectors. But for computational reasons, the original 147 sectors are aggregated into 30 sectors for this multi-period model. The 30 sectors are, in turn, divided into two groups: 17 labelled as "production-oriented" and 13 as "consumption-oriented." The 17 sectors include minerals, metals, machinery, fuel, power and rail transport. These are the sectors on which India's import substitution program has been mainly focused. The 13 consumption-oriented industries include food processing, textiles and paper--all based upon agriculture and forestry products. These sectors are the source of traditional exports. It is assumed that they provide negligible interindustry deliveries.

The model makes two alternative choices for the asymptotic growth rate, g = 8 per cent and 6 per cent. Three alternative time patterns of foreign aid inflows are considered. Numerical results worked out with the help of the model reveal the macroeconomic implications of the three alternative aid programs and the two alternative choices for g. The model also experiments with the length of the plan period, time horizon is reduced from 8 to 6 years in a number of runs.

The Planning Commission prepared a model "A Technical Note on the Approach to the Fifth Plan of India (1974-79)" which might be regarded as an outline of the Fifth Plan.[20] This official model is similar in many respects to a semi-official model "Perspective of Development: 1961-76, Implications of Planning for a Minimum Level of Living," 1962. Both these models are distinguishable from other models in the sense that they are based on certain normative considerations regarding the consumption levels of lower-income groups.

The "Approach to the Fifth Plan" is an open static leontief model ensuring terminal year consistency amongst the output levels of different sectors. A "consumption sub-model" is developed which links the redistribution of consumption amongst different sections of the population with the inter-industry model. The document sets an aim that the lowest 30 per cent of the population would, on the average, enjoy a certain minimum level of consumption. In one case, "it is assumed that the inequality in expenditure in 1978-79 would remain the same as in the base year 1973-74." In this case the average (monthly) private consumption for the poorest 30 per cent of the population will amount to RS.26.33 in the rural area and RS.28.44 in the urban area. The distribution of monthly per capita aggregate expenditure amongst population, urban as well as rural, is assumed to be log-normal.

Imports are estimated endogenously through using suitable import coefficient matrices. The import coefficients are, however, reduced in cases of import substitution.

Several variational exercises with the help of the model were carried out with different assumptions on the growth of gross domestic product and exports, in some cases considering import substitution and reduction in the inequality in the expenditure distribution.

The effect of redistribution of private consumption in favour of the poorer classes of the population is reflected in the increase in the output levels of some of the essential commodities and a decrease in the output levels of some of the non-essential and luxury goods sectors. The effect of import substitution is reflected in higher growth rates in the domestic production, particularly in sectors where import substitution has been envisaged.

Finally we refer to Guha's work which also attempts to explain the effect of various kinds of income distribution schemes on the economy.[21] The consumption patterns of different income groups differ, so that the composition of the final demand vector is altered every time a new distribution of income is considered. He found that in many cases the result of redistribution of income was to increase the value of objective function, i.e., the discounted value of gross output. Redistribution between the two lower income groups led to higher values of objective function than redistribution between the two upper income groups. Moreover, redistribution in the rural sector led to higher value of objective function than redistribution in the urban sector.

In all his cases where he has shown increase in the value of the objective function, the relative share of the agriculture sector increased.

As we can see above, Indian planning models are very broad in scope and deal with many problems facing the Indian economy. The models have contributed greatly by providing insights into the working of the economy which could be of immense help to policy makers.

The models are, however, not without weaknesses.

They leave out all those aspects which cannot be analyzed mathematically. It is impossible to take into account all factors, economic and non-economic, regardless of how important these factors may be in the developmental process, while formulating a quantitative model.

Indian plan models have paid little attention to the limited availability of human and natural resources. The models have generally ignored the constraints arising from the scarcity of these resources. It can be argued, not without reason, that the Indian economy does not face a human resource constraint because of having an abundant supply of labour. But it may not be true in the case of the supply of skilled labour. The case for natural resources constraints is obviously there. Most of the model builders have avoided incorporation of natural resources constraints into their models mainly for technical reasons. Only Eckaus and Parikh have, in the long-term variants of their Basic model, the Guidepath models, introduced land constraint. The Guidepath models allow for shifting of resources from traditional agriculture to modern agriculture (see Chapter 4 for details).

One purpose of our work is to deal with the problem arising from limited availability of land in the case of India. The question of agriculture versus industry has been at the heart of all debates on strategies for development.

It is possible to increase, to some extent, the effective quantity of land for agricultural use by reclaiming land or by raising productivity of land by providing more irrigational facilities and wider application of fertilizers and modern machinery. But all this puts severe strains on other sectors of the economy. It is very difficult to estimate costs (the amount and nature) involved in raising the productivity of land. So we have had to be satisified with the indirect means we have devised to bring in the land constraint; the exact method of introducing the land constraint is detailed in the next chapter which outlines the structure of our model.

FOOTNOTES

CHAPTER 3

1. Two notable attempts at putting together "plans" for India even before independence were the Bombay Plan in 1944 and the Peoples Plan also about the same time. The Bombay Plan was drawn up by a few industrialists; signatories to the plan were: J. R. D. Tata, G. Birla, R. P. Thakurdas, A. Dalal, J. Mathai, A. D. Shraff, and K. Lalbhai. The Peoples Plan was drawn up by M. N. Roy. However, these exercises did not involve any "plan models" as such.

2. Ashok Rudra's book (1975) "Indian Plan Model" surveys, in a connected and detailed manner, most of the works done in this area till the early 1970s. Also see Bhagawati and Chakravarty (1969), and Gupta (1973).

3. Planning Commission, The First Five Year Plan, Government of India Press, 1952, Chapter 1.

4. See Mahalanobis (1953). The Mahalanobis model can be compared with the one built by the Soviet economist, Fel'dman, in 1928, which was applied in the USSR for setting up heavy industries.

5. Mahalanobis (1955).

6. Komiya (1959).

7. Frisch (1960).

8. Sandee (1960).

9. Reddaway (1965).

10. Desai (1963).

11. Manne, Rudra, and Others (1965).

12. Manne, Rudra, and Others (1965), quoted in Rudra (1975), p. 121.

13. Srinivasan, Saluja, and Sabherwal (1965).

14. Bergsman, and Manne (1966).

15. Eckaus and Parikh (1968).

16. Srinivasan (1965), reprinted in Wadhva (1973).

17. Weisskopf (1971).

18. Tendulkar (1971).

19. Manne, and Weisskopf (1970).

20. Planning Commission, Perspective Planning Division (1973).

21. Guha (1976).

CHAPTER 4

THE PLANNING MODEL

4.1 INTRODUCTION

In this chapter we describe the model we have used to study the implications of the industrial strategy which emphasizes heavy industries in the Indian economy. Our model is a dynamic multisectoral planning model defined over 5 sectors and 5 periods. The study is conducted within the framework of a linear programming[1] optimisation model.

Linear programming techniques have been widely used in model building. In this technique, a specific objective function is maximized subject to certain technological and behaviouristic constraints. The constraint set determines the boundaries of the economy's choice set. Linear programming provides an efficient means for the exploration of the choice set. One other advantage of a programming approach is that the solution of the model provides a set of shadow prices corresponding to the various constraints of the model. These shadow prices have very useful economic meaning.

A linear programming problem can be stated as follows:

$$\text{Max } c'x$$
$$\text{Subject to } Ax \leq b$$
$$x \geq o$$

The above primal problem has a dual form

$$\text{Min } p'b$$
$$\text{Subject to } p'A \geq c'$$
$$p' \geq o$$

The shadow prices p' are the solution of the dual problem. The shadow price corresponding to a constraint is the value of change in the objective function when there is a relaxation in the particular constraint by one unit. If a particular constraint is not binding the associated shadow price is zero, but it is binding if the shadow price is positive.

Linear programming models provide an approximate replica of competitive resource allocation. The resource allocative role of shadow prices is comparable to that of actual prices in an economy in full general equilibrium. The shadow prices from the solution of an economy-wide linear programming model thus reflect, in an approximate way, the "real resource trade-offs" in the economy.[2]

One essential imperative of the heavy industries strategy is that large investments be made in the economy during the plan period in order to increase future consumption.

In such a strategy capital is not considered malleable which could be easily transferred between sectors and periods or could be consumed. To ensure such non-transferability of capital, we have introduced a capacity constraint in our model. This constraint ensures that there is non-negative investment in each sector in each period. The effects of this constraint on the pattern of economic development are analyzed by comparing the results of experiments with and without the capacity constraint.

India is a land-scarce nation. The total amount of available cultivable land delimits the output of the agricultural sector. In other words, the limited availability of land is generally believed to act as a binding constraint on growth in general and on the agricultural sector in particular. We have entered this constraint into our model by putting upper limits to the output of the agricultural sector. The model without the land constraint, on the other hand, depicts the situation where the nation is assumed to have abundant supply of land. Agricultural output, in that case, is not constrained by land.

The effects of the land constraint on the growth of other sectors and on the objective function are analyzed by comparing the results from the model with and without the land constraint.

In the case of limited availability of cultivable land, agricultural output can be increased by raising land productivity. Traditional agriculture is associated with low land productivity. Thus by replacing traditional agriculture with modern (high land productivity) agriculture, a substantial increase in productivity can be achieved. The transformation, however, as discussed earlier, is not costless. Besides its distributional effects, modern agriculture or use of modern techniques in agriculture requires many "new" inputs such as chemical fertilizers, power, and machinery which puts heavy demand on the industrial sector.

We have tried to study the impact of such a technological transformation in agriculture on the growth of the Indian economy and on its pattern of industrial development. In our model this transformation is achieved by replacing the traditional agricultural activity by a modern agricultural activity. This required separate data for input and investment requirements in terms of input/output and capital/output coefficients for modern agriculture. For lack of Indian data, these coefficients were taken from Japanese input/output and capital/output tables.

Japan here was chosen because there are many similarities between Japanese agriculture and Indian agriculture. Both nations are predominantly rice growing. Land holdings are small in both coutries as a result of high population to land ratio. High irrigational needs in agriculture is another common feature.

The column vector coefficients of the agricultural sector in the Japanese input/output table are generally higher in value than the respective coefficients in the Indian input/output table. This shows that, as expected, Japanese agriculture uses more intermediate inputs. But the same is not true of the respective coefficients in the capital/output table. The column vector coefficients of the agricultural sector in the Japanese capital/output table are lower in value than the respective Indian coefficients. These coefficients should, however, be interpreted as incremental capital/output coefficients. Indian agriculture lacks developed infrastructural facilities and in early stages of modernization the marginal costs of providing more infrastructural facilities are very high. Japanese agriculture, on the other hand, is highly developed which may explain why the marginal capital requirements are less in Japanese agriculture. The differences in the capital/output coefficients could also be accounted for by difference in the nature of agricultural technology used in the two countries. Modern agricultural technology can broadly be classified into two categories: (a) "mechanical engineering technology" (e.g., use of harvesters, tractors, and power pumps for irrigation) which is basically labour saving but with little effect on yield, and (b) "bio-chemical technology" (e.g. hypbrid seeds and other improved plant materials, new breeds of cattle, and fertizilers and insecticides) which has land saving and yield increasing impact.[3] High yield in Japanese agriculture can be attributed to the use of "bio-chemical technology." In India, agricultural modernization, so far, has been mainly in terms of increased use of "mechanical engineering technology." In one variant of our model, we assume that the overhead capital costs associated with modern agricultural technology are the same as those in Japanese agriculture. In other variants of the model, we retain the Indian capital/outlay coefficients.

We also allow, in some of our experiments, for the possibility of both the Indian and Japanese agricultural technologies being used simultaneously in proportions determined endogenously by the model itself.

The objective function mostly used in our experiments is the present discounted value of private consumption over the plan period. There are, however, two other objective functions also which are used in simulations of our model.

One of the underlying propositions of the heavy industries strategy is that there is a trade-off between present and future consumption. Maximization of consumption in the short-run does not give any consideration to future consumption. It may actually dwarf the economy's growth potential, and future generations may be left worse off as a result. If an explicit consideration is given to future consumption in planning process, the resulting developmental pattern may be very different. To study these questions, some simulations of our model are performed with an objective function which includes both plan-period consumption as well as consumption stream of the post plan period.

One other way of dealing with the issues related to the choices between present and future consumption is to give an explicit attention to capital formation in the planning process. The short-run objectives of planning should then seek an increase both in consumption and investment. In some simulations of our model, an objective function which gives equal weights to consumption and investment is used.

Some features of our model have been taken from Guha's model.[4] The nature of our work being basically experimental we found it unnecessary to build those "standard" features anew.

We now describe our model in detail.

4.2 THE MODEL

The economy is divided into five sectors. These are:

(1) agriculture (X_1)

(2) equipment-manufacturing industries (X_2)

(3) consumer goods industries (X_3)
(4) services and transportation (X_4)
(5) construction industries (X_5)

The gross output vector, X_t, over the planning period t = 1,------5 is thus

$$X_t = \begin{bmatrix} X_{1t} \\ X_{2t} \\ X_{3t} \\ X_{4t} \\ X_{5t} \end{bmatrix} \qquad (4.1)$$

(1) Objective Function

The objective function mostly used in our study is the present discounted value of private consumption over the plan period:

$$\sum_{t=1}^{5} \frac{u'F_t}{(1+d)^{t-1}} \qquad (4.2a)$$

where F_t is the private consumption vector
u' is the unit vector
d is the social discount rate

The two other objective functions used in simulations of the model are as follows.

One objective function includes both plan period consumption and consumption stream of the post-plan period:

$$\sum_{t=1}^{5} \frac{u'F_t}{(1+d)^{t-1}} + \sum_{t=6}^{\infty} \frac{u'F_t}{(1+d)^{t-1}}$$

It is assumed here that consumption in the post-plan period is maintained at the level of final period consumption.

Thus, the objective function can be written as

$$\sum_{t=1}^{5} \frac{u'F_t}{(1+d)^{t-1}} + \sum_{t=6}^{\infty} \frac{u'F_5}{(1+d)^{t-1}}$$

or

$$\sum_{t=1}^{4} \frac{u'F_t}{(1+d)^{t-1}} + u'F_5 \sum_{t=5}^{\infty} \frac{1}{(1+d)^{t-1}}$$

or

$$\sum_{t=1}^{4} \frac{u'F_t}{(1+d)^{t-1}} + \frac{u'F_5}{d(1+d)^3} \qquad (4.2b)$$

The other objective function which emphasizes investment in the economy so that future consumption could be increased, includes both consumption and investment over the plan period:

$$\sum_{t=1}^{5} \frac{u'(F_t+K_t)}{(1+d)^{t-1}} \qquad (4.2c)$$

where K_t is the investment vector. This may be interpreted as an alternative way of taking account of post-plan consumption.

2. Production Accounting Relationships

The basic structural relationship in this model is a material balance equation:

$$a_t+K_t+W_t+E_t+G_t+F_t \leq X_t+M_t \qquad (4.3)$$

where a_t represents intermediate inputs, K_t deliveries of investment goods for capital formation, W_t inventory requirements, F_t private consumption, G_t government consumption, E_t exports and M_t competitive imports.

Unlike developed economies which are constrained by lack of effective demand, India is characterised as a supply constrained economy, i.e., the main problem the economy faces is not so much a lack of demand as not enough output to meet various demands.[5] The above material balance equation captures that supply constraint.

Intermediate Inputs:

The intermediate requirements for output in each period are determined by a Leontief-type relationship:

$$a_t = AX_t \qquad (4.4)$$

where A is an input/output coefficients matrix.

$$A = [A_{ij}]_{5x5} \qquad (4.5)$$

where A_{ij} is the requirement of commodity i as intermediate input for producing one unit of commodity j. We can also write

$$A = [A_{i1}\ A_{i2}\ A_{i3}\ A_{i4}\ A_{i5}] \qquad (4.6)$$

where A_{i1} is the column vector of intermediate input requirements for producing one unit of agriculture output, and so on.

Investment Requirements:

These represent the deliveries made by the capital goods sector for the purpose of capital formation and are determined by the following relationship:

$$K_t = B_1K(X_{t+1}-X_t)+B_2K(X_{t+2}-X_{t+1}) \qquad (4.7)$$

where B_1 and B_2 are the matrices of input requirements for producing one unit of additional capital with one and two period gestation lags; and K is the diagonal matrix of incremental capital/output ratios.

Inventory Requirements:

The ratio of stocks of inventories to output levels is assumed to be fixed. The changes in stocks of inventories is thus proportional to changes in output levels.

$$W_t = W(X_{t+1}-X_t) \qquad (4.8)$$

where W is the matrix of inventory requirements per unit of output.

Exports:

Exports are assumed to be given exogenously.

$$E_t = \overline{E}_t \qquad (4.9)$$

Government Consumption:

Government consumption is also assumed to be given exogenously.

$$G_t = \overline{G}_t \qquad (4.10)$$

Private Consumption:

Households are divided into two sectors, rural (R) and urban (U). Each of these sectors is again divided into three groups according to the size distribution of income: R1 and U1 comprise the poorest 30 per cent of households in rural and urban sectors respectively; R2 and U2 comprise the middle 50 per cent of households in rural and urban sectors respectively; and R3 and U3 the richest 20 per cent of households in rural and urban sectors respectively.

The consumption requirements of all these groups are different from each other. Vector C_{R1} shows the ratio of expenditure in a particular sector to total expenditure for the group R1. C_{R2}, C_{R3}, C_{U1}, C_{U2}, and C_{U3} are similarly defined for the rest of the groups.

The six groups are denoted by xy, where

$x = R,U$

and $y = 1, 2, 3$

The final consumption demand of various groups is given by the following equation.

$$F_{xy}(t) = C_{xy}(1-s_{xy})h_{xy}u'\hat{v}X_t \qquad (4.11)$$

where F_{xy} is the final consumption demand vector of group xy

s_{xy} is the average propensity to save of group xy

h_{xy} is the proportion of total income going to group xy

$\hat{v}$ is the value added conversion matrix

$$\hat{v} = \begin{bmatrix} 1-\sum_i A_{i1}-M^*_{11} & 0 & 0 & 0 & 0 \\ 0 & 1-\sum_i A_{i2}-M^*_{22} & 0 & 0 & 0 \\ 0 & 0 & 1-\sum_i A_{i3}-M^*_{33} & 0 & 0 \\ 0 & 0 & 0 & 1-\sum_i A_{i4}-M^*_{44} & 0 \\ 0 & 0 & 0 & 0 & 1-\sum_i A_{i5}-M^*_{55} \end{bmatrix}$$

where M*'s are elements of the matrix M, defined later in the chapter.

Equation (4.3) can be rewritten as

$$AX_t+B_1K(X_{t+1}-X_t)+B_2K(X_{t+2}-X_{t+1})+W(X_{t+1}-X_t)$$
$$+\bar{E}_t+\bar{G}_t+\Sigma\Sigma C_{xy}(1-s_{xy})h_{xy}u'\hat{v}X_t \leq X_t+M_t \qquad (4.12)$$

As mentioned above, to study the impact of technological transformation in Indian agriculture, we introduce Japanese agricultural technology in our model. Three different possible schemes are considered.

(i) Japanese technology is introduced in the agricultural sector. This is done by replacing the first column coefficients of the Indian input/output matrix, A_{i1}, by the respective coefficients from the Japanese input/output matrix, A_{Ji1}. Group (JI) includes all such cases.

(ii) Japanese technology is introduced in the agricultural sector, and the marginal capital requirements in the agricultural sector are assumed to be equal to those in Japanese agriculture. This is done by replacing the first column coefficients of the Indian input/output matrix A and capital/output matrices (B_1K) and (B_2K) by the respective coefficients from the Japanese input/output matrix A_J and capital/output matrices $(B_1K)_J$ and $(B_2K)_J$. Group (J) includes all such cases.

(iii) In this case we allow for the possibility of both Indian and Japanese agricultural technologies to be used simultaneously and let the model choose itself the appropriate mix. Here, as in case (JI) we retain Indian incremental capital/output coefficients. Agricultural output X_{1t} is produced by both technologies: X_{I1t} using Indian agricultural technology, and X_{J1t} using the Japanese. Thus X_t in equation (4.4) is changed to

$$\begin{bmatrix} X_{I1t} \\ X_{J1t} \\ X_{2t} \\ X_{3t} \\ X_{4t} \\ X_{5t} \end{bmatrix}$$

Matrix A is changed to

$$[A_{i1} \quad A_{Ji1} \quad A_{i2} \quad A_{i3} \quad A_{i4} \quad A_{i5}]$$

and

$$X_{1t} = X_{I1t} + X_{J1t} \qquad (4.13)$$

Group (H), also referred to as the hybrid group, includes all such cases.

The group consisting of cases with the Indian technology and capital costs is called Group (I)

3. Capacity Constraints

Some of the planning models discussed in chapter 3 do not differentiate between capacity and output levels. Treatment of capital as putty makes the transfer of capital between sectors and time periods unrealistically feasible. Even in the highly elaborate planning model of Eckaus and Parikh, decumulation of capital is possible to the extent of depreciation.[6] In Guha's model, investment is related to changes in the output levels. Given that the output levels in some sectors may decline in some periods, investment could even be negative. The implication of this is that his model saves on capital formation in one period or allows negative capital formation in one period in order to be able to provide more consumption in other periods--in other words, allows for consuming capital before it exists.

We have introduced differentiation between capacity levels (C_t) and output levels (X_t) in some sets of experiments with our model. The deliveries made by the capital goods sector for the purpose of capital formation are now related to changes in the capacity levels. X's in equation (4.4) are replaced by C's, thus

$$K_t = B_1K(C_{t+1}-C_t)+B_2K(C_{t+2}-C_{t+1}) \quad (4.14)$$

To make sure that enough capacity to produce the required outputs is available in each sector in each period, the following constraint, referred to as the adequacy constraint, is imposed.

$$C_{jt}-X_{jt} \geq 0 \quad (4.15)$$

Finally, to prevent the already created capacity from falling, the following constraint is imposed.

$$C_{jt+1} \geq C_{jt} \quad (4.16)$$

With the capacity constraint, capital is treated as clay. The constraint, however, allows for the possibility of decline in the output levels.

(4) Land Constraint

The land constraint is introduced by putting upper limits to outputs of the agricultural sector. In Group (H) which allows for the possibility of both the Indian and Japanese technologies being used simultaneously, the constraint takes the following form:

$$x_{I1t} + x_{J1t}/n \leq \bar{X}_{1t} \qquad (4.17)$$

where n is the ratio of Japanese agricultural yield (output per unit of land) to Indian agricultural yield, and $\bar{X}_{1t}$ is an exogenously specified upper limit to output of the agricultural sector.

5. Foreign Exchange Constraints

The model allows for two types of imports--competitive and non-competitive. The demand for foreign exchange for the purposes of imports is given by

$$u'(M_t + MX_t)$$

where M is the diagonal matrix of non-competitve import requirements per unit of output produced.

The total supply of foreign exchange is given by exports and foreign aid, both of which are specified exogenously. The demand for foreign exchange cannot exceed its supply. Thus

$$u'(M_t+MX_t) \leq u'\bar{E}_t+\bar{V}_t \tag{4.18}$$

where $\bar{V}_t$ is foreign aid.

(6) Initial Period Constraints

Output levels in the first two plan years are constrained by the level of capital formation in the pre-plan years because of the two period gestation lag assumed.

$$X_1 \leq \bar{Z}_1 \tag{4.19}$$

$$X_2 \leq \bar{Z}_2 \tag{4.20}$$

where $\bar{Z}_1$ and $\bar{Z}_2$ are the vectors of maximum outputs possible in the first two plan years.

(7) Post-terminal Growth Assumptions

Because of the particular lag structure in our model, the deliveries made by the capital goods sector for the purpose of capital formation in the last one/two periods are related to changes in the output levels in the one/two post-terminal years. It is assumed here that gross output levels in the two post-terminal years are the same as that obtained for the final year.

$$X_5 = X_6 = X_7 \qquad (4.21)$$

(8) Minimum Output Constraints

The linear nature of the model allows for the possibility of corner solutions. As a result, some sectors could have zero output levels. Such results, however, will be totally unacceptable. To avoid such cases, we put certain lower limits to the sectoral output levels.

$$X_t \geq \bar{L}_t \qquad (4.22)$$

where $\bar{L}_t$ is the vector of minimum outputs.

4.3 THE APPLICATION

The main body of data and tables related to India have been either adapted from Guha (1976) or worked out according to the procedures used by him. The sources of data are the following:

(i) A Technical Note on the Approach to the Fifth Plan of India, 1974-79 (Government of India, Planning Commission, April 1973).

(ii) Draft OUtline for the Fifth Plan (Government of India, Planning Commission, 1974).

(iii) Household Income, Saving and Consumer Expenditure (National Council of Applied Economic Research, 1970).

(iv) Planning for Growth by Eckaus and Parikh (1968).

The source of data tables related to Japan is: "Efficient Paths of accumulation and the Turnpike of the Japanese Economy" by Murakami, Takoyama, and Tsukui (1970).

As mentioned earlier, we have divided the economy into five sectors. The Technical Note and the Draft Outline have a 66-sector classification of the economy; Eckaus and Parikh, an 11-sector classification; and Murakami, Takoyama and Tsukui, a 10-sector classification. The correspondence between our sectoral classification and that of others is as follows. Our agriculture sector corresponds to the following sectors in three other classifications:

Planning Commission	Eckaus and Parikh	Japanese
1. Foodgrains	1. Agriculture and plantations	1. Agriculture, fishery, forestry and food
2. Other agriculture		
3. Animal husbandry		
4. Plantations		
5. Forestry		
11. Sugar and gur		
12. Vegetable oil		
13. Tea and coffee		
14. Other food products		

Our equipment-manufacturing industries sector corresponds to the following:

Planning Commission	Eckaus and Parikh	Japanese
6. Coal	2. Mining and metals	4. Metals
7. Miscellaneous coal and petroleum products	3. Equipment	5. Machinery
8. Iron ore	7. Electricity	6. Transportation equipment
9. Crude oil		7. Energy including coal, petroleum, their primary products, electricity and gas
10. Other minerals		
23. Fertilizers		
24. Inorganic heavy chemicals		
25. Organic heavy chemicals		
29. Other chemicals		
30. Petroleum products		
32. Refractories		
33. Other non-metallic mineral products		
34. Iron and steel		
35. Non-ferrous metals		
36. Bolts and nuts		
37. Metal containers		
38. Other metal products		
39. Ball bearings		

41. Agricultural implements

42. Machine tools

43. Other machinery

44. Electric motors

45. Electric wires

46. Electronics

47. Batteries

50. Telephone and telegraphic equipment

51. Other electricals

54. Ships and boats

55. Aircraft

56. Rail equipment

57. Other transport equipment

62. Electricity

Our consumer goods industries sector corresponds to the following:

Planning Commission	Eckaus and Parikh	Japanese
15. Cotton textiles	4. Chemicals	2. Textiles, pulp, paper, leather and rubber products
16. Jute textiles	5. Cement and non-metals (glass, wooden products, ect.)	3. Chemicals, ceramics, and non-coal mining
17. Other textiles	6. Food, clothing, and leather	
18. Miscellaneous		
19. Wood products		

20. Pulp and paper products

21. Leather products

22. Rubber products

26. Plastics

27. Cosmetics and drugs

28. Man-made fibres

40. Office and domestic equipment

48. Electrical household goods

49. Radios

52. Motorcycles

58. Watches and clocks

59. Miscellaneous scientific instruments

60. Other industries

61. Printing

Our services and transportation sector corresponds to the following:

Planning Commission	Eckaus and Parikh	Japanese
64. Railways	8. Transport	9. Transportation and communication
65. Other transport		
66. Other services		10. Trade and services

Finally, our construction industries sector corresponds to the following:

Planning Commission	Eckaus and Parikh	Japanese
31. Cement	9. Construction	8. Construction
65. Construction	10. Housing	
	11. Others and margin	

The A and M matrices were derived from the Technical Note by collapsing the 66-sector classification into a 5-sector classification.

$$A = \begin{bmatrix} .20281936 & .00600970 & .15660305 & .00781281 & .06891044 \\ .04453051 & .33616449 & .12420063 & .02423270 & .14388172 \\ .00327623 & .02022161 & .19326021 & .01458008 & .02203813 \\ .07241034 & .15856755 & .10826021 & .04870775 & .13151783 \\ .01238643 & .02264744 & .01879003 & .01275309 & .12772695 \end{bmatrix}$$

$$M = \begin{bmatrix} .00540165 & 0 & 0 & 0 & 0 \\ 0 & .06675555 & 0 & 0 & 0 \\ 0 & 0 & .04166538 & 0 & 0 \\ 0 & 0 & 0 & .00158654 & 0 \\ 0 & 0 & 0 & 0 & .00791580 \end{bmatrix}$$

The K, B_1, B_2, and W matrices were derived from Eckaus and Parikh's tables by collapsing the 11-sector classification into a 5-sector one. The B_1 and B_2 matrices are equivalent to p', p'', and p''' matrices of Eckaus and Parikh. In their model, equipment, construction, and "others and margin" sectors contribute to capital formation. The equipment, and "others and margin" sectors have two-year gestation lag; the construction sector has three-year gestation lag. In our model, equipment and construction sectors contribute to capital formation. The equipment sector has one-year gestation lag, and the construction sector has two-year gestation lag.

$$K = \begin{bmatrix} 1.510 & 0 & 0 & 0 & 0 \\ 0 & 1.794 & 0 & 0 & 0 \\ 0 & 0 & .785 & 0 & 0 \\ 0 & 0 & 0 & 2.173 & 0 \\ 0 & 0 & 0 & 0 & 1.612 \end{bmatrix}$$

$$B_1K = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ .21895 & .92681 & .43438 & 2.173 & .09071 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$B_2K = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1.28803 & .86494 & .34999 & 0 & 1.5216 \end{bmatrix}$$

$$W = \begin{bmatrix} .318 & .007 & .189 & 0 & .007 \\ .001 & .275 & .240 & .003 & .026 \\ .074 & .037 & .179 & .016 & .036 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

The Japanese input/output and stock-flow matrices were obtained from Murakami, Takoyama, and Tsukui's tables by collapsing the 10-sector classification to a 5-sector one. The stock-flow matrix was then divided into three matrices $(B_1K)_J$, $(B_2K)_J$ and W_J to correspond to the respective Indian matrices. The column vector corresponding to agriculture sector in matrix A_J is

$$\begin{bmatrix} .38546 \\ .07969 \\ .02737 \\ .05979 \\ .01594 \end{bmatrix}$$

In matrix $(B_1K)_J$, it is

$$\begin{bmatrix} 0 \\ .10788 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

In the matrix $(B_2K)_J$, it is

$$\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ .33670 \end{bmatrix}$$

Finally, in matrix W_J, it is

$$\begin{bmatrix} .14694 \\ .03646 \\ .00127 \\ .02903 \\ 0 \end{bmatrix}$$

It was assumed that

$$s_{R1} = s_{U1} = 0$$

$$s_{R2} = s_{U2} = 0.1$$

$$s_{R3} = s_{U3} = 0.2$$

The consumption expenditure ratios C_{xy} for different income groups were calculated from the data available in the Technical Note and NCAER data. The Technical Note gives data on sectoral consumption proportions, based on the 66-sector classification, in 27 different expenditure classes (for rural and urban areas separately). Income distribution figures were obtained from NCAER data.

$$C_{R1} = \begin{bmatrix} .72224018 \\ .00832736 \\ .12248240 \\ .13435103 \\ .01259903 \end{bmatrix} \qquad C_{R2} = \begin{bmatrix} .54992506 \\ .02110958 \\ .16288959 \\ .24419935 \\ .02187642 \end{bmatrix} \qquad C_{R3} = \begin{bmatrix} .50279406 \\ .02276143 \\ .16919947 \\ .27928101 \\ .02596403 \end{bmatrix}$$

$$C_{U1} = \begin{bmatrix} .56229525 \\ .04437262 \\ .14157278 \\ .19666642 \\ .05509293 \end{bmatrix} \qquad C_{U2} = \begin{bmatrix} .42285470 \\ .03978867 \\ .17004262 \\ .27101454 \\ .09629947 \end{bmatrix} \qquad C_{U3} = \begin{bmatrix} .41282627 \\ .03980245 \\ .17689075 \\ .27551445 \\ .09496608 \end{bmatrix}$$

$h_{R1} = .0867 \qquad h_{R2} = .3031 \qquad h_{R3} = .3180$

$h_{U1} = .0277 \qquad h_{U2} = .1046 \qquad h_{U3} = .1554$

Exports (E_t) and government consumption (G_t) for the pre-plan year 1973-74 and for the terminal year (estimate) of the plan 1978-79 were obtained from the Technical Note by aggregating the 66-sector classification to a 5-sector one.

The values for the intermediate years were interpolated linearly.

The figures for the foreign aid V_t were obtained from the Draft Outline. V_t has been maintained at the level of Rs.5000 million for the first four years of the plan and assumed to be zero in the last year of the plan.

The social discount rate d is assumed to be 10 per cent. Although the discount rate is high, but because it is kept constant in all our experiments, the magnitude of the rate is not of much significance from the point of view of comparisons between various versions of the model.

Finally, n, the ratio of Japanese agricultural yield to Indian agricultural yield was calculated from the data given in Production Yearbook, FAO, 1979. Its value was found to be equal to 4.49. This high ratio reflects the highly modernized nature of Japanese agriculture, especially the use of yield-augmenting "bio-chemical technology." In Indian context, increase in yield in the short-run is likely to be much more moderate, so, in some "runs" of the model, it was arbitrarily assigned a lower value equal to 2.

Altogether there are ten variants of the model which are described below.

There are three cases with Indian input/output and capital/output coefficients. Case (I) is the bench mark case; it is without capacity and land constraints. Case (IC) is the case with capacity constraint, and without land constraint. Case (ICL) is the case with both capacity and land constraint.

There are two cases with Japanese input/output coefficients: Case (JI) is the case without capacity constraint; and Case (JIC) is the case with the capacity constraint.

There are two cases with Japanese input/output and capital/output coefficients: Case (J) is the case without capacity constraint; and Case (JC) is the case with capacity constraint.

Finally, there are three hybrid cases. Case (H) is the case without capacity and land constraints. Cases (HCL1) and (HCL2) are the cases with both capacity and land constraints.

4.4 SOME FURTHER COMMENTS ABOUT TECHNOLOGICAL TRANSFORMATION IN AGRICULTURE

Eckaus and Parikh (1968) also deal with the problem of technological transformation in agriculture. Their Guide-path Models provide for a shift from traditional to modern technology in the agricultural sector. Their treatment of the problem is, however, very different from ours. The main differences are:

(i) They consider the issue of technological transformation in agriculture as a long-term planning issue. The models which allow for such transformation, the Guidepath Models, have time span of 18 to 30 years. We have, on the other hand, tried to analyze the short-run effects of technological transformation in agriculture. Our model has a time span of only five years.

(ii) While the issue of technological transformation in agriculture is one of the central issues in our work, it is attached only marginal importance in Eckaus and Parikh's work. The basic Target and Transit models on which the main focus of their book lies, allow only traditional technology in the agricultural sector.

(iii) We have considered four different possible schemes for incorporating modern agricultural technology as described above. Eckaus and Parikh introduce modern agriculture in an "incremental" way. "The process of modernization is not one in which the modern sector displaces the traditional sector on existing land. Rather, it is as if incremental inputs to supplement the traditional inputs are applied to the same piece of land. The land then yields both traditional and incremental output."[7]

4.5 SUMMARY

The dynamic planning model described above is used to study the implications of industrial strategy which emphasizes heavy industries in the Indian economy. First, the benchmark model, Case (I), is run, and then several experiments are performed with the model by changing the constraints or the objective function and comparisons are made between various versions of the model in order to evaluate the impacts of these changes. The capacity constraint is introduced in the model in order to ensure non-transferability of capital between sectors and periods and to prevent consumption of capital even before it exists. The land constraint is introduced in order to evaluate the effect of the limited availability of land on economic growth. To study the impact of technological transformation in agriculture on economic growth, in some experiments Japanese agricultural input/output and capital/output coefficients are used. Finally, the issues related to trade-offs between present and future consumption are studied by using two alternative objective functions which directly or indirectly take future consumption into consideration.

The results of the model--of all its variants--are reported and analyzed in the next three chapters.

FOOTNOTES

CHAPTER 4

1. See Dorfman, Samuelson, and Solow (1958).
2. See Taylor (1975), and Bruno (1975).
3. See Sen (1959), Kaneda (1969), and Hayami and Ruttan (1971).
4. Guha (1976).
5. The possibility of demand constraints being important can be taken into consideration in future work.
6. Eckaus and Parikh (1968), p. 160.
7. Eckaus and Parikh (1968), p. 29.

CHAPTER 5

ANALYSIS OF THE RESULTS

5.1 INTRODUCTION

In this chapter we analyze the empirical results of our study. Several experiments are performed with our model as described in Chapter 4, under varied assumptions and restrictions. We start with the initial case, Case (I), and then we introduce the capacity constraint, the land constraint, and the Japanese agricultural technology into our model. The results of the various cases are then compared with the results of the benchmark case (I) and also among themselves. In this chapter the objective function is the present discounted value of private consumption over the plan period. Simulations are performed with two different objective functions also, the results of which are analyzed in the next chapter.

While the analysis of the results in this chapter, as well as in the next chapter, is conducted both in terms of quantities and shadow prices emerging from the solutions of the linear programming models, the emphasis is, however, on the quantities. Chapter 7 is devoted to a detailed examination of the role and behaviour of the shadow prices generated by the solutions.

5.2 THE INITIAL CASE

In this section we analyze the results of the initial case, Case (I). In this case, there is no distinction between output and capacity levels, hence, no capacity constraint; there is no land constraint; and the agricultural sector uses the traditional (Indian) technology. Table (5.1) shows yearly gross sectoral output levels and the value of the objective function. Agricultural output shows growth in all periods except in the second period. The growth is substantial in the later periods: in the fourth period, the increase in agricultural output is of 22 per cent over the previous period. The share of the agricultural sector in the total output is 38.66 per cent (see Table 5.7). In Table 5.2 we see that there is surplus agricultural output in periods 1, 2, 4 and 5. Although not used, production of this output generates income and, thus, consumption.

Domestic production of equipment goods increases in the second period but declines continuously after that. After the second period, there are imports of equipment goods to supplement the domestic production (see Table 5.3). The share of equipment goods in the total output is 11.81 per cent. Part of the demand for equipment goods is investment demand. The equipment sector contributes to capital formation after one period in our model. As there is no capacity constraint to distinguish between output levels and capacities in this case, if output of one sector was to decline next period, its demand for equipment goods as capital goods will be negative in this period. Equipment goods from this sector could be made available for use by other sectors as investment goods in the next period (and also as intermediate goods in this period). The net domestic supply of equipment goods, i.e., domestic production and imports minus exports, declines after the second period (see Table 5.2). This can be explained partly by the post-terminal growth assumptions we have made. As there is no increase in output levels in the two post-terminal years, the demand for equipment goods as capital goods in the last period is zero. If different post-terminal growth assumptions were made allowing for positive growth in the post-terminal years, we would expect the supply of equipment goods not to decline in the later periods.

Output of consumer goods remains more or less unchanged in the initial three periods, but in the last two periods there is some growth. The net domestic supply of consumer goods increases sharply in period three. There are imports of consumer goods in the third and the final period. The share of consumer goods in the total output is 13.59 per cent.

Output of the services and transport sector increases continuously. In the first two periods, domestic production of services is constrained by the initial restrictions (the upper limits being binding in this case). In these periods, part of the demand for services is met by imports. In the later periods, the increased demand is, however, met by domestic production as there are no binding restrictions on the production levels. The share of services in total output is 29.14 per cent. The high share of services reflects the critical importance of services in the Indian economy. Services are needed for intermediate use because the country's developmental process requires a substantial growth in the infrastructure. Services are also important for both private and government consumption. As a matter of fact, government consumption is primarily composed of services (see Table 5.2).[1]

The construction sector shows growth in the earlier periods. In the initial two periods, the output is constrained by the upper limits. It peaks in the third period. The share of the construction sector in total output is 6.80 per cent. Like the equipment sector, the construction sector also contributes to capital formation, but the gestation lag is of two years in this case. The construction investment has to take place in the first period for the new capacity to be operative in the third period at the earliest. That explains the high construction activity in the earlier periods. In the fourth and the fifth periods, the demand for construction as capital is zero because of the particular post-terminal growth assumptions. Production in these periods drops to the level required for intermediate use and consumption.

Gross output shows an increase of 14.2 per cent over the plan period, from Rs.564846.04 million in the first year to Rs.645244.08 million in the final year of the plan. In terms of annual growth it works out to be 3.4 per cent per annum, which is very close to the average growth rate achieved by the Indian economy.

The value of the objective function is Rs.1375275.46 million in this case. Domestic use of various sectors' output in each period is shown in Table 5.2. The rows of the table give the deliveries made by each sector for the purposes of intermediate use, private and government consumption, and investment as well as surplus. The agricultural and consumer goods are primarily for private consumption, and, to a small extent, they are also needed for intermediate use. Services, on the other hand, are needed for intermediate use and for both private and government consumption. Private consumption demand for equipment goods is relatively small; these goods are primarily for intermediate use and for investment. Finally, most of the construction sector's output is for intermediate use, private consumption, and, in the initial periods, also for investment.

Table 5.4 gives the shadow prices of different sectors (of material balance constraints), and Table 5.5 the shadow prices of the initial and minimum output constraints. The shadow price associated with the first material balance constraint is zero. It implies that an increase in the supply of agriculture output by one unit in the first period will not contribute anything to the objective function. In other words, this constraint is not binding. On the other hand, the services sector has the largest shadow price, 2.6808 in the first period. It means that an increase in the supply of services by one unit in the first period will contribute 2.6808 to the objective function. Shadow prices in the first two periods are higher than those in the later periods. This is because, in our model, output levels in the first two periods are restricted by the initial (preplan) capital endowments.

The shadow prices of imports and foreign exchange are given in Table 5.6. The shadow price of foreign exchange in the first period is also 2.6808. An increase of one unit of foreign exchange in the first period will raise the objective function by 2.6808. The unit of foreign exchange can be used best by importing the product with the highest shadow price, namely, services and transportation, and thus has the same shadow price.

From tables 5.3, 5.5, and 5.6 we observe that in any period only those goods with highest shadow prices are imported, and the shadow price of foreign exchange in that period is equal to those highest shadow prices. For example, the services sector has the highest shadow price in the first two periods, thus, only services are imported in these two periods. This analysis suggests that in periods 1 and 2 the services sector is the bottleneck sector. If we import agricultural goods in the first period, the objective function will not increase because there is already an excess supply of agricultural goods in the first period, or, in other words, there will be no benefit, only import costs. That explains why there are no agricultural imports in the first period. In the last three periods, the equipment sector's shadow prices are highest in value, as a result, equipment goods are imported in all these periods. The imports of consumer goods in the third and the fifth periods are similarly explained.

The overall pattern of development as defined by Case (I) can be summarized as follows. The agricultural and services sectors are the two most important sectors from the point of view of private consumption. The services sector also figures prominently in government consumption demand.

TABLE 5.1

GROSS OUTPUT

(in million Rs.)

	Case (I)	Case (IC)	Case (ICL)
Period 1			
Agriculture	215262.62	234932.31	234887.21
Equipment	81904.38	89090.69	89103.64
Consumer Goods	74629.99	73060.57	73086.78
Services and Transport	153049.05**	153049.05**	153049.05**
Construction	40000.00**	15000.00*	15000.00*
Gross Output	564846.04	565132.62	565126.68
Period 2			
Agriculture	185767.98	178122.45	178133.64
Equipment	99012.81	110000.00**	110000.00**
Consumer Goods	76485.19**	76485.19**	76485.19**
Services and Transport	154775.36**	154775.36**	154775.36**
Construction	45000.00**	28386.84	29059.58
Gross Output	561041.34	547769.84	548453.77
Period 3			
Agriculture	216165.98	220554.70	220804.63
Equipment	73332.67	109374.78	110000.00
Consumer Goods	76910.67	90246.20	88825.12
Services and Transport	179986.12	169834.83	170142.26
Construction	52623.10	31174.99	31175.96
Gross Output	599018.54	621185.50	620947.97
Period 4			
Agriculture	263969.26	280000.00	250000.00**
Equipment	50000.00*	94131.27	110000.00
Consumer Goods	90289.73	93107.21	93326.57
Services and Transport	191599.88	185716.41	183930.51
Construction	32408.55	34782.21	41038.13
Gross Output	628267.42	687737.10	678295.21
Period 5			
Agriculture	277896.46	280000.00	250000.00**
Equipment	50000.00*	80769.52	108668.97
Consumer Goods	89112.72	93107.21	93326.57
Services and Transport	194354.73	194451.50	196388.20
Construction	33880.17	46047.57	46374.66
Gross Output	645244.08	694375.80	694758.40
VALUE OF THE OBJECTIVE FUNCTION	1375275.46	1400059.97	1388455.23

NOTE: Values which are at a lower bound are indicated by a single asterisk, while values at an upper bound are indicated by double asterisks.

TABLE 5.2

DOMESTIC USE OF OUTPUT
Case (I)
(in million Rs.)

	Inter-mediate	Consum-ption	Invest-ment	Gov't	Surplus	Total Supply
Period 1						
Agriculture	50918	160279	0	464	39850	251511
Equipment	61107	7953	14409	2271	0	85740
Consumer Goods	18887	50177	0	3824	0	72888
Services and Transport	49369	76878	0	38253	0	164500
Construction	12984	12923	28690	3503	0	58100
Total	193265	308211	43099	48315	39850	632739
Period 2						
Agriculture	64181	156610	0	505	7388	228684
Equipment	54625	7771	38514	3254	0	104164
Consumer Goods	22694	49029	0	4404	0	76127
Services and Transport	50889	75118	0	40653	0	166660
Construction	13702	12627	15315	4186	0	45830
Total	206091	301156	53829	53002	7388	621465
Period 3						
Agriculture	78785	173020	0	546	0	252351
Equipment	52114	8585	18056	4237	0	82992
Consumer Goods	25365	54166	0	4985	0	84516
Services and Transport	51295	82989	0	43053	0	177337
Construction	14800	13950	19766	4868	0	53384
Total	222359	332710	37822	57689	0	650580
Period 4						
Agriculture	75927	185358	0	587	38557	300429
Equipment	48861	9197	8658	5220	0	71936
Consumer Goods	23750	58029	0	5565	0	87344
Services and Transport	50412	88907	0	45454	3807	188580
Construction	12681	14945	0	5550	0	33176
Total	211631	356437	8658	62376	42364	681465
Period 5						
Agriculture	74472	190742	0	629	48735	314578
Equipment	49836	9464	0	6204	0	65504
Consumer Goods	22723	59714	0	6146	0	88583
Services and Transport	51621	91489	0	47854	0	190964
Construction	13055	15379	0	6233	0	34667
Total	211707	366789	0	67066	48735	694296

TABLE 5.3

COMPETITIVE IMPORTS

(in million Rs.)

	Case (I)	Case (IC)	Case (ICL)
Period 1			
Agriculture	0	0	0
Equipment	0	0	0
Consumer Goods	0	0	0
Services and Transport	13358.52	13035.84	13034.13
Construction	0	0	0
Period 2			
Agriculture	0	0	0
Equipment	0	0	0
Consumer Goods	0	2410.33	2241.04
Services and Transport	14163.14	11192.17	11356.06
Construction	0	0	0
Period 3			
Agriculture	0	0	0
Equipment	7324.95	0	306.64
Consumer Goods	10177.21	0	0
Services and Transport	0	14702.71	14411.69
Construction	0	0	0
Period 4			
Agriculture	0	0	0
Equipment	20292.79	0	0
Consumer Goods	0	1245.96	0
Services and Transport	0	15887.38	16180.24
Construction	0	0	0
Period 5			
Agriculture	0	0	0
Equipment	14441.37	0	0
Consumer Goods	2716.30	3340.56	2671.46
Services and Transport	0	11488.82	10442.71
Construction	0	0	0

TABLE 5.4

SHADOW PRICES OF MATERIAL BALANCE CONSTRAINTS

	Case (I)	Case (IC)	Case (ICL)
Period 1			
Agriculture	0	0	0
Equipment	.2810	.4617	.4615
Consumer Goods	.1783	.2115	.2115
Services and Transport	2,6808	2.4471	2.4455
Construction	.6031	.0175	.0274
Period 2			
Agriculture	0	.2005	.1772
Equipment	.7589	1.4754	1.3238
Consumer Goods	2.2104	2.2956	2.2600
Services and Transport	5.8019	2.2956	2.2600
Construction	.4229	.6699	.6264
Period 3			
Agriculture	.0515	.2049	0
Equipment	.5158	.8090	.8196
Consumer Goods	.5158	.9538	.6544
Services and Transport	.0623	1.4604	.8196
Construction	.1941	.4013	.1214
Period 4			
Agriculture	0	0	0
Equipment	.2735	.3170	.3212
Consumer Goods	.1782	.8263	.6818
Services and Transport	0	.8263	.8137
Construction	.1441	.0266	0
Period 5			
Agriculture	0	0	0
Equipment	.1832	0	0
Consumer Goods	.1832	.2895	.3005
Services and Transport	.1506	.2895	.3005
Construction	.1400	0	0

TABLE 5.5

SHADOW PRICES OF INITIAL AND MINIMUM OUTPUT,
AND LAND CONSTRAINTS

	Case (I)	Case (IC)	Case (ICL)
Initial Constraints			
Period 1			
Agriculture	0	0	0
Equipment	0	0	0
Consumer Goods	0	0	0
Services and Transport	3.3502	2.5770	2.5754
Construction	.2644	.2283	.2194
Period 2			
Agriculture	0	0	0
Equipment	0	.6870	.5640
Consumer Goods	1.4209	1.8710	1.8337
Services and Transport	5.8091	1.9779	1.9729
Construction	.0416	0	0
Minimum Output Constraints			
Period 4			
Equipment	.1077	0	0
Period 5			
Equipment	.2219	0	0
Land Constraints			
Period 3			
Agriculture			0
Period 4			
Agriculture			.1668
Period 5			
Agriculture			.2444

TABLE 5.6

SHADOW PRICES OF IMPORTS AND FOREIGN EXCHANGE

	Case (I)	Case (IC)	Case (ICL)
IMPORT LOWER BOUNDS			
Period 1			
Agriculture	2.6828	2.4471	2.4455
Equipment	2.3998	1.9854	1.9839
Consumer Goods	2.5025	2.2355	2.2340
Services and Transport	0	0	0
Construction	2.0777	2.4295	2.4180
Period 2			
Agriculture	5.8019	2.0951	2.0828
Equipment	5.0430	.8202	.9361
Consumer Goods	3.5915	0	0
Services and Transport	0	0	0
Construction	5.3790	1.6257	1.6335
Period 3			
Agriculture	.4643	1.2555	.8196
Equipment	0	.6514	0
Consumer Goods	0	.5065	.1652
Services and Transport	.4535	0	0
Construction	.3217	1.0591	.6982
Period 4			
Agriculture	.2735	.8263	.8137
Equipment	0	.5093	.4925
Consumer Goods	.0953	0	.1318
Services and Transport	.2735	0	0
Construction	.1294	.7997	.8137
Period 5			
Agriculture	.1832	.2895	.3005
Equipment	0	.2895	.3005
Consumer Goods	0	0	0
Services and Transport	.0325	0	0
Construction	.0431	.2895	.3005
FOREIGN EXCHANGE			
Period 1	2.6808	2.4471	2.4455
Period 2	5.8019	2.2956	2.2600
Period 3	.5158	1.4604	.8196
Period 4	.2735	.8263	.8137
Period 5	.1832	.2895	.3005

TABLE 5.7

SECTORAL SHARES OF GROSS DOMESTIC OUTPUT

Sectors	Agriculture	Equipment	Consumer Goods	Services and Transport	Construction	Total
Case (I)						
Period 1	38.11	14.50	13.21	27.10	7.08	100.0
Period 2	33.11	17.65	13.63	27.59	8.02	100.0
Period 3	36.09	12.24	12.84	30.05	8.78	100.0
Period 4	42.01	7.96	14.37	30.50	5.16	100.0
Period 5	43.07	7.75	13.81	30.12	5.25	100.0
Total	38.66	11.81	13.59	29.14	6.80	100.0
Case (IC)						
Period 1	41.58	15.76	12.93	27.08	2.65	100.0
Period 2	32.52	20.08	13.96	28.26	5.18	100.0
Period 3	35.51	17.61	14.53	27.34	5.02	100.0
Period 4	40.71	13.69	13.54	27.00	5.06	100.0
Period 5	40.33	11.63	13.41	28.00	6.63	100.0
Total	38.30	15.51	13.67	27.53	4.99	100.0
Case (ICL)						
Period 1	41.57	15.76	12.93	27.08	2.65	100.0
Period 2	32.48	20.05	13.94	28.22	5.30	100.0
Period 3	35.56	17.72	14.30	27.40	5.02	100.0
Period 4	36.85	16.22	13.76	27.12	6.05	100.0
Period 5	35.99	15.64	13.43	28.27	6.67	100.0
Total	36.49	16.98	13.68	27.62	5.23	100.0

TABLE 5.8

CAPACITY LEVELS

	Case (IC)	Case (ICL)
Period 1		
Agriculture	250000.00	250000.00
Equipment	100000.00	100000.00
Consumer Goods	75604.13	75604.13
Services and Transport	153049.05	153049.05
Construction	40000.00	40000.00
Period 2		
Agriculture	280000.00	280000.00
Equipment	110000.00	110000.00
Consumer Goods	76485.19	76485.19
Services and Transport	154775.36	154775.36
Construction	45000.00	45000.00
Period 3		
Agriculture	280000.00	280000.00
Equipment	110000.00	110000.00
Consumer Goods	90246.20	88825.12
Services and Transport	169834.83	170142.26
Construction	46047.57	46374.66
Period 4		
Agriculture	280000.00	280000.00
Equipment	110000.00	110000.00
Consumer Goods	93107.21	93326.57
Services and Transport	185716.41	183930.51
Construction	46047.57	46374.66
Period 5		
Agriculture	280000.00	280000.00
Equipment	110000.00	110000.00
Consumer Goods	93107.21	93326.57
Services and Transport	194451.50	196388.20
Construction	46047.57	46374.66

There is a capital build-up in periods 1, 2, and 3, to allow expansion of the sectors which contribute relatively more to consumption in periods 3, 4, and 5. Reduction in agricultural output in period 2 supplies capital to the equipment sector to allow expansion of services in period 3. The equipment investment in periods 3 and 4 is also primarily to allow expansion of the services sector. The construction investment in the initial three periods is primarily to allow agricultural growth in the periods 3, 4, and 5.

5.3 INTRODUCTION OF THE CAPACITY CONSTRAINT

In the initial case discussed above, output levels of the agricultural, equipment and construction sectors fall in some periods. Given the one/two period gestation lags, this implies negative investment (deliveries of capital goods) in these sectors in some earlier periods. The transfer of capital between sectors and between periods is possible because capital is treated here as putty. To avoid such unrealistic transfers of capital, we have introduced the capacity constraint in our model.

The capacity constraint distinguishes between output and capacity levels. As a result, the investment requirements, i.e., the deliveries made by the equipment and construction sectors for the purpose of capital formation, are related to changes in the capacity levels. As described earlier, there are upper limits to the output levels in the first and second periods. So the capacities in the first and second periods are set equal to the specified upper limits of the output levels. The capacities in the later periods can only increase, or at least they are prevented from falling. The results of the initial case with the capacity constraint, Case (IC), given in tables 5.1 and 5.3 - 5.9, are analyzed below in this section. Although the capacity constraint adds some new restrictions in the model, Case (IC) is, however, not a constrained version of Case (I). Separation of output levels and capacities also introduces some flexibility in the model. As the capacities are not linked to intermediate and import requirements, they can take higher values much more easily than the output levels. These higher capacity levels may in effect reduce investment requirements in some sectors because the investment deliveries are related to changes in the capacity levels.

The effect of the capacity constraint on agricultural production is generally not very significant. As in the initial case, agricultural production in this case also declines in the second period, but there is significant growth in the later periods. In the last two periods, agricultural production is at the second period's capacity level. The agricultural sector's share in total output is 38.30 per cent in this case (see Table 5.7). There is surplus agricultural output in periods 1, 4 and 5.

The share of the equipment sector becomes 15.51 per cent in this case. This is very high compared to the initial case discussed above. Production of equipment goods even surpasses that of consumer goods. Equipment goods are produced at capacity level in the second period and that level is almost sustained in the third period. In the last two periods, despite a decline, production remains relatively high. Equipment goods are not imported in any period. One reason accounting for a high equipment goods' share is the increase in deliveries made by this sector for the purpose of investment (see Table 5.9). Unlike the previous case, needs for equipment goods as capital goods cannot be negative because of the capacity constraint in this case. Because equipment cannot be transferred between sectors, more needs to be produced in order to provide the required capacity. As the specified capacities in the second period are higher than those in the first period, there is necessary capacity build-up during this period. To satisfy the capital requirements, equipment goods are at least needed in the first period even if there is no increase in capacity levels after the second period.

Production of consumer goods increases over time but at a slow rate. There is full capacity-utilization in the last four periods (see Table 5.8 for capacity levels). The share of consumer goods in production is 13.67 per cent in this case, almost unchanged from the previous case. There are imports of consumer goods in three periods, although in small quantities. Like consumer goods, the production of services also increases at a low rate. In the initial two periods, the production upper limits are binding and the capacity constraints are binding in the subsequent periods. Services' sectoral share in total output declines from 29.14 in the previous case to 27.53 per cent in this case. There are, however, more imports of services; services are imported in all five periods in this case. There is full capacity-utilization in all five periods in this sector. This sector has the largest shadow price in each period, and, as in Case (I), the highest shadow price occurs in the second period.

The construction sector's output increases gradually over time but its share in total output is relatively low. Because of the lag-structure of the model, the specified capacity-increases in the second period do not require construction like they do equipment goods. And as there are only small increases in capacities in the consumer goods and construction sectors in period 3, the needs for construction as investment in period 1 are low. (Increase in capacities in services does not require construction investment--refer to matrix B_2K in section 4.3). There is capacity build-up in the construction sector in the third period, but that remains largely unutilized until the last period. The shadow price of the construction sector--one of the two sectors which supply capital goods--is relatively low in period 1, which explains why capacity is built in advance in this sector.

These results show that the capacity constraint significantly increases production in the equipment sector. But the effect of the constraint on the construction sector is not favourable. Despite the unfavourable effect on the construction sector, the capital goods sectors, as a whole, benefit from the capacity constraint. The burden of growth in the capital goods sector is borne by the services sector. If an industrial strategy which emphasizes capital formation in the economy is pursued, some sacrifice will need be made in terms of output of some other (i.e., non-capital goods) sector(s). The results of this case in this regard suggest that the sacrifice is made by the services sector with the resulting short-fall made up by imports. It is also to be inferred from these results that the agricultural sector need not bear the burden of the growth in the equipment sector.

The changes in the composition of imports as a result of the introduction of the capacity constraint are in conformity with the import substitution policies implied by the heavy industries strategy. The imports of the equipment

TABLE 5.9

DOMESTIC USE OF OUTPUT
Case (IC)
(in million Rs.)

	Inter-mediate	Consum-ption	Invest-ment	Gov't	Surplus	Total Supply
Period 1						
Agriculture	44678	161470	0	464	64569	271181
Equipment	62220	8012	20423	2271	0	92926
Consumer Goods	16945	50550	0	3824	0	71319
Services and Transport	48475	77449	0	38253	0	164177
Construction	10169	13019	6409	3503	0	33100
Total	182487	310501	26832	48315	64569	632703
Period 2						
Agriculture	68041	152493	0	505	0	221039
Equipment	65536	7566	38796	3254	0	115152
Consumer Goods	26393	47740	0	4404	0	78537
Services and Transport	49893	73143	0	40653	0	163689
Construction	11734	12295	1001	4186	0	29216
Total	221597	293238	39797	53002		607633
Period 3						
Agriculture	82362	173832	0	546	0	256740
Equipment	63094	8625	35754	4237	0	111710
Consumer Goods	28270	54420	0	4985	0	87675
Services and Transport	55455	83379	0	43053	0	181887
Construction	13052	14015	0	4868	0	31935
Total	242233	334272	35754	57689	0	669947
Period 4						
Agriculture	75771	196453	0	587	43649	316460
Equipment	61826	9748	18981	5220	0	95775
Consumer Goods	24340	61502	0	5565	0	91407
Services and Transport	58900	94229	0	45454	0	198583
Construction	14161	15839	0	5550	0	35550
Total	234998	377772	18981	62376	43649	737775
Period 5						
Agriculture	76550	200158	0	629	39345	316682
Equipment	62523	9931	0	6204	3174	81832
Consumer Goods	24394	62662	0	6146	0	93202
Services and Transport	58689	96006	0	47854	0	202549
Construction	15409	16138	0	6233	9054	46834
Total	237565	384897	0	67066	51573	741098

goods are stopped; the economy, thus, produces all required capital goods domestically. The economy imports services and consumer goods to meet part of the demand for these sectors' goods.

Compared to the initial case, the shadow prices of the material balance constraints in this case are somewhat higher in the later periods. The capital goods strategy thus creates some upward pressure on the (general) price level in the economy in the later part of the plan. The shadow prices of foreign exchange and imports also exhibit similar changes. Thus in the later periods, foreign exchange also becomes more scarce and expensive as a result of the introduction of the capacity constraint.

In summary, the main effect of the capacity constraint is to strengthen the equipment sector. The constraint raises the deliveries made by the equipment sector for the purpose of investment. This increased investment activity is provided for by an increase in domestic production of equipment goods.

5.4 INTRODUCTION OF THE LAND CONSTRAINT

In the previous cases, it is implicitly assumed that the economy faces no natural resource constraint. This assumption is, however, unrealistic in the case of the agricultural sector, which is inhibited by the limited availability of land. To capture this land constraint, we have exogenously specified upper limits to the agricultural sector's output levels in some of the experiments. The results of the cases with Indian agricultural technology and with capacity and land constraints are analyzed in this section. Case (ICL) is one such case which has both the capacity and land constraints. The land constraint in this case is introduced by having the same upper limit on agricultural output in all five periods, the limit being equal to the first period's maximum possible agricultural output (i.e., Rs.250000 million). It is assumed here that the limited availability of land precludes the possibility of agricultural output surpassing the specified output limit in the plan period. Later in this section, this constraint is relaxed. Tables 5.1 and 5.3 - 5.8 give the results of this case.

The introduction of the land constraint reduces the share of the agricultural sector in total output: in this case it is 36.49 per cent--a low share in comparison to 38.30 per cent in the initial case with the capacity constraint. Agricultural output declines in the second period and then rises later. Only in the last two years it reaches the allowed maximum level. There are no imports of agricultural goods in any period. The shares of non-agricultural sectors, except consumer goods, increase at the expense of the agricultural sector; the share of consumer goods stays almost the same.

The share of equipment goods is 16.98 per cent, which is one of the highest shares of this sector among all the cases considered. Here again, as in Case (IC) we find that the equipment goods' share is more than the consumer goods' share. Production of equipment goods in the second period is at this period's capacity level and this level of production is maintained until the last plan period. In Case (IC) there is unused capacity in the equipment sector in all but period 2. So, increases in equipment production (up to the capacity levels) do not require additional capacity creation. That explains why equipment production is increased more than production of services and consumer goods, which require additional capacity creation.

The share of services in this case is 27.62 per cent. Production of services increases over time as in Case (IC), and services are imported in all periods in this case. The share of construction goods is 5.23 per cent, marginally larger than in Case (IC).

A comparison of the shadow prices of the material balance constraints between this case and Case (IC) shows that shadow prices in the later periods are marginally lower which indicates that supply constraints are somewhat less restrictive in these periods. This is because of the restrictive growth assumption regarding the agricultural sector which reduces the agricultural sector's demand for inputs. The shadow prices of the land constraint are positive only in the last two periods, as this constraint is binding only in these two periods.

When the land constraint is relaxed, the result is predictably a movement toward Case (IC). In one case, the land constraint is relaxed such that agricultural output is allowed to grow up to Rs.260000 million. In other respects it is similar to the previous case. One obvious outcome of the relaxation of land constraint is that, compared to the previous case, the share of the agricultural sector in production increases while those of other sectors decline. The decline is more severe in the construction sector and in the equipment sector, while the shares of consumer goods and services change only marginally. The value of the objective function registers a small increase. When the land constraint is relaxed even further, with agricultural output allowed to grow up to Rs.270000 million, the results become very similar to those of Case (IC).

In the earlier cases without the land constraint, the agricultural sector experiences a very rapid growth. These cases, however, overestimate the contribution of the agricultural sector because this high agricultural growth is unrealistic in the Indian circumstances. By implication, these cases underestimate the contributions of the other sectors. The land constraint has the effect of limiting the agricultural sector's growth and shifting growth to the other sectors, especially the capital goods sectors.

It may be possible to increase agricultural output by raising land productivity even in the case of limited availability of land. An increase in productivity can be achieved by replacing traditional agriculture with modern agriculture. The next sections of this chapter analyze the results of the experiments in which there is technological substitution in the agricultural sector.

5.5 INTRODUCTION OF JAPANESE TECHNOLOGY

A technological transformation in agriculture, while raising the possibility of an increase in agricultural output, also has repercussions for other sectors as it vastly alters the linkage-pattern in the economy. To evaluate the effects of the use of modern techniques in agriculture on economic development, we have introduced the Japanese agricultural technology in the agricultural sector. To take into account the possibility of larger increases in agricultural output, the initial period constraints for the agricultural sector were relaxed. The introduction of Japanese technology is first considered without capacity and land constraints. This section discusses the results of these cases, reported in tables 5.10 - 5.16. In the later sections, the introduction of Japanese technology is considered along with the capacity and land constraints. The introduction of Japanese technology in the agricultural sector is accomplished in two stages.

5.5.1 Stage One: Replacement of the Input/Output Coefficients

In the first stage, the Japanese input/output coefficients replace the respective Indian coefficients in the agricultural sector. As described in Chapter 4, Case (JI) represents this stage. In the Japanese agricultural technology, the input coefficients are higher than those in the Indian technology, except in the case of the services sector. The technological transformation may thus raise the cost of production of agricultural goods. The increased cost of production lowers the value added component in the agricultural sector and thus makes the agricultural sector less efficient in generating income and consumption. A comparison of the results of this case with those of the initial case reveals the nature and extent to which agricultural modernization along Japanese lines affects the developmental process (see tables 5.10 - 5.15 for Case JI, and tables 5.1 - 5.8 for Case I).

One effect of this transformation is that the value of the objective function declines to Rs.1270149.58 million which is 7.6 per cent lower than in the initial case. The total consumption of goods and services in the economy is thus reduced. The sectoral composition of production and its temporal pattern also undergo wide changes.

Despite the increase in the cost of production of agricultural goods, agricultural output, as compared to the initial case, (I), is considerably larger in the first three periods. In the last two periods it is lower, however. Agricultural output is large in the first two periods, drops in the third period, and recovers somewhat in the last two periods. The share of agriculture in total output also rises to 39.91 per cent. The increase in the agricultural sector's output can be accounted for by the following two factors. One, with the Japanese agricultural technology, the agricultural sector's own input coefficient almost doubles. This means that more agricultural goods will be needed as inputs in this sector. Two, although the overall cost of production of agricultural goods increases, the input coefficient of services (i.e., the input cost in terms of services) is lower in the Japanese agricultural technology. The large levels of output in periods one and two correspond to surplus production, and thus serve primarily to generate income.

The impact of modern agricultural technology is felt most in the services sector. With the introduction of the

Japanese technology, the input demand for services in the agricultural sector becomes less. As a result, the share of services in total output declines to 26.82 per cent, compared to 29.14 per cent in the initial case. The output of the service sector increases till the fourth period, but in the last period it falls. In periods one and two the production of services is at capacity and has the largest shadow price (with consumer goods). Thus the level of consumption is constrained by the ability to supply services in these periods. On the other hand, in period four there is surplus production whose main role is to generate income.

The intermediate input demand for goods from the other sectors in the agricultural sector increases with the introduction of the Japanese technology. The modern agricultural technology gives a boost to the capital goods sectors. In comparison with the initial case (I), both capital goods sectors record moderate improvements in their shares in total output. Domestic production of equipment goods increases in the second period but declines after that. The expansion in the construction sector, on the other hand, takes place in the later periods. Surplus output takes place in the construction sector in periods four and five, generating additional income and consumption.

The intermediate input coefficient of consumer goods in agriculture also is larger when the Japanese technology is introduced. This increases the need for consumer goods as intermediate inputs into the agricultural sector. Domestic production of consumer goods increases over time, except in the third period. The share of consumer goods in total output, however, shrinks to 12.55 per cent. The supply of consumer goods in the initial three periods is, however, augmented by imports of these goods.

The shadow price of agricultural goods rises in periods three, four and five as a result of the introduction of the Japanese technology. The increase in price is, however, not big enough to warrant their imports. In the first and second periods, the shadow prices of both the consumer goods and the services sectors are largest in value. As a result, there are imports in both these sectors in the first two periods. In the third period, the shadow price of the consumer goods sector is highest in value and therefore, all imports occur in this sector in the third period. In periods four and five, equipment goods have the largest shadow price and are imported, in order to supply intermediate inputs.

Gross output shows only a small increase over time. The output in the fifth period is about 11 per cent higher than that in the first period.

TABLE 5.10

GROSS OUTPUT
(in million Rs.)

	Case (JI)	Case (J)	Case (H)
Period 1			
Agriculture	276311.92	270189.39	202675.79
Equipment	96740.51	93784.58	97843.96
Consumer Goods	75604.13**	75604.13**	75604.13**
Services and Transport	153049.05**	153049.05**	153049.05**
Construction	20668.97	31964.82	15000.00*
Gross Output	622374.58	624591.97	544172.93
Period 2			
Agriculture	279606.05	216493.44	273796.43
Equipment	110000.00**	110000.00**	110000.00**
Consumer Goods	76485.19**	76485.19**	76485.19**
Services and Transport	154775.36**	154775.36**	154775.36**
Construction	15000.00*	41550.21	15000.00*
Gross Output	635866.60	599304.20	630056.98
Period 3			
Agriculture	243573.61	294970.62	277760.72
Equipment	96855.08	57654.95	68075.52
Consumer Goods	71929.78	92834.03	73042.44
Services and Transport	178053.44	186595.82	191118.18
Construction	65586.96	63765.43	40987.06
Gross Output	655998.87	695820.85	650983.92
Period 4			
Agriculture	251948.16	457727.96	283427.81
Equipment	50000.00*	50000.00*	50000.00*
Consumer Goods	92668.03	102342.59	93231.26
Services and Transport	201966.66	176882.44	195503.33
Construction	71971.99	37733.30	33551.13
Gross Output	668554.84	824686.29	655713.53
Period 5			
Agriculture	252132.96	280034.74	287497.28
Equipment	69111.51	56640.42	50000.00*
Consumer Goods	93103.64	86153.90	94600.27
Services and Transport	188189.04	172508.17	197504.05
Construction	80831.83	31410.16	34657.94
Gross Output	683368.98	626747.39	664259.54
VALUE OF THE OBJECTIVE FUNCTION	1270149.58	1289834.81	1398191.62

NOTE: Values which are at a lower bound are indicated by a single asterisk, while values at an upper bound are indicated by double asterisks.

TABLE 5.11

COMPETITIVE IMPORTS
(in million Rs.)

	Case (JI)	Case (J)	Case (H)
Period 1			
Agriculture	0	0	0
Equipment	0	0	0
Consumer Goods	3832.99	4469.93	3828.38
Services and Transport	8317.81	7821.85	8691.39
Construction	0	0	0
Period 2			
Agriculture	0	0	0
Equipment	0	0	0
Consumer Goods	868.50	1964.53	1775.81
Services and Transport	12291.79	11326.50	11415.86
Construction	0	0	0
Period 3			
Agriculture	0	0	0
Equipment	0	17360.93	0
Consumer Goods	15891.85	0	17756.02
Services and Transport	0	0	0
Construction	0	0	0
Period 4			
Agriculture	0	0	0
Equipment	19929.00	0	20049.88
Consumer Goods	0	0	0
Services and Transport	0	18725.19	0
Construction	0	0	0
Period 5			
Agriculture	0	0	0
Equipment	15492.87	16880.34	15994.55
Consumer Goods	0	0	0
Services and Transport	0	0	871.41
Construction	0	0	0

TABLE 5.12

SHADOW PRICES OF MATERIAL BALANCE CONSTRAINTS

	Case (JI)	Case (J)	Case (H)
Period 1			
Agriculture	0	0	0
Equipment	.2551	.1476	.2930
Consumer Goods	2.2989	1.7448	2.5051
Services and Transport	2.2989	1.7448	2.5051
Construction	.3225	.1199	.2925
Period 2			
Agriculture	0	.0765	0
Equipment	.6330	1.2077	.9525
Consumer Goods	3.5070	1.8965	3.3806
Services and Transport	3.5070	1.8965	3.3806
Construction	.2453	.1739	.2781
Period 3			
Agriculture	.2183	.0265	0
Equipment	.4375	.7709	.6309
Consumer Goods	.7092	.6720	.8047
Services and Transport	.0652	.6260	.3303
Construction	.1164	0	.0595
Period 4			
Agriculture	.1095	0	0
Equipment	.2140	.3766	.3972
Consumer Goods	.1970	.4166	.2368
Services and Transport	0	.4899	0
Construction	0	.2479	.1640
Period 5			
Agriculture	.0819	0	0
Equipment	.2825	.6809	.5765
Consumer Goods	.1440	.4430	.4395
Services and Transport	.0147	.5228	.5765
Construction	0	.0461	.1423

TABLE 5.13

SHADOW PRICES OF INITIAL AND MINIMUM OUTPUT CONSTRAINTS

	Case (JI)	Case (J)	Case (H)
INITIAL CONSTRAINTS			
Period 1			
Agriculture	0	0	0
Equipment	0	0	0
Consumer Goods	2.0656	1.6208	2.2333
Services and Transport	2.7705	2.1843	2.9691
Construction	0	0	.0899
Period 2			
Agriculture	0	0	0
Equipment	.1426	1.7319	.6995
Consumer Goods	2.6312	1.8939	2.6408
Services and Transport	3.6706	4.0881	4.1845
Construction	.1100	0	.1133
MINIMUM OUTPUT CONSTRAINTS			
Period 4			
Equipment	.0565	.3269	.0292
Period 5			
Equipment	0	0	.1472

TABLE 5.14

SHADOW PRICES OF IMPORTS AND FOREIGN EXCHANGE

	Case (JI)	Case (J)	Case (H)
IMPORT LOWER BOUNDS			
Period 1			
Agriculture	2.2989	1.7448	2.5051
Equipment	2.0438	1.5972	2.2121
Consumer Goods	0	0	0
Services and Transport	0	0	0
Construction	1.9763	1.6248	2.2126
Period 2			
Agriculture	3.5070	1.8199	3.3806
Equipment	2.8740	.6888	2.4280
Consumer Goods	0	0	0
Services and Transport	0	0	0
Construction	3.2617	1.7226	3.1025
Period 3			
Agriculture	.4908	.7443	.8047
Equipment	.2717	0	.1737
Consumer Goods	0	.0988	0
Services and Transport	.6440	.1448	.4744
Construction	.5928	.7709	.7452
Period 4			
Agriculture	.1044	.4899	.3972
Equipment	0	.1132	0
Consumer Goods	.0169	.0732	.1603
Services and Transport	.2140	0	.3972
Construction	.2140	.2420	.2331
Period 5			
Agriculture	.2005	.6809	.5765
Equipment	0	0	0
Consumer Goods	.1384	.2378	.1370
Services and Transport	.2677	.1580	0
Construction	.2825	.6347	.4342
FOREIGN EXCHANGE			
Period 1	2.2989	1.7448	2.5051
Period 2	3.5070	1.8965	3.3806
Period 3	.7092	.7709	.8047
Period 4	.2140	.4899	.3972
Period 5	.2825	.6809	.5765

TABLE 5.15

SECTORAL SHARES OF GROSS DOMESTIC OUTPUT

Sectors	Agriculture	Equipment	Consumer Goods	Services and Transport	Construc- tion	Total
Case (JI)						
Period 1	44.40	15.54	12.15	24.59	3.32	100.00
Period 2	43.98	17.30	12.03	24.34	2.35	100.00
Period 3	37.13	14.76	10.96	27.14	10.00	100.00
Period 4	37.69	7.48	13.86	30.21	10.76	100.00
Period 5	36.90	10.11	13.62	27.54	11.83	100.00
Total	39.91	12.94	12.55	26.82	7.78	100.00
Case (J)						
Period 1	43.26	15.01	12.10	24.50	5.12	100.00
Period 2	36.13	18.35	12.76	25.83	6.93	100.00
Period 3	42.40	8.28	13.34	26.82	9.16	100.00
Period 4	55.51	6.06	12.41	21.45	4.57	100.00
Period 5	44.69	9.03	13.74	27.53	5.01	100.00
Total	45.07	10.92	12.86	25.03	6.12	100.00
Case (H)						
Period 1	37.25	17.98	13.89	28.13	2.75	100.00
Period 2	43.46	17.46	12.14	24.56	2.38	100.00
Period 3	42.67	10.46	11.22	29.36	6.29	100.00
Period 4	43.23	7.62	14.22	29.82	5.11	100.00
Period 5	43.29	7.52	14.24	29.74	5.21	100.00
Total	42.13	11.95	13.13	28.36	4.43	100.00

5.5.2 Stage Two: Replacement of the Input/Output and Capital/Output Coefficients

In the second stage of the technological transformation, the Japanese input/output and capital/output coefficients in the agricultural sector replace the respective Indian coefficients. Case (J) represents this stage. Some of the trends which were established in the previous case are further accentuated in this case. In this case, total agricultural output increases drastically because the Japanese capital/output coefficients in the agricultural sector are lower than the replaced Indian coefficients which makes the increase of capacity in the agricultural sector cheaper. The share of agriculture in total output becomes 45.07 per cent in this case, the highest share of this sector in all the cases considered. One obvious outcome of this is that output of the other sectors shrinks in relative terms. Agricultural output, after declining in the second period, shoots up in the third and fourth periods. Compared to the first period, agricultural output in the fourth period is almost 70 per cent higher. In this fifth period, however, there is a big drop. In periods one, four and five there is surplus output in the agricultural sector, which serves to generate income and consumption.

Domestic production of equipment goods declines drastically in this case, reaching its lowest level in the fourth period. In the third and fifth periods, however, there are imports of equipment goods which enhance its supply. The share of equipment goods in total output falls to 10.92 per cent. This is the lowest share of this sector among all cases considered.

The drastic growth in agricultural production raises the demand for consumer goods as inputs into the agricultural sector, as well as for consumption. As a result, compared to the previous case, production of consumer goods increases moderately in this case, especially in the third and fourth periods.

Production of services records further decline in this case. The production is especially low in the last two periods. There are, however, imports of services in the fourth period, in which services have the highest shadow price. The share of services in total output is 25.03 per cent in this case.

The input coefficient of the construction sector in providing agricultural capital is reduced significantly with the technological transformation. As a result, the investment needs for construction are also reduced. That brings down the construction sector's share in total output to 6.12 per cent in this case.

The weakening of the capital goods sectors is consequent upon the lowering of capital/output coefficients as a result of the introduction of the Japanese technology. These lower coefficients are, however, an understatement in the Indian context. The Japanese coefficients used in our study reflect bio-chemical technology, and they are marginal coefficients. Given the highly developed infrastructure in agriculture, they represent the additional investments required to raise agricultural output. Raising agricultural output in India will require much higher levels of investment in agriculture, not lower, as suggested by the Japanese coefficients. If the Indian capital/output coefficients were replaced by coefficients higher in value, the outcome would have been, in all likelihood, a substantial growth in the capital goods sectors. The results of this case and of the other cases in group (J) should therefore be qualified.

The value of the objective function is Rs.1289834.81 million, which is more than in the previous case because there are relatively less investment needs in this case, but it still remains less compared to the initial case (I). Gross output increases in the initial periods but declines substantially in the last period. Gross output in the fourth period is 32.0 per cent higher than in the first period.

5.5.3 The Hybrid Case

In the two cases described above, the technological transformation covers the whole of the agricutural sector, i.e., the traditional techniques in the agricultural sector are completely replaced with the modern techniques. In some experiments of our model (the hybrid cases), we allow for partial replacement of the traditional techniques with the modern techniques: the traditional agricultural techniques are replaced with the modern agricultural techniques only on part of the cultivated land and only in certain periods. Case (H) is one such hybrid case. In this case, both Indian and Japanese agricultural technologies are allowed to be used simultaneously in proportions determined endogenously by the model. The technological transformation is similar to the first stage, i.e., only the input/output coefficients of the agricultural sector, not the capital/output coefficients,are replaced. The results of this case are described below.

The Japanese technology is used only in the second period,producing all agricultural output in this period. The share of the agricultural sector in total output is 42.13 per cent in this case, which is considerably higher than in the initial case. The reason for only one period use of the Japanese agricultural technology is that it is

TABLE 5.16

AGRICULTURAL PRODUCTION BY INDIAN AND JAPANESE TECHNOLOGY IN CASE (H)

(in million Rs.)

(Figures in parentheses are in percentage)

Period	By Indian Technology		By Japanese Technology		Total
1	202675.79	(100.00)	0	(0)	202675.79
2	0	(0)	273796.43	(100.00)	273796.43
3	277760.72	(100.00)	0	(0)	277760.72
4	283427.81	(100.00)	0	(0)	283427.81
5	287497.28	(100.00)	0	(0)	287497.28

costlier than the Indian technology, except that it requires less services as input. Therefore, only in the second period in which services are most scarce and costly of all sectoral products (see Table 5.4) is the Japanese technology used in the agricultural sector.

The other sectors, except the construction sector, record some improvement in production in this case (in comparison with the initial case [I]). The share of equipment goods in total output is marginally higher in this case than in the initial case, while those of consumer goods and services are marginally lower. The construction sector, however, experiences a significant diminution in its share: its share in total output falls to 4.43 per cent, the lowest share of this sector among all the cases considered.

As this case provides more flexibility than the initial case (I), the value of the objective function is Rs.1398191.62 million, slightly more than in the initial case.

5.6 THE CAPACITY CONSTRAINT AND THE JAPANESE AGRICULTURAL TECHNOLOGY

The effects of the use of modern techniques in agriculture in conjunction with the capacity constraint are explored in this section. Tables 5.17 - 5.23 give the results of the cases with the capacity constraint and the Japanese agricultural technology.

5.6.1 The First Stage

Case (JIC) is a case in which the agricultural sector's input/output coefficients are taken from the Japanese matrix. The effects of the introduction of Japanese technology, which can be assessed by comparing the results of this case with those of the initial case with the capacity constraint, Case (IC), are described below.

The agricultural sector's share in total output is 39.34 per cent in this case, which is moderately higher than in Case (IC). The levels of agricultural production are substantially higher in the first three periods. As with the Japanese technology, the agricultural sector's demand for inputs from the capital goods sectors increases, the growth in the agricultural sector strengthens the capital goods sectors. The effect on the construction section is particularly significant: its share in total output is 6.83 per cent in this case, compared with 4.49 per cent in Case (IC). Capacity utilization in the capital goods sectors is almost full in this case, as opposed to Case (IC) where there was excess capacity in the later periods.

The shares of consumer goods and services fall as a result of the introduction of the Japanese technology. The change in consumer goods' share is very small, but in the case of services, it is substantial. The decline in the

TABLE 5.17

GROSS OUTPUT
(in million Rs.)

	Case (JIC)	Case (JC)	Case (HCL1)	Case (HCL2)
Period 1				
Agriculture	280000.00**	280000.00**	234920.36	234866.04
Equipment	100000.00**	95613.74	89106.81	89124.55
Consumer Goods	75604.13**	75604.13**	73050.20	73078.86
Services and Transport	153049.05**	153049.05**	153049.05**	153049.05**
Construction	22944.37	25954.20	15000.00*	15000.00*
Gross Output	641597.55	630221.12	565126.42	565118.50
Period 2				
Agriculture	216949.27	200501.57	177706.17	177649.13
Equipment	110000.00**	110000.00**	110000.00**	110000.00**
Consumer Goods	76485.19**	76485.19**	76485.19**	76485.19**
Services and Transport	154775.36	154775.36**	154775.36**	154775.36**
Construction	28891.40	29618.90	28963.56	29840.88
Gross Output	587101.22	571381.02	547930.28	548750.56
Period 3				
Agriculture	251642.98	260016.26	218834.15	218726.79
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	90978.31	89010.74	90438.82	89036.19
Services and Transport	166044.64	168257.14	169630.73	170047.45
Construction	54034.63	41086.95	31125.03	31090.36
Gross Output	672700.56	668371.09	620028.73	618900.79
Period 4				
Agriculture	280000.00	301333.79	274138.92	250000.00
Equipment	110000.00	110000.00	103478.00	110000.00
Consumer Goods	94039.39	95327.77	94990.06	95494.45
Services and Transport	174266.91	176695.30	184166.96	183484.24
Construction	54354.20	45000.00	34746.68	37692.53
Gross Output	712660.50	728356.86	691520.61	676671.22
Period 5				
Agriculture	280000.00	322965.53	280000.00	280000.00
Equipment	97477.23	94641.10	91748.63	99341.43
Consumer Goods	96181.10	98451.68	94990.06	95494.45
Services and Transport	181453.49	182777.13	195159.40	197183.42
Construction	66831.71	45000.00	45948.25	46326.28
Gross Output	721943.53	743835.44	707846.33	718345.58
VALUE OF THE OBJECTIVE FUNCTION	1265172.56	1268084.70	1391996.87	1388863.45

Note: Single and double asterisks indicate values at lower and upper bound, respectively.

TABLE 5.18

COMPETITIVE IMPORTS
(in million Rs.)

	Case (JIC)	Case (JC)	Case (HCLI)	Case (HCL2)
Period 1				
Agriculture	0	0	0	0
Equipment	1680.01	0	0	0
Consumer Goods	0	4596.46	0	0
Services and Transport	10215.27	7567.79	13035.26	13033.18
Construction	0	0	0	0
Period 2				
Agriculture	0	0	0	0
Equipment	2631.98	7996.67	0	0
Consumer Goods	4677.73	0	2359.06	2154.09
Services and Transport	6079.05	5475.18	11241.12	11439.45
Construction	0	0	0	0
Period 3				
Agriculture	0	0	0	0
Equipment	0	2813.65	0	666.06
Consumer Goods	0	0	0	0
Services and Transport	14287.60	11609.68	14662.96	14055.53
Construction	0	0	0	0
Period 4				
Agriculture	0	0	0	0
Equipment	124.70	0	0	0
Consumer Goods	0	0	0	0
Services and Transport	15773.70	15799.69	16465.35	16117.10
Construction	0	0	0	0
Period 5				
Agriculture	0	0	0	0
Equipment	0	0	0	0
Consumer Goods	0	0	2498.06	2819.39
Services and Transport	13442.07	13475.43	11519.61	10664.20
Construction	0	0	0	0

TABLE 5.19

SHADOW PRICES OF MATERIAL BALANCE CONSTRAINTS

	Case (JIC)	Case (JC)	Case (HCL1)	Case (HCL2)
Period 1				
Agriculture	0	0	0	0
Equipment	1.4337	.1483	.4615	.4615
Consumer Goods	.0723	1.3645	.2115	.2115
Services and Transport	1.4337	1.3645	2.4459	2.4455
Construction	.1283	0	.0248	.0274
Period 2				
Agriculture	0	.0833	.2160	.1772
Equipment	1.2465	1.3905	1.3580	1.3238
Consumer Goods	1.2465	.8813	2.3737	2.2600
Services and Transport	1.2465	1.3905	2.3737	2.2600
Construction	.2169	.2996	.6852	.6264
Period 3				
Agriculture	.0089	0	.0675	0
Equipment	.6954	.8556	.8259	.8196
Consumer Goods	.6586	.5179	.7265	.6544
Services and Transport	.9293	.8556	.9549	.8196
Construction	.0913	.0714	.1954	.1214
Period 4				
Agriculture	0	0	0	0
Equipment	.3412	.4151	.3188	.3212
Consumer Goods	.3142	.4627	.7658	.6818
Services and Transport	.3412	.6145	.8550	.8137
Construction	0	0	.0209	0
Period 5				
Agriculture	0	0	0	0
Equipment	0	.1866	0	0
Consumer Goods	.2452	.4483	.2941	.3005
Services and Transport	.3401	.6033	.2941	.3005
Construction	0	0	0	0

TABLE 5.20

SHADOW PRICES OF INITIAL OUTPUT AND LAND CONSTRAINTS

	Case (JIC)	Case (JC)	Case (HCL1)	Case (HCL2)
INITIAL CONSTRAINTS				
Period 1				
Agriculture	.0135	.0697	0	0
Equipment	1.2183	0	0	0
Consumer Goods	.2006	1.2908	0	0
Services and Transport	1.7866	1.6273	2.5758	2.5754
Construction	0	0	.2217	.2194
Period 2				
Agriculture	0	0	0	0
Equipment	.6270	1.0185	.5476	.5640
Consumer Goods	.9338	.6389	1.9113	1.8337
Services and Transport	1.4224	1.5164	2.0253	1.9729
Construction	0	0	0	0
LAND CONSTRAINTS				
Period 4				
Agriculture			.1284	.1668
Period 5				
Agriculture			.1490	.2308

TABLE 5.21

SHADOW PRICES OF IMPORTS AND FOREIGN EXCHANGE

	Case (JIC)	Case (JC)	Case (HCL1)	Case (HCL2)
IMPORT LOWER BOUNDS				
Period 1				
Agriculture	1.4337	1.3645	2.4459	2.4451
Equipment	0	1.2162	1.9843	1.9839
Consumer Goods	1.3614	0	2.2344	2.2340
Services and Transport	0	0	0	0
Construction	1.3053	1.3645	2.4210	2.4180
Period 2				
Agriculture	1.2465	1.3072	2.1577	2.0828
Equipment	0	0	1.0156	.9361
Consumer Goods	0	.5092	0	0
Services and Transport	0	0	0	0
Construction	1.0296	1.0909	1.6884	1.6335
Period 3				
Agriculture	.9204	.8556	.8873	.8196
Equipment	.2338	0	.1289	0
Consumer Goods	.2706	.3377	.2284	.1652
Services and Transport	0	0	0	0
Construction	.8380	.7842	.7595	.6982
Period 4				
Agriculture	.3412	.6145	.8550	.8137
Equipment	0	.1994	.5362	.4925
Consumer Goods	.0270	.1518	.0891	.1318
Services and Transport	0	0	0	0
Construction	.3412	.6145	.8340	.8137
Period 5				
Agriculture	.3401	.6033	.2941	.3005
Equipment	.3401	.4166	.2941	.3005
Consumer Goods	.0948	.1549	0	0
Services and Transport	0	0	0	0
Construction	.3401	.6033	.2941	.3005
FOREIGN EXCHANGE				
Period 1	1.4337	1.3645	2.4459	2.4455
Period 2	1.2465	1.3905	2.3737	2.2600
Period 3	.9293	.8556	.9549	.8196
Period 4	.3412	.6145	.8550	.8137
Period 5	.3401	.6033	.2941	.3005

TABLE 5.22

SECTORAL SHARES OF GROSS DOMESTIC OUTPUT

Sectors	Agriculture	Equipment	Consumer Goods	Services and Transport	Construction	Total
Case (JIC)						
Period 1	44.34	15.83	11.97	24.23	3.63	100.00
Period 2	36.95	18.74	13.03	26.36	4.92	100.00
Period 3	37.41	16.35	13.53	24.68	8.03	100.00
Period 4	39.30	15.43	13.20	24.45	7.62	100.00
Period 5	38.79	13.50	13.32	25.14	9.25	100.00
Total	39.34	15.85	13.03	24.94	6.83	100.00
Case (JC)						
Period 1	44.43	15.17	11.99	24.29	4.12	100.00
Period 2	35.10	19.25	13.38	27.09	5.18	100.00
Period 3	38.91	16.46	13.32	25.17	6.14	100.00
Period 4	41.38	15.10	13.09	24.26	6.17	100.00
Period 5	43.42	12.72	13.24	24.57	6.05	100.00
Total	40.84	15.57	13.01	25.00	5.58	100.00
Case (HCL1)						
Period 1	41.57	15.77	12.93	27.08	2.65	100.00
Period 2	32.43	20.08	13.96	28.25	5.28	100.00
Period 3	35.29	17.74	14.59	27.36	5.02	100.00
Period 4	39.65	14.96	13.74	26.63	5.02	100.00
Period 5	39.56	12.96	13.42	27.57	6.49	100.00
Total	37.85	16.10	13.73	27.35	4.97	100.00
Case(HCL2)						
Period 1	41.57	15.77	12.93	27.08	2.65	100.00
Period 2	32.37	20.05	13.94	28.21	5.43	100.00
Period 3	35.34	17.77	14.39	27.48	5.02	100.00
Period 4	36.95	16.25	14.11	27.12	5.57	100.00
Period 5	38.98	13.83	13.29	27.45	6.45	100.00
Total	37.13	16.58	13.73	27.45	5.11	100.00

TABLE 5.23

CAPACITY LEVELS

	Case (JIC)	Case (JC)	Case (HCL1)	Case (HCL2)
Period 1				
Agriculture	280000.00	280000.00	280000.00	280000.00
Equipment	100000.00	100000.00	100000.00	100000.00
Consumer Goods	75604.13	75604.13	75604.13	75604.13
Services and Transport	153049.05	153049.05	153049.05	153049.05
Construction	40000.00	40000.00	40000.00	40000.00
Period 2				
Agriculture	280000.00	280000.00	280000.00	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	76485.19	76485.19	76485.19	76485.19
Services and Transport	154775.36	154775.36	154775.36	154775.36
Construction	45000.00	45000.00	45000.00	45000.00
Period 3				
Agriculture	280000.00	301333.79	280000.00	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	90978.31	89010.74	90678.52	89036.19
Services and Transport	166044.64	168257.14	169630.73	170047.45
Construction	54354.20	45000.00	45948.25	46326.28
Period 4				
Agriculture	280000.00	301333.79	280000.00	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	94039.39	95327.77	94990.06	95494.45
Services and Transport	174266.91	176695.30	184166.96	183484.24
Construction	54354.20	45000.00	45948.25	46326.28
Period 5				
Agriculture	280000.00	322965.53	280000.00	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	96181.10	98451.68	94990.06	95494.45
Services and Transport	181453.49	182777.13	195159.40	197183.42
Construction	66831.71	45000.00	45948.25	46326.28

share of services can be accounted for by the agricultural sector's relatively low demand for services as input in the Japanese technology. In the initial periods, imports of services also decline,leaving as a result, the supply of services lower in all periods compared to Case (IC).

The value of the objective function is substantially lower than in Case (IC), indicating that the Japanese technology is inappropriate in the context of the other sectors of the Indian economy. A comparison of the results of this case with those of Case (JI), the Japanese Technology case (with Japanese input/output coefficients), shows that the capacity constraint has the effect of strengthening the equipment sector. Unlike the Japanese technology case (with Japanese input/output coefficients), in which production of equipment goods declines drastically in the later periods, there are only minor fluctuations in this case.

5.6.2 The Second Stage

Case (JC) is one other Japanese technology case with the capacity constraint in which the agricultural sector's capital/output as well as input/output coefficients are taken from the Japanese matrix.

As mentioned above, the capital/output coefficients are lower in the Japanese technology. A comparison of the results of this case with those of the previous case shows that the second stage of the technological transformation raises agricultural output, mainly in the later periods. Although, in terms of shares, the difference is small.

Other consequences of this transformation are felt in the capital goods sectors where production and shares in total output decline in comparison to the previous case. The decline in production is particularly visible in the construction sector in the later periods, and, as a result, this sector's share is 5.58 per cent in this case, down from 6.83 per cent in the previous case. This decline is a result of the lower capital/output coefficients associated with Japanese agriculture.

In other respects, the results of this case are not much different from the previous case. There are more imports of equipment goods in the earlier periods at the cost of imports of services. The value of the objective function in this case is slightly higher than in the previous case, but still substantially less than in Case (IC). The increase in production comes after three periods--in the first three periods gross output is less compared to the previous case. The same is reflected in the shadow prices: the shadow prices of the material balance constraints and foreign exchange are generally lower in the first and third periods (compared to the previous case), and higher in the later periods. A comparison of this case with the Japanese technology case with both Japanese input/output and capital/output coefficients (but without the capacity constraint) shows that the capacity constraint prevents the recurrence of an extremely high agricultural sector share and low equipment sector share.

The results of the hybrid case with the capacity constraint are exactly similar to the initial case with the capacity constraint--the Japanese technology is not used at all in the hybrid case with the capacity constraint--so the results are not reported here. The above analysis suggests that although the application of the Japanese agricultural technology raises agricultural production, its effect on consumption (the objective function) and on other sectors of the economy may not be favourable if the technological transformation is limited to the agricultural sector alone. We may, therefore, conclude that the Japanese agricultural technology is not appropriate to the current structure of the Indian economy.

5.7 THE CAPACITY CONSTRAINT, THE LAND CONSTRAINT, AND THE JAPANESE AGRICULTURAL TECHNOLOGY

Finally, this section presents the results of the cases with the capacity constraint, the land constraint, and the Japanese agricultural technology. Here the land constraint is only imposed in the hybrid case, i.e., in the case where both the Japanese and Indian technologies are simultaneously used. In the situation where the Japanese technology completely replaces the Indian technology in the agricultural sector--in groups (JI) and (J)--the land constraint may not be a restraining factor.

Case (HCL1) is a hybrid case with both capacity and land constraints. The land constraint is introduced in this case in the way described by equation 4.17, Chapter 4. The value of n, the ratio of Japanese and Indian agricultural yields, is 4.49 in this case (see Chapter 4). The yield-ratio is reduced later in Case (HCL2). The value of $\bar{X}_{it}$, the land constraint translated into agricultural output terms, is Rs.250000 million. Aggregate agricultural output, i.e., the combined agricultural output produced by using both Japanese and Indian agricultural technologies, can be larger than Rs.250000 million in this case. (In the Indian technology case, which has similar capacity and land constraints, Case (ICL), Rs.250000 million is the maximum agricultural output limit in all periods). The results of these two cases are also given in tables 5.17 - 5.24.

It was noted above that one of the consequences of imposition of the land constraint in the initial case with the capacity constraint was to reduce the share of the agricultural sector and increase that of the equipment sector. A comparison of the results of this case (i.e., the hybrid case with both capacity and land constraints) with those of the initial case with the capacity constraint shows that the land constraint has similar effects here also, but to a lesser degree. The land constraint induces the use of modern agricultural technology which, in turn, lessens the severity of the constraint. That is why, despite the land constraint, the reduction in agricultural production is only marginal.

The Japanese agricultural technology is used in the fourth and fifth periods, producing 11.32 and 13.78 per cent of agricultural output, respectively. The land constraint in this case is binding in only these two periods with shadow price of the constraint equal to .128 and 1.49, respectively. In other respects, the results of this case are very close to the initial case with the capacity constraint.

In the above case, the value of n, the ratio of Japanese and Indian agricultural yields, is quite high. In the following case, Case (HCL2), the value of n is arbitrarily lowered to 2 for the purpose of experimentation; in other respects this case is identical to the previous case.

The reduction in the yield-ratio undermines the land-augmenting advantage of the Japanese technology. In other words, the effectiveness of the land constraint is somewhat restored by the yield-ratio reduction. A comparison of this case, Case (HCL2), with the previous case shows that the share of the agricultural sector is slightly lower in

TABLE 5.24

AGRICULTURAL PRODUCTION BY INDIAN AND JAPANESE TECHNOLOGY
(in million Rs.)
(Figures in parentheses are in percentage)

Period	By Indian Technology		By Japanese Technology		Total
	Case (HCL1)				
1	234920.36	(100.00)	0	(0)	234920.36
2	177706.17	(100.00)	0	(0)	177706.17
3	218834.15	(100.00)	0	(0)	218834.15
4	243092.07	(88.68)	31046.84	(11.32)	274138.92
5	241414.79	(86.22)	38585.20	(13.78)	280000.00
	Case (HCL2)				
1	234866.04	(100.00)	0	(0)	234866.04
2	177649.13	(100.00)	0	(0)	177649.13
3	218726.79	(100.00)	0	(0)	218726.79
4	250000.00	(100.00)	0	(0)	250000.00
5	220000.00	(78.57)	60000.00	(21.43)	280000.00

this case, and the share of the equipment sector slightly higher. The Japanese technology is only used in the last period in this case (in the previous case it was used in the last two periods). The proportion of agricultural output produced with the Japanese technology in the last period is, however, higher in this case (21.43 per cent) than in the previous case (13.78 per cent).

The above discussion in this chapter shows that our model provides many interesting results. The high points of the discussion are summarized in the concluding chapter of this study. But before that, the results of some simulations of the model are analyzed in the next chapter, and the role and behaviour of shadow prices is explored in Chapter 7.

FOOTNOTES

CHAPTER 5

1. The high share of services in the total output could also reflect disguised unemployment in the economy. In that case, services are not really an important constraint as, with economic growth, they could be used much more efficiently. This question, however, can only be examined with a more disaggregated model which could reveal the nature of the demand for services.

CHAPTER 6

SOME SIMULATION RESULTS WITH ALTERNATIVE OBJECTIVE FUNCTIONS

6.1 INTRODUCTION

In the previous chapter, the objective function was the present discounted value of consumption over the plan period. This objective function valued consumption in the earlier periods more than in the later periods. However, an alternative objective function, as described in Chapter 4, maximizes the present discounted value of consumption during the plan period as well as of the consumption stream of the post-plan period. This objective function weighs the final year consumption in such a way as to take into account, besides the final year's consumption, the future consumption stream of the post-terminal years also. It thus, in effect, assigns much higher weights to the final year consumption. This objective function is referred to as "future consumption."

The issues related to the choices between present and future consumption can alternatively be dealt with by giving explicit attention to capital formation in the planning process. The short-run objectives of planning should then not only include the increase in consumption but should also include the increase in domestic production of investment goods. To assess and to highlight the significance of this proposition, one other alternative objective function maximizes the present discounted value of consumption plus investment over the plan period. This objective function is referred to as "consumption and investment over the plan period."

The results of simulations of the model with these two alternative objective functions are analyzed in this chapter.

6.2 THE INDIAN AGRICULTURAL TECHNOLOGY AND THE ALTERNATIVE OBJECTIVE FUNCTIONS

6.2.1 The Initial Case

In this section we analyze the results of two cases which have future consumption, and consumption and investment over the plan period as the objective functions, but in other respects they are similar to the initial case, Case (I), described in the previous chapter. The results of these cases are reported in tables 6.1 - 6.2 and 6.4 - 6.9 under Case (I).

6.2.1(a) Future Consumption as the Objective Function

When future consumption is maximized instead of consumption over the plan period, the results of the initial

Case (I) change in several important ways. There is a significant decline in the share of the agricultural sector while the non-agricultural sectors (except construction) record increases in their shares. The increase in share is most noteworthy in the equipment sector. However, in the final period the largest increase in production occurs in the services sector.

As mentioned above, the objective function which maximizes future consumption places heavy emphasis on consumption in the last period. This is reflected in the shift in production away from the earlier periods to the final period. Although agricultural production is lower in all periods as a result of changing the objective function, there is a large increase in agricultural production between the fourth and fifth periods.

There is also a large increase in production in the services sector between these periods. The value added coefficient, and therefore the contribution to consumption, is the highest in the services sector. The production of services in the final period is therefore provided a relatively high priority in this case. This explains the significant rise in the production of services in the final period. The shadow prices of the material balance constraints for both the agriculture and services sectors are zero in the final period, indicating that there is surplus output in in these sectors, whose main role is to generate income.

The increased levels of production in the last period require that appropriate investments be made in the earlier periods. The increase in production of equipment goods in the earlier periods, especially in the fourth period, is one important consequence of changing the objective function.

6.2.1(b) Consumption and Investment over the Plan Period as the Objective Function

Maximization of consumption and investment over the plan period generates a production pattern which resembles closely the previous case's pattern analyzed just above. There are some minor differences, however: the shares of the consumer goods and the services sectors are slightly higher while those of other sectors are slightly lower.

Although they have different objective functions, these two cases are quite similar in one sense in that they both favour investment activity. In the present case, the objective function directly values investment. In the previous case high production and consumption in the last period requires large investment in the earlier periods. That is the reason for the basic similarity of the results of these two cases.

TABLE 6.1

GROSS OUTPUT
(in million Rs.)
(Objective Function: Future Consumption)

	Case (I)	Case (IC)	Case (ICL)
Period 1			
Agriculture	206941.36	204554.12	204887.43
Equipment	88272.65	90589.20	90533.43
Consumer Goods	74041.21	73204.76	72956.58
Services and Transport	153049.05**	153049.05**	153049.05**
Construction	40000.00**	40000.00**	40000.00**
Gross Output	562304.27	561397.13	561426.49
Period 2			
Agriculture	173400.00	169872.94	167432.37
Equipment	110000.00**	110000.00**	110000.00**
Consumer Goods	76485.19**	76485.19**	75992.98
Services and Transport	154775.36**	154775.36**	154775.36**
Construction	43204.00	26863.25	27728.47
Gross Output	556964.55	537996.74	535929.18
Period 3			
Agriculture	201601.49	202490.53	196958.99
Equipment	89002.67	110000.00	110000.00
Consumer Goods	80598.56	87267.49	84979.75
Services and Transport	180401.68	170716.60	173347.54
Construction	48334.15	30368.90	31581.99
Gross Output	599938.55	600843.52	596868.27
Period 4			
Agriculture	218612.54	232012.40	219302.53
Equipment	103053.96	110000.00	110000.00
Consumer Goods	90406.30	95890.37	87389.04
Services and Transport	182306.29	187975.92	192563.36
Construction	32273.28	33643.63	33028.65
Gross Output	626652.37	659522.32	642283.58
Period 5			
Agriculture	262438.15	280000.00	250000.00**
Equipment	50000.00*	92589.84	110000.00
Consumer Goods	94287.89	95890.37	87389.04
Services and Transport	222687.48	206785.71	211322.34
Construction	34904.20	59467.70	62758.82
Gross Output	664317.72	734733.62	721470.20
Value of the O.F.	3710648.9	3868759.1	3800168.2

Note: Single and double asterisks indicate values at lower and upper bound, respectively.

TABLE 6.2

GROSS OUTPUT
(in million Rs.)
(Objective Function: Consumption and Investment over the Plan Period)

	Case (I)	Case (IC)	Case (ICL)
Period 1			
Agriculture	207239.03	204428.75	204207.23
Equipment	88125.37	90568.22	90659.57
Consumer Goods	73952.48	73355.31	73446.24
Services and Transport	153049.05**	153049.05**	153049.05**
Construction	40000.00**	40000.00**	40000.00**
Gross Output	562365.93	561401.33	561362.09
Period 2			
Agriculture	173455.14	171785.61	170924.47
Equipment	110000.00**	110000.00**	110000.00**
Consumer Goods	76485.19**	76485.19**	76485.19**
Services and Transport	154775.36**	154775.36**	154775.36**
Construction	39855.12	26944.65	31119.73
Gross Output	554570.81	539990.81	543304.75
Period 3			
Agriculture	200961.57	207177.83	201922.66
Equipment	86806.51	110000.00	110000.00
Consumer Goods	85794.12	86785.63	85327.56
Services and Transport	180213.41	171515.32	171382.28
Construction	46524.84	50586.21	56182.04
Gross Output	600300.45	626064.99	624814.54
Period 4			
Agriculture	218093.56	230341.56	213391.36
Equipment	95027.66	110000.00	110000.00
Consumer Goods	90438.38	86785.63	85327.56
Services and Transport	188337.46	185970.61	185656.24
Construction	33487.57	33129.41	32337.35
Gross Output	625384.63	646227.21	626712.51
Period 5			
Agriculture	257019.51	293256.84	250000.00**
Equipment	50000.00*	73717.98	79134.79
Consumer Goods	93669.25	78992.70	79663.13
Services and Transport	225592.30	205868.46	207631.99
Construction	34803.40	40443.97	78785.26
Gross Output	661084.46	692279.95	695215.17
Value of the O.F.	1534016.9	1538996.7	1536630.3

Note: Single and double asterisks indicate values at lower and upper bound, respectively.

TABLE 6.3

DOMESTIC USE OF OUTPUT
Case (IC)
(Objective Function: Future Consumption)

	Inter-mediate	Con-sumption	Invest-ment	Gov't	Surplus	Total
Period 1						
Agriculture	47084	158382	0	464	34873	240803
Equipment	63872	7859	20423	2271	0	94425
Consumer Goods	18056	49583	0	3824	0	71463
Services and Transport	49816	75968	0	38253	0	164037
Construction	13022	12770	28805	3503	0	58100
Total	191850	304562	49228	48315	34873	628828
Period 2						
Agriculture	62588	149696	0	505	0	212789
Equipment	64417	7428	44381	3254	0	119480
Consumer Goods	25136	46864	0	4404	0	76404
Services and Transport	49094	71802	0	40653	0	161549
Construction	11438	12069	0	4186	0	27693
Total	212673	287860	44381	53002	0	597915
Period 3						
Agriculture	69865	168265	0	546	0	238676
Equipment	67577	8349	37504	4237	0	117667
Consumer Goods	27033	52678	0	4985	0	84696
Services and Transport	53861	80709	0	43053	0	177623
Construction	12694	13567	0	4868	0	31129
Total	231030	323568	37504	57689	0	649791
Period 4						
Agriculture	81842	186043	0	587	0	268472
Equipment	64603	9231	40874	5220	0	119928
Consumer Goods	29137	58243	0	5565	0	92945
Services and Transport	58204	89236	0	45454	0	192894
Construction	13861	15000	0	5550	0	34411
Total	247647	357755	40874	62376	0	708650
Period 5						
Agriculture	78078	210619	0	629	27356	316682
Equipment	69071	10451	0	6204	7926	93652
Consumer Goods	25646	65937	0	6146	0	97729
Services and Transport	63230	101024	0	47854	0	212108
Construction	17600	16981	0	6233	19440	60254
Total	253625	405013	0	67066	54722	780425

TABLE 6.4
COMPETITIVE IMPORTS
(in million Rs.)

	Objective Function: Future Consumption			Objective Function: Consumption and Investment over the Plan Period		
	Case (I)	Case (IC)	Case (ICL)	Case (I)	Case (IC)	Case (ICL)
Period 1						
Agriculture	0	0	0	0	0	0
Equipment	0	0	0	0	0	0
Consumer Goods	0	0	0	0	0	0
Services and Transport	13002.89	12895.99	12908.25	13014.81	12891.79	12883.10
Construction	0	0	0	0	0	0
Period 2						
Agriculture	0	0	0	0	0	0
Equipment	0	4328.34	5040.93	0	2838.10	2224.94
Consumer Goods	0	277.78	0	595.18	1326.32	1093.99
Services and Transport	13517.83	9052.99	8645.02	12941.74	9483.71	10300.80
Construction	0	0	0	0	0	0
Period 3						
Agriculture	0	0	0	0	0	0
Equipment	11139.99	5331.22	8762.97	16362.62	0	0
Consumer Goods	5274.42	0	0	0	0	0
Services and Transport	0	9556.42	6236.09	0	14721.09	14766.14
Construction	0	0	0	0	0	0
Period 4						
Agriculture	0	0	0	0	0	0
Equipment	10665.93	8284.69	11347.11	17525.19	4558.44	9152.20
Consumer Goods	0	0	5296.03	0	4763.93	4193.91
Services and Transport	6341.16	7938.00	0	0	7295.95	3431.28
Construction	0	0	0	0	0	0
Period 5						
Agriculture	0	0	0	0	0	0
Equipment	15614.98	0	0	15324.28	0	0
Consumer Goods	1357.51	5084.87	10868.46	1699.45	15842.83	15380.64
Services and Transport	0	8713.66	2250.87	0	0	0
Construction	0	0	0	0	0	0

TABLE 6.5

SHADOW PRICES OF MATERIAL BALANCE CONSTRAINTS

	Objective Function: Future Consumption			Objective Function: Consumption and Investment over the Plan Period		
	Case (I)	Case (IC)	Case (ICL)	Case (I)	Case (IC)	Case (ICL)
Period 1						
Agriculture	0	0	0	0	0	0
Equipment	.2691	.4508	.4407	.6564	.4491	.4486
Consumer Goods	.1749	.2088	.2063	.2457	.2084	.2083
Services and Transport	2.4484	2.3239	2.2082	1.8643	2.3037	2.2987
Construction	1.9619	.7832	1.5022	1.1482	.9089	.9397
Period 2						
Agriculture	.5801	1.3683	.8774	.1271	.3206	.3123
Equipment	3.4011	5.0779	4.1166	1.9319	2.4356	2.4146
Consumer Goods	7.1356	5.0779	.5534	3.9139	2.4356	2.4146
Services and Transport	17.0986	5.0779	4.1166	3.9139	2.4356	2.4146
Construction	1.8737	2.6012	1.7094	.8899	.9050	.8916
Period 3						
Agriculture	1.5908	2.0186	1.0141	.6353	.4743	.4861
Equipment	2.8990	4.0921	3.1374	1.5026	1.6543	1.6141
Consumer Goods	2.8990	3.1626	2.0347	1.4242	1.5910	1.6315
Services and Transport	2.3717	4.0921	3.1374	.9592	1.8785	1.9448
Construction	2.0601	2.6573	1.5977	.9588	.8199	.8381
Period 4						
Agriculture	1.1118	1.8568	.9647	.0809	.2192	.2147
Equipment	2.2611	3.3176	2.5143	.9368	1.0810	1.0487
Consumer Goods	2.0741	2.8953	2.5143	.8356	1.0810	1.0487
Services and Transport	2.2611	3.3176	2.2225	.9123	1.0810	1.0487
Construction	1.0881	2.1758	1.3279	0	.3618	.3444
Period 5						
Agriculture	0	0	0	0	0	0
Equipment	1.3041	0	0	.5334	.4484	.3798
Consumer Goods	1.3041	3.2741	.4400	.5334	.5882	.5274
Services and Transport	0	3.2741	.4400	0	.4156	.3071
Construction	.9870	0	0	.1319	0	0

TABLE 6.6

SHADOW PRICES OF IMPORT LOWER BOUNDS

	Objective Function: Future Consumption			Objective Function: Consumption and Investment over the Plan Period		
	Case (I)	Case (IC)	Case (ICL)	Case (I)	Case (IC)	Case (ICL)
Period 1						
Agriculture	2.4484	2.3239	2.2082	1.8643	2.3037	2.2987
Equipment	2.1792	1.8730	1.7675	1.2078	1.8545	1.8500
Consumer Goods	2.2735	2.1150	1.0019	1.6185	2.0952	2.0904
Services and Transport	0	0	0	0	0	0
Construction	.4864	1.5407	.7060	.7160	1.3947	1.3590
Period 2						
Agriculture	16.5185	3.7096	3.2391	3.7868	2.1150	2.1023
Equipment	13.6975	0	0	1.9820	0	0
Consumer Goods	9.9630	0	3.5631	0	0	0
Services and Transport	0	0	0	0	0	0
Construction	15.2249	2.4766	2.4071	3.0240	1.5305	1.5230
Period 3						
Agriculture	1.3082	2.0735	2.1232	.8672	1.4041	1.4587
Equipment	0	0	0	0	.2241	.3307
Consumer Goods	0	.9295	1.1026	.0784	.2874	.3133
Services and Transport	.5273	0	0	.5433	0	0
Construction	.8389	1.4348	1.5396	.5438	1.0585	1.1066
Period 4						
Agriculture	1.1492	1.4607	1.5496	.8558	.8617	.8339
Equipment	0	0	0	0	0	0
Consumer Goods	.1870	.4223	0	.1011	0	0
Services and Transport	0	0	.2918	.0244	0	0
Construction	1.1730	1.1418	1.1864	.9368	.7192	.7042
Period 5						
Agriculture	1.3041	3.2741	.4400	.5334	.5882	.5274
Equipment	0	3.2741	.4400	0	.1397	.1476
Consumer Goods	0	0	0	0	0	0
Services and Transport	1.3041	0	0	.5334	.1726	.2202
Construction	.3171	3.2741	.4400	.4015	.5882	.5274

TABLE 6.7

SECTORAL SHARES OF GROSS DOMESTIC OUTPUT

(Objective Function: Future Consumption)

Sectors	Agriculture	Equipment	Consumer Goods	Services and Transport	Construction	Total
Case (I)						
Period 1	36.80	15.70	13.17	27.22	7.11	100.00
Period 2	31.13	19.75	13.73	27.79	7.60	100.00
Period 3	33.60	14.84	13.43	30.07	8.06	100.00
Period 4	34.89	16.44	14.43	29.09	5.15	100.00
Period 5	39.50	7.53	14.19	33.52	5.26	100.00
Total	35.31	14.63	13.81	29.67	6.57	100.00
Case (IC)						
Period 1	36.44	16.14	13.04	27.26	7.12	100.00
Period 2	31.57	20.45	14.22	28.77	4.99	100.00
Period 3	33.70	18.31	14.53	28.41	5.05	100.00
Period 4	35.18	16.68	14.54	28.50	5.10	100.00
Period 5	38.11	12.60	13.05	28.15	8.09	100.00
Total	35.19	16.58	13.86	28.22	6.15	100.00
Case (ICL)						
Period 1	36.49	16.13	13.00	27.26	7.12	100.00
Period 2	31.24	20.53	14.18	28.88	5.17	100.00
Period 3	33.00	18.43	14.24	29.04	5.29	100.00
Period 4	34.14	17.13	13.61	29.98	5.14	100.00
Period 5	34.65	15.25	12.11	29.29	8.70	100.00
Total	33.96	17.35	13.37	28.94	6.38	100.00

TABLE 6.8

SECTORAL SHARES OF GROSS DOMESTIC OUTPUT

(Objective Function: Consumption and Investment over the Plan Period)

Sectors	Agriculture	Equipment	Consumer Goods	Services and Transport	Construction	Total
Case (I)						
Period 1	36.85	15.67	13.15	27.22	7.11	100.00
Period 2	31.28	19.83	13.79	27.91	7.19	100.00
Period 3	33.48	14.46	14.29	30.02	7.75	100.00
Period 4	34.87	15.20	14.46	30.12	5.35	100.00
Period 5	38.88	7.56	14.17	34.12	5.27	100.00
Total	35.18	14.31	13.99	30.03	6.48	100.00
Case (IC)						
Period 1	36.41	16.13	13.07	27.26	7.13	100.00
Period 2	31.81	20.37	14.17	28.66	4.99	100.00
Period 3	33.09	17.57	13.86	27.40	8.08	100.00
Period 4	35.64	17.02	13.43	28.78	5.13	100.00
Period 5	42.36	10.65	11.41	29.74	5.84	100.00
Total	36.11	16.12	13.13	28.41	6.23	100.00
Case (ICL)						
Period 1	36.38	16.15	13.08	27.26	7.13	100.00
Period 2	31.46	20.25	14.08	28.49	5.72	100.00
Period 3	32.32	17.60	13.66	27.43	8.99	100.00
Period 4	34.05	17.55	13.62	29.62	5.16	100.00
Period 5	35.96	11.38	11.46	29.87	11.33	100.00
Total	34.10	16.38	13.12	28.59	7.81	100.00

TABLE 6.9

CAPACITY LEVELS

	Objective Function: Future Consumption		Objective Function: Consumption and Investment over the Plan Period	
	Case (IC)	Case (ICL)	Case (IC)	Case (ICL)
Period 1				
Agriculture	250000.00	250000.00	250000.00	250000.00
Equipment	100000.00	100000.00	100000.00	100000.00
Consumer Goods	75604.13	75604.13	75604.13	75604.13
Services and Transport	153049.05	153049.05	153049.05	153049.05
Construction	40000.00	40000.00	40000.00	40000.00
Period 2				
Agriculture	280000.00	280000.00	280000.00	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	76485.19	76485.19	76485.19	76485.19
Services and Transport	154775.36	154775.36	154775.36	154775.36
Construction	45000.00	45000.00	45000.00	45000.00
Period 3				
Agriculture	280000.00	280000.00	280000.00	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	95890.37	84979.75	86785.63	85327.56
Services and Transport	170716.60	173347.54	171515.32	171382.28
Construction	59467.70	61975.85	61562.29	61898.86
Period 4				
Agriculture	280000.00	280000.00	280000.00	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	95890.37	87389.04	86785.63	85327.56
Services and Transport	187975.92	192563.36	185970.61	185656.24
Construction	59467.70	61975.85	61562.29	64262.78
Period 5				
Agriculture	280000.00	280000.00	293256.84	280000.00
Equipment	110000.00	110000.00	110000.00	110000.00
Consumer Goods	95890.37	87389.04	86785.63	85327.56
Services and Transport	206785.71	211322.34	205868.46	207631.99
Construction	59467.70	62758.82	61562.29	78785.26

6.2.2 The Capacity Constraint

In this section the effects of imposition of the capacity constraint when the objective function is future consumption or consumption and investment over the plan period are analyzed. The results of these cases are reported in tables 6.1 - 6.9 under Case (IC).

It was noted above that in the initial case, one of the effects of maximizing future consumption (or consumption and investment over the plan period) instead of consumption over the plan period alone, was the strengthening of the equipment sector. As a result of the imposition of the capacity constraint, the equipment sector is further strengthened. In the above two cases, i.e., the cases without the capacity constraint, there was a sharp decline in production of equipment goods in the last period; in these cases with the capacity constraint, although equipment production still declines in the last period, it (the decline) is, however, much less. The strengthening of the equipment sector comes mainly at the cost of the service sector. The large increase in production of services in the last period which was one of the main outcomes of the changes in the objective function, is not repeated in these cases: the capacity constraint limits the size of that increase. As the capacity constraint disallows transfer of capital from one sector to another (and from one period to another), the economy's ability to mobilize capital resources needed for the last period increase in services' production becomes less as a result of the constraint.

As the domestic production of equipment goods is increased, there are less imports of these goods as a result of the capacity constraint, and more services are imported instead. The shadow prices of the material balance constraints, imports, and foreign exchange rise in the last three periods reflecting the added demand pressure caused by the capacity constraint. The shadow prices of the material balance constraints for the agriculture, equipment, and construction sectors are zero in the final period. This indicates that surplus output in these sectors is mainly to generate income, while ability to supply goods for consumption is limited by the consumer goods and services sectors.

The cases with the capacity constraint are not constrained versions of the cases without the constraint (refer to Section 5.3). As a matter of fact, the values of the objective functions in the cases with the capacity constraint are higher than in the cases without the constraint.

Domestic use of various sectors' output for Case (IC) when the objective function is future consumption, is shown in Table 6.2. A comparison of the pattern of the use of output between this case and Case (IC) when the objective function is consumption over the plan period provides some very useful insights. As a result of this inclusion of post-plan period consumption into the objective function, consumption levels decline in the initial four periods. But there is a 5.2 per cent increase in the final period consumption, and, therefore, in the future consumption stream of the post-plan period. Investment deliveries made by the equipment sector increase in all four (initial) periods, the increase in investment in the fourth period is especially significant. Investment deliveries made by the construction sector in the first period also increase significantly.

6.2.3 The Capacity Constraint and the Land Constraint

The land constraint in our model captures the land-scarcity aspect of Indian agriculture by specifying upper limits to agricultural production. Here that upper limit is Rs.250000 million, so that agricultural output cannot surpass this limit in the plan period. The implications of the land constraint in conjunction with the capacity constraint are analyzed below. The results are reported in tables 6.1 - 6.2 to 6.4-6.9 under Case (ICL).

As expected, in both cases with the alternative objective functions, production and the share of the agricultural sector diminish--in comparison with the previous two cases--as a result of the land constraint. Agricultural production falls in all five periods, even though the land constraint is binding only in the last period. The land constraint in these two cases results in the lowest shares of this sector among all the cases considered.

The land constraint by limiting agricultural production limits the agricultural sector's demand for input resources. These freed resources can now be available to the other sectors. This is illustrated by the results which show that the other sectors generally increase production as a result of the land constraint.

In the case when future consumption is maximized, the equipment sector attains its highest share among all the cases considered. The services and construction sectors also record growth. The consumer goods sector, however, records diminution in its production and share. But there are increased imports of consumer goods so the supply of these goods is not reduced by much. The increase in consumer goods' imports came at the cost of services' imports. The shadow prices of the material balance constraints and foreign exchange decline, reflecting the easing of demand pressure by the land constraint. The decline in the shadow prices is most visible in the last period when the land constraint is binding.

The role of the agriculture, equipment and construction sectors in generating income (and surplus output) is similar to Case (IC), but with the reduction of agricultural output, this role is shifted to the other sectors. The overall income and consumption level falls as a result of the land constraint, both in the final period and in the earlier periods.

The value of the objective function is reduced by about 2 per cent as a result of the land constraint.

In the case when consumption and investment over the plan period are maximized, it is the construction sector which benefits most as a result of the land constraint. There is substantial growth in construction activity in the last period. This sector's share in total output becomes 7.81 per cent in this case.

6.3 THE JAPANESE AGRICULTURAL TECHNOLOGY AND THE ALTERNATIVE OBJECTIVE FUNCTIONS

The remaining part of this chapter deals with the consequences of Japanese agricultural technology replacing the Indian technology either totally or partially (in the hybrid cases) in the agricultural sector when the objective function is future consumption or consumption plus investment over the plan period. To avoid repetition, only important results are reported and discussed.

As discussed in the earlier chapters, the agricultural technology transformation is accomplished in two stages: In the first stage, the agricultural sector's Indian input/output coefficients are replaced with the respective Japanese coefficients; and in the second stage, a similar transformation is performed with respect to the agricultural sector's capital/output coefficients as well. Finally, a simultaneous application of both Indian and Japanese technologies in the agricultural sector is considered in the hybrid case.

6.3.1 The First Stage

The effects of the first-stage technological transformation are analyzed by comparing the results of the Japanese agricultural technology cases (reported in tables 6.10 - 6.15 under Case JI) with the similar Indian technology cases discussed above in section 6.2.1.

In the case when the objective function is consumption and investment over the plan period, the modern agricultural technology results in increased shares of the agricultural, equipment, and construction sectors. The growth in these sectors comes about mainly at the cost of services. The effects of modern agricultural technology in this case are very similar to the ones caused by a similar technological transformation in the case when the objective function was consumption (only) over the plan period (see Section 5.5.1).

TABLE 6.10

GROSS OUTPUT
(in million Rs.)
(Objective Function: Future Consumption)

	Case (JI)	Case (J)	Case (H)
Period 1			
Agriculture	261028.91	265693.11	199016.14
Equipment	96617.41	92019.00	97874.82
Consumer Goods	75604.13**	75604.13**	75604.13**
Services and Transport	153049.05**	153049.05**	153049.05**
Construction	32364.17	40000.00**	18617.63
Gross Output	618663.67	626365.29	544161.77
Period 2			
Agriculture	267444.91	194445.07	270752.08
Equipment	110000.00**	110000.00**	110000.00**
Consumer Goods	76485.19**	76485.19**	76485.19**
Services and Transport	154775.36**	154775.36**	154775.36**
Construction	15000.00*	35960.73	15000.00*
Gross Output	623705.46	571666.35	627012.63
Period 3			
Agriculture	234176.68	229094.58	218697.32
Equipment	115217.84	124822.46	93023.74
Consumer Goods	86805.03	84799.99	90248.72
Services and Transport	164020.72	161101.63	176109.90
Construction	56271.02	36186.92	72384.89
Gross Output	656491.29	636005.58	650464.57
Period 4			
Agriculture	241243.39	265453.82	237451.05
Equipment	131417.05	122019.59	100150.94
Consumer Goods	89914.25	91966.28	94773.65
Services and Transport	166295.93	174499.04	177414.81
Construction	32227.24	33224.15	43210.87
Gross Output	661097.86	687162.88	653001.32
Period 5			
Agriculture	264047.33	360162.98	304371.95
Equipment	68581.66	78700.84	52607.88
Consumer Goods	96479.15	103783.51	98689.18
Services and Transport	212000.57	201819.20	205696.25
Construction	61739.75	37509.57	36070.71
Gross Output	702848.46	781976.10	697435.97
Value of the O.F.	3343820.7	3489316.1	3811051.8

NOTE: Single and double asterisks indicate values at lower and upper bound, respectively.

TABLE 6.11

GROSS OUTPUT
(in million Rs.)
(Objective Function: Consumption and Investment over the Plan Period)

	Case (JI)	Case (J)	Case (H)
Period 1			
Agriculture	272403.40	262032.34	201507.17
Equipment	91899.74	93045.49	90789.38
Consumer Goods	75604.13**	75604.13**	75604.13**
Services and Transport	153049.05**	153049.05**	153049.05**
Construction	40000.00**	40000.00**	40000.00**
Gross Output	632956.32	623731.01	560949.73
Period 2			
Agriculture	217120.77	201019.20	193099.15
Equipment	110000.00**	110000.00**	110000.00**
Consumer Goods	76485.19**	76485.19**	76485.19**
Services and Transport	154775.36**	154775.36**	154775.36**
Construction	45000.00**	42435.58	45000.00**
Gross Output	603381.32	584715.33	579359.70
Period 3			
Agriculture	234632.80	238107.41	215978.66
Equipment	86039.92	87371.77	69961.01
Consumer Goods	87185.14	88095.68	89571.13
Services and Transport	176008.49	177242.89	185637.30
Construction	63948.19	62703.64	64331.60
Gross Output	647814.54	653521.39	625479.70
Period 4			
Agriculture	237144.34	245566.18	238722.46
Equipment	120572.52	117627.88	65214.81
Consumer Goods	87258.83	90952.48	95047.19
Services and Transport	166670.60	169304.87	193066.95
Construction	51917.32	51833.17	56510.59
Gross Output	663563.61	675284.58	648562.00
Period 5			
Agriculture	254052.19	271837.65	295726.92
Equipment	89392.81	76088.05	50635.54
Consumer Goods	76826.61	98446.70	96719.10
Services and Transport	196646.96	197390.10	202497.31
Construction	76977.52	86300.24	35376.70
Gross Output	693896.09	730062.74	680952.57
Value of the O.F.	1402744.0	1403045.0	1537621.6

Note: Single and double asterisks indicate values at lower and upper bound, respectively.

TABLE 6.12

COMPETITIVE IMPORTS (in million Rs.)

	Objective Function: Future Consumption			Objective Function: Consumption and Investment over the Plan Period		
	Case (JI)	Case (J)	Case (H)	Case (JI)	Case (J)	Case (H)
Period 1						
Agriculture	0	0	0	0	0	0
Equipment	0	0	0	0	0	0
Consumer Goods	3382.34	4241.85	3728.31	1151.63	4205.22	66.05
Services and Transport	8766.65	8128.47	8780.53	11190.40	8116.35	12733.06
Construction	0	0	0	0	0	0
Period 2						
Agriculture	0	0	0	0	0	0
Equipment	0	8101.55	0	0	4721.13	0
Consumer Goods	2787.24	0	2256.24	3288.32	666.84	2233.63
Services and Transport	10438.74	5352.82	10951.87	9972.01	7979.62	11156.45
Construction	0	0	0	0	0	0
Period 3						
Agriculture	0	0	0	0	0	0
Equipment	0	0	0	16042.71	15904.99	17099.10
Consumer Goods	0	0	0	0	0	0
Services and Transport	14193.01	13826.46	15467.99	0	0	0
Construction	0	0	0	0	0	0
Period 4						
Agriculture	0	0	0	0	0	0
Equipment	0	1842.60	0	0	0	19022.15
Consumer Goods	0	0	0	0	0	0
Services and Transport	15037.73	13585.28	16838.35	15737.98	15731.65	0
Construction	0	0	0	0	0	0
Period 5						
Agriculture	0	0	0	0	0	0
Equipment	15436.60	14145.53	16406.24	0	14640.21	16677.25
Consumer Goods	0	0	0	14823.90	0	0
Services and Transport	0	0	0	0	0	0
Construction	0	0	0	0	0	0

TABLE 6.13

SHADOW PRICES OF MATERIAL BALANCE CONSTRAINTS

	Objective Function: Future Consumption			Objective Function: Consumption and Investment over the Plan Period		
	Case (JI)	Case (J)	Case (H)	Case (JI)	Case (J)	Case (H)
Period 1						
Agriculture	0	0	0	0	0	0
Equipment	.2551	.1468	.2920	.5473	.5671	.6619
Consumer Goods	2.2989	1.7296	2.4895	1.1170	1.2328	1.7131
Services and Transport	2.2989	1.7296	2.4895	1.1170	1.2328	1.7131
Construction	.3225	.2223	.3922	1.0223	.9276	1.1877
Period 2						
Agriculture	0	.1108	0	0	.2698	.0317
Equipment	3.9856	5.0426	4.7784	1.9462	2.0882	1.9403
Consumer Goods	5.9775	0	6.9561	2.4064	2.0882	3.3539
Services and Transport	5.9775	5.0426	6.9561	2.4064	2.0882	3.3539
Construction	.6957	.9618	.7903	.7823	.7159	.8992
Period 3						
Agriculture	.9514	1.6469	1.1617	.6570	.5645	.5877
Equipment	3.0673	3.7340	3.7355	1.4730	1.5570	1.5003
Consumer Goods	2.7593	2.2860	3.3213	1.1396	1.1903	1.3048
Services and Transport	3.1374	4.4572	3.7843	1.0114	1.1327	.9333
Construction	1.2642	1.1214	1.6958	.8651	.8336	.9580
Period 4						
Agriculture	.4488	1.8844	.2701	.1980	.2424	.0631
Equipment	2.1610	3.0217	2.5615	.9176	.9781	.9331
Consumer Goods	1.9173	2.4515	2.3412	.7893	.8233	.8021
Services and Transport	2.5933	3.0217	3.3535	.9303	1.0317	.8983
Construction	.2768	1.7656	0	0	0	0
Period 5						
Agriculture	.5266	0	0	.1205	.0346	0
Equipment	2.8186	5.8439	4.9394	.5173	.6423	.6571
Consumer Goods	1.1708	3.5978	2.4399	.5334	.6207	.5467
Services and Transport	0	2.9020	1.3269	0	.1512	0
Construction	0	1.3723	1.5737	0	0	.1533

TABLE 6.14

SECTORAL SHARES OF GROSS DOMESTIC OUTPUT

(Objective Function: Future Consumption)

Sectors	Agriculture	Equipment	Consumer Goods	Services and Transport	Construction	Total
Case (JI)						
Period 1	42.20	15.62	12.22	24.74	5.22	100.00
Period 2	42.88	17.64	12.26	24.82	2.40	100.00
Period 3	35.67	17.55	13.22	24.99	8.57	100.00
Period 4	36.49	19.88	13.60	25.16	4.87	100.00
Period 5	37.58	9.75	13.72	30.17	8.78	100.00
Total	38.86	15.99	13.03	26.06	6.06	100.00
Case (J)						
Period 1	42.42	14.69	12.07	24.44	6.38	100.00
Period 2	34.01	19.24	13.38	27.08	6.29	100.00
Period 3	36.02	19.63	13.33	25.33	5.69	100.00
Period 4	38.64	17.76	13.38	25.39	4.83	100.00
Period 5	46.06	10.06	13.27	25.81	4.80	100.00
Total	39.80	15.97	13.10	25.59	5.54	100.00
Case (H)						
Period 1	36.58	17.98	13.89	28.13	3.42	100.00
Period 2	43.19	17.54	12.20	24.68	2.39	100.00
Period 3	33.62	14.30	13.87	27.08	11.13	100.00
Period 4	36.37	15.34	14.51	27.17	6.61	100.00
Period 5	43.65	7.54	14.15	29.49	5.17	100.00
Total	38.79	14.30	13.74	27.33	5.84	100.00

TABLE 6.15

SECTORAL SHARES OF GROSS DOMESTIC OUTPUT
(Objective Function: Consumption and Investment over the Plan Period)

Sectors	Agriculture	Equipment	Consumer Goods	Services and Transport	Construction	Total
Case (JI)						
Period 1	43.04	14.52	11.94	24.18	6.32	100.00
Period 2	35.99	18.23	12.67	26.65	7.46	100.00
Period 3	36.22	13.28	13.46	27.17	9.87	100.00
Period 4	35.74	18.17	13.15	25.12	7.82	100.00
Period 5	36.61	12.88	11.07	28.34	11.10	100.00
Total	37.49	15.36	12.44	26.13	8.57	100.00
Case (J)						
Period 1	42.01	14.92	12.12	24.54	6.41	100.00
Period 2	34.38	18.81	13.08	26.47	7.26	100.00
Period 3	36.44	13.37	13.48	27.12	9.59	100.00
Period 4	36.37	17.42	13.47	25.07	7.67	100.00
Period 5	37.24	10.42	13.48	27.04	11.82	100.00
Total	37.29	14.82	13.15	26.07	8.67	100.00
Case (H)						
Period 1	35.93	16.18	13.48	27.28	7.13	100.00
Period 2	33.33	18.99	13.20	26.72	7.76	100.00
Period 3	34.54	11.18	14.32	29.68	10.28	100.00
Period 4	36.82	10.05	14.65	29.77	8.71	100.00
Period 5	43.44	7.43	14.20	29.74	5.19	100.00
Total	36.99	12.49	14.00	28.72	7.79	100.00

However, in the case when future consumption is maximized, a somewhat different pattern emerges as a result of the technological transformation. Here the share of the construction sector does not increase, instead, it declines marginally. The share of consumer goods declines in this case also, but the decline is relatively small.

6.3.2 The Second Stage

The second stage of the technological transformation lowers the capital cost of agricultural production. Although this transformation does not alter the overall sectoral shares significantly, it does cause temporal shifts in production, especially in the agricultural sector. The results of these cases are also given in tables 6.10 - 6.15 under case (J).

In the case when future consumption is maximized, the second-stage technological transformation produces a significant temporal shift in agricultural production away from the second period to the last period. This shift is in accordance with the weight structure associated with future consumption maximization which values production in the last period much more than in the earlier periods.

In the case when consumption and investment over the plan period are maximized, the second-stage technological transformation produces a gradual temporal shift in agricultural production away from the initial two periods to the last three periods. This pattern of shift induces more investment activity and, thus, is in accordance with the consumption and investment maximization objective. In this case the construction sector attains its highest sectoral share (8.67 per cent) among all the cases considered.

6.3.3 The Hybrid Cases

In the last two cases, both Japanese and Indian agricultural technologies are allowed to be used simultaneously in proportions determined endogenously by the model. The results of these cases are given in tables 6.10 - 6.16 under Case (H).

A comparison of the results of these cases with the similar Indian technology cases (discussed in section 6.2.1) shows that the agricultural sector benefits from the technological choice. In the case when future consumption is maximized, the Japanese agricultural technology is used only in the second period, but in that period it totally replaces the Indian technology. The use of modern agricultural technology raises agricultural production in the second period considerably. The share of the agricultural sector rises significantly in this case. The shares of the other sectors, especially of services, decline as a result.

When consumption and investment over the plan period

TABLE 6.16

AGRICULTURAL PRODUCTION BY INDIAN

AND JAPANESE TECHNOLOGY IN CASE (H)

(in million Rs.)

(Figures in parentheses are in percentage)

	By Indian Technology		By Japanese Technology	
Objective Function: Future Consumption				
Period 1	199016.14	(100.00)	0	(0)
Period 2	0	(0)	270752.14	(100.00)
Period 3	218697.32	(100.00)	0	(0)
Period 4	237451.05	(100.00)	0	(0)
Period 5	304371.95	(100.00)	0	(0)
Objective Function: Consumption and Investment Over the Plan Period				
Period 1	201507.17	(100.00)	0	(0)
Period 2	77329.11	(40.05)	115770.03	(59.95)
Period 3	215978.66	(100.00)	0	(0)
Period 4	238722.46	(100.00)	0	(0)
Period 5	295726.92	(100.00)	0	(0)

are maximized, the Japanese agricultural technology produces about 60 per cent of the aggregate agricultural output in the second period. The share of the construction sector also increases in this case.

6.4 SUMMARY

The results of the simulations of our model show that the main effect of inclusion of the consumption stream of the post-plan period in the objective function is to strengthen the equipment sector. The strengthening of the equipment sector comes mainly at the cost of the agricultural sector. Similarly, inclusion of investment in the objective function also results in a strengthening of the equipment sector. In this situation, the other capital goods sector, the construction sector, is also benefitted.

CHAPTER 7

ROLE OF SHADOW PRICES

In the previous chapter, we analyzed the results of our study mainly in terms of the quantities generated by the solutions of our linear programming models in the primal form. The quantities are of primary concern in planning exercises because almost all the planning objectives are set in quantity terms whether they are couched in terms of consumption maximization or in some other terms such as output or employment maximization. But it is equally necessary to analyze the role and behaviour of prices also because in mixed economies like India, which do not practice direct physical planning, planning has to operate, to a significant extent, through markets. In this chapter we concentrate mainly on the prices as generated by the dual solutions of our linear programming models.

Linear programming models are very convenient in the sense that the solution of the dual problem provides shadow prices whose resource allocative role is comparable to that of actual prices in an economy in full general equilibrium. Thus, the shadow price system has an interpretation which is very close to that of a competitive system.

The linear programming simplex algorithm ensures efficient use of resources by using more of the inputs which are relatively less expensive (low shadow prices), and vice versa. Other efficiency criteria such as equalization of marginal cost and price of output, are satisfied as well. Thus, the shadow prices make good economic sense, This justifies as well as makes it essential to examine the dual problem separately. The dual variables (shadow prices) also help to understand the primal solution better as is evident from our discussion in the previous two chapters.

The primal and dual problems of Case (I), the initial case (with consumption over the plan period as the objective function), are shown in "detached coefficients" form[1] in Table 7.1. If the primal and dual problems of Case (I) are expressed in the standard way as

Primal	Dual
Max $c'x$	Min $p'b$
subject to $Ax \leq b$	subject to $p'A \geq c'$
$x \geq o$	$p' \geq o$

then, the area inside the central rectangle in Table 7.1 corresponds to the matrix A of the above problems. The resource constraints, b, are written in the right margin.

The activities of the primal problem in Case (I), elements of the gross output vector X_t and competitive

TABLE 7.1

DETACHED COEFFICIENTS TABLEAU OF CASE (I)

	X_1	X_2	X_3	X_4	X_5	M_1	M_2	M_3	M_4	M_5	
1) p'_1	$-(I-\bar{A}+\bar{B}_1)$	$(\bar{B}_1+W-\bar{B}_2)$	$\bar{B}_2$			$-I$					$\leq -(\bar{E}_1+\bar{G}_1)$
2) p'_2		$-(I-\bar{A}+\bar{B}_1)$	$(\bar{B}_1+W-\bar{B}_2)$	$\bar{B}_2$			$-I$				$\leq -(\bar{E}_2+\bar{G}_2)$
3) p'_3			$-(I-\bar{A}+\bar{B}_1)$	$(\bar{B}_1+W-\bar{B}_2)$	$\bar{B}_2$			$-I$			$\leq -(\bar{E}_3+\bar{G}_3)$
4) p'_4				$-(I-\bar{A}+\bar{B}_1)$	$(\bar{B}_1+W)$				$-I$		$\leq -(\bar{E}_4+\bar{G}_4)$
5) p'_5					$-(I-\bar{A}-W)$					$-I$	$\leq -(\bar{E}_5+\bar{G}_5)$
6) f'_1	$u'M$					u'					$\leq u'\bar{E}_1+\bar{V}_1$
7) f'_2		$u'M$					u'				$\leq u'\bar{E}_2+\bar{V}_2$
8) f'_3			$u'M$					u'			$\leq u'\bar{E}_3+\bar{V}_3$
9) f'_4				$u'M$					u'		$\leq u'\bar{E}_4+\bar{V}_4$
10) f'_5					$u'M$					u'	$\leq u'\bar{E}_5+\bar{V}_5$
11) s'_1	$-I$										$\leq -\bar{L}_1$
12) s'_2		$-I$									$\leq -\bar{L}_2$
13) s'_3			$-I$								$\leq -\bar{L}_3$
14) s'_4				$-I$							$\leq -\bar{L}_4$
15) s'_5					$-I$						$\leq -\bar{L}_5$
MAX	$u'N$	$\frac{u'N}{(1+d)}$	$\frac{u'N}{(1+d)^2}$	$\frac{u'N}{(1+d)^3}$	$\frac{u'N}{(1+d)^4}$						

imports M_t (where t=1.......5), are written along the top of the table.

The sets of inequality constraints of Case (I) are represented by rows of the central matrix in Table 7.1. The first row can be written as follows:

$$-(I-\bar{A}+\bar{B}_1)X_1+(\bar{B}_1+W-\bar{B}_2)X_2+\bar{B}_2X_3-M_1\leq(\bar{E}_1+\bar{G}_1) \quad (7.1)$$

This expresses the material balance constraints in equation 4.12 during period one, where

$$\bar{A} = A-W+\Sigma\Sigma C_{xy}(1-s_{xy})h_{xy}u'\hat{v} \quad (7.2)$$

$$\bar{B}_1 = B_1K \quad (7.3)$$

and $\bar{B}_2 = B_2K$ (7.4)

Similarly, rows 2 to 5 express the material balance constraints in equation 4.12 during periods 2 to 5, respectively.

Rows 6 to 10 express the foreign exchange constraints in equation 4.18:

$$u'MX_t+u'M_t \leq u'\bar{E}_t+\bar{V}_t$$

And finally, rows 11 to 15 express the constraints on output levels (lower and upper bounds) in equations 4.19, 4.20, and 4.22:

$$-X_t \leq -\bar{L}_t$$

Using equation 4.11, the objective function given in equation 4.2a can be written as

$$\sum_{t=1}^{5} \frac{u'F_t}{(1+d)^{t-1}} = \sum_{t=1}^{5} \frac{u'NX_t}{(1+d)^{t-1}} \qquad (7.5)$$

where $N = \Sigma\Sigma C_{xy}(1-s_{xy})h_{xy}u'\hat{v}$

The primal maximand weights in Case (I): N, N/(1+d),------ $N/(1+d)^4$ are written along the bottom of the table.

The dual variables (shadow prices) are written in the left margin, where

p'_t = shadow price of output during period t

f'_t = shadow price of foreign exchange during period t

s'_t = shadow price of the lower bounds during period t

These shadow prices determine which activities will have positive values in the optimal solution of a linear program. For an activity to be positive, the marginal benefits should be equal to the marginal costs for that activity. If the marginal benefits are less than the marginal costs for an activity or, in other words, if an activity is unprofitable, evaluated at the optimal shadow prices, then that activity is operated at the zero level.

This is one of the basic theorems in linear programming.

In terms of the dual problem stated above, p'A represents the marginal costs of activity x, and c' the marginal benefits. If x is positive, then, for an optimal solution, p'A = c'. If $p'A \geq c'$, then x will be zero. This property, referred to as "complementary slackness," can be represented mathematically as follows: (p'A-c')x = o.

Since all elements of the output vector X_t are required to be operated at positive levels in Case (I), then, by complementary slackness, the condition p'A=c' should hold for each of them. For X_1, the output vector in period 1, this condition is represented by column 1 of Table 7.1:

$$-p_1'(I-\bar{A}+\bar{B}_1)+f_1'u'M-s_1' = u'N \qquad (7.6)$$

$$\text{or} \quad p_1'(\bar{A}-I)+f_1'u'M = u'N+s_1'+p_1'\bar{B}_1 \qquad (7.6a)$$

The left-hand-side of equation 7.6a represents the costs of producing one additional unit of X_1. $(\bar{A}-I)$ gives the net additional requirements in terms of X_1 itself; and $p_1'(\bar{A}-I)$, the costs of those requirements. The second term represents the foreign exchange costs of the additional requirement in terms of non-competitive imports, u'M.

The marginal benefits of X_1 are represented by the right-hand-side of equation 7.6a. One unit increase in X_1 will reduce (X_2-X_1) by the same amount. The given lag structure in the model requires that for any increase in output in one year over the previous year, proportional investments in terms of the equipments to be made one year in advance (i.e., in the previous year). So, one unit reduction in the future output increase, (X_2-X_1), reduces the investment requirements in terms of equipment in the first period by $\bar{B}_1$. These savings (or benefits) are represented by the third term, $p_1'\bar{B}_1$. s_1', the shadow price of the lower bounds in periods 1, can be interpreted as subsidies[2] paid in order to keep the sectoral output levels above certain minimum levels. The benefits in terms of the reduced subsidies as a result of one unit increase in X_1 are captured by the second term, s_1'. And finally, one unit increase in X_1 will make u'N contribution to the objective function, given the primal maximand weight of X_1 equal to u'N. This is represented by the first term.

The second column of Table 7.1 gives the following set of equations:

$$p_1'(\bar{B}_1+W-\bar{B}_2)-p_2'(I-\bar{A}+\bar{B}_1)+f_2'u'M-s_2' = u'N/(1+d) \qquad (7.7)$$

The first term on the left-hand-side of equation 7.7 represents the marginal costs (or marginal benefits) of X_2 in terms of X_1. In order to increase X_2 by one unit, some additional investments would be required in the previous period, the first period, in terms of equipment, the costs of which are represented by $p_1'\bar{B}_1$. Similarly, $p_1'W$ represents the costs of the additional inventory requirements in the first period. One unit increase in X_2 will reduce (X_3-X_2) by one. Any increase in output in the third period over the second period requires proportional investments in terms of construction goods two years in advance, i.e., in the first period. So less investment (construction) in the first period will be required because of the reduction in the future output increase, (X_3-X_2). $p_1'\bar{B}_2$ represents the savings (marginal benefits) resulting from such a reduction in the investment requirements.

$u'N/(1+d)$, the primal maximand weight of X_2, represents the contribution of X_2 to the objective function. In other respects, equation 7.7 is similar to equation 7.6.

Similar conditions for the output vectors in the third, fourth, and final plan period are given by columns 3, 4, and 5 respectively.

$$p_1'\bar{B}_2+p_2'(\bar{B}_1+W-\bar{B}_2)-p_3'(I-\bar{A}-\bar{B}_1)+f_3'u'M-s_3'=u'N/(1+d)^2 \qquad (7.8)$$

$$p_2'\bar{B}_2+p_3'(\bar{B}_1+W-\bar{B}_2)-p_4'(I-\bar{A}+\bar{B}_1)+f_4'u'M-s_4'=u'N/(1+d)^3 \qquad (7.9)$$

$$p_3'\bar{B}_2+p_4'(\bar{B}_1+W)-p_5'(I-\bar{A}-W)+f_5'u'M-s_5' = u'N/(1+d)^4 \qquad (7.10)$$

The contribution of output to the objective function, represented by the term $u'N/(1+d)^{t-1}$ in period t, declines at an annual rate of d, the discount rate in the model. If the left-hand-side terms of each of the equations 7.6, and 7.7 to 7.10 are referred to as "net" marginal costs of output in periods 1 to 5 respectively, then these equations imply that the net marginal cost declines at an annual rate of d. The reduction in the net marginal cost can be related to the reduction in prices over time. For example, the following equation which is derived from equations 7.8 and 7.9

$$\frac{(p_1'-p_2')\bar{B}_2+(p_2'-p_3')(\bar{B}_1+W-\bar{B}_2)+(p_3'-p_4')(\bar{A}-I-\bar{B}_1)+(f_3'-f_4')u'M+(s_4'-s_3')}{p_2'\bar{B}_2+p_3'(\bar{B}_1+W-\bar{B}_2)+p_4'(\bar{A}-I-\bar{B}_1)+f_4'u'M-s_4'} = d \qquad (7.11)$$

shows precisely how the d per cent reduction in the net marginal cost of output between periods 3 and 4 is related to reductions in prices and subsidies.

Unlike X_t, some elements of M_t may operate at zero level. In this regard, our model provides choice. Then in terms of the dual problem, the condition $p'A \geq c'$ should hold for the elements of M_t. For M_1, the competitive imports in period 1, this inequality will be represented by column 6:

$$f_1'u'-p_1' \geq o \qquad (7.12)$$

If equality holds for certain commodities, then there will be imports of those commodities. $f_1'u'$ represents the marginal costs in terms of foreign exchange of importing one commodity. p_1' represents the price or the marginal costs of producing that commodity domestically. Only when the costs of imports and production are equal to each other, is that commodity imported. If the costs of imports are higher than the costs of production, i.e., $f_1'u' \geq p_1'$, that commodity is not imported. In other words, those goods which cost less to produce at home are not imported.

Similar inequality relationships for $M_2 \ldots M_5$ are given by columns 7...10 of Table 7.1:

$$f'_t u' - p'_t \geq o \qquad t = 2,----,5 \qquad (7.13)$$

For the purpose of illustration, the marginal costs and benefits of X_{31} (consumer goods in the first period) are calculated below using actual values of the coefficients from the primal problem of Case (I) and of the shadow prices from the dual solution of Case (I).

An increase in production of X_{31} requires some additional deliveries from the other sectors as well as some additional foreign exchange. The net additional requirements of one unit increase in X_{31} are: .1273 units of X_{11}, .1848 units of X_{41}, .0316 units of X_{51}, and .0416 units of foreign exchange. If we multiply each of the above coefficients by their respective shadow prices given in tables 5.4 and 5.5, we will get a measure of the costs of producing that extra unit of X_{31}. Similarly we can calculate the benefits. One extra unit of X_{31} will mean .9357 units of itself in net terms. .9357 multiplied by the shadow price of X_{31} will give us the benefit in terms of X_{31} itself. One extra unit production of X_{31} will also reduce $X_{32}-X_{31}$ by one. This will reduce the investment needs in terms of equipment in the first period, X_{21}, given the lag structure in our model. The net saving (investment needs reduction minus other requirements) here works out to be .5422 units of X_{21}. This, .5422 multiplied by the shadow price of X_{21} gives us another benefit. The last benefit is that the extra unit of X_{31} will increase the objective function by .3072. By adding all these, we will get a measure of the benefits of producing that extra unit of X_{31}. We find that the costs and benefits of producing the extra unit of X_{31} are equal in value.

The shadow prices from the solutions of the dual problems of the other cases (other than Case I) can also be analyzed in basically the same way as above. The additional constraints such as, the capacity constraint, and the land constraint, make the analysis a little more complex, but their incorporation does not present any methodological problem. The shadow prices from the dual solution of a case with capacity constraint, Case (IC) (with consumption over the plan period as the objective function), are analyzed below.

Table 7.2 shows the primal and dual problems of Case (IC) in detached coefficients form. The activities of

TABLE 7.2

DETACHED COEFFICIENTS TABLEAU OF CASE (IC)

	X_1	X_2	X_3	X_4	X_5	C_3	C_4	C_5	M_1	M_2	M_3	M_4	M_5	
1) p_1'	$-(I-\bar{A})$	W				$\bar{B}_2$			$-I$					$\leq -(\bar{E}_1+\bar{G}_1)+\bar{B}_1\bar{C}_1-(\bar{B}_1-\bar{B}_2)\bar{C}_2$
2) p_2'		$-(I-\bar{A})$	W			$(\bar{B}_1-\bar{B}_2)$	$\bar{B}_2$			$-I$				$\leq -(\bar{E}_2+\bar{G}_2)+\bar{B}_1\bar{C}_2$
3) p_3'			$-(I-\bar{A})$	W		$-\bar{B}_1$	$(\bar{B}_1-\bar{B}_2)$	$\bar{B}_2$			$-I$			$\leq -(\bar{E}_3+\bar{G}_3)$
4) p_4'				$-(I-\bar{A})$	W		$-\bar{B}_1$	$\bar{B}_1$				$-I$		$\leq -(\bar{E}_4+\bar{G}_4)$
5) p_5'					$-(I-\bar{A}-W)$								$-I$	$\leq -(\bar{E}_5+\bar{G}_5)$
6) c_3'			I			$-I$								≤ 0
7) c_4'				I			$-I$							≤ 0
8) c_5'					I			$-I$						≤ 0
9) g_4'						I	$-I$							≤ 0
10) g_5'							I	$-I$						≤ 0
11) f_1'	$u'M$								u'					$\leq u'\bar{E}_1+\bar{V}_1$
12) f_2'		$u'M$								u'				$\leq u'\bar{E}_2+\bar{V}_2$
13) f_3'			$u'M$								u'			$\leq u'\bar{E}_3+\bar{V}_3$
14) f_4'				$u'M$								u'		$\leq u'\bar{E}_4+\bar{V}_4$
15) f_5'					$u'M$								u'	$\leq u'\bar{E}_5+\bar{V}_5$
16) s_1'	$-I$													$\leq -\bar{L}_1$
17) s_2'		$-I$												$\leq -\bar{L}_2$
18) s_3'			$-I$											$\leq -\bar{L}_3$
19) s_4'				$-I$										$\leq -\bar{L}_4$
20) s_5'					$-I$									$\leq -\bar{L}_5$
21) g_3'						$-I$								$\leq -\bar{C}_2$
MAX	$u'N$	$u'N/(1+d)$	$u'N/(1+d)^2$	$u'N/(1+d)^3$	$u'N/(1+d)^4$									

the primal problem of this case which are written along the top of the table include, along with X_t and M_t, the capacity levels in the third, fourth, and fifth periods.

The central matrix of Table 7.2 has 21 rows and 13 columns. The first row of the table expresses the material balance constraints in the first period:

$$-(I-\bar{A})X_1+WX_2+\bar{B}_2C_3-M_1\leq-(\bar{E}_1+\bar{G}_1)+\bar{B}_1\bar{C}_1-(\bar{B}_1-\bar{B}_2)\bar{C}_2 \qquad (7.14)$$

Equation 7.14 is different from equation 7.1 because, in Case (IC), the deliveries made by the capital goods sectors for the purpose of capital formation are related to the capacity levels, not to the output levels as in Case (I). The material balance constraints in other periods are expressed by rows 2 to 5 of Table 7.2.

Rows 6 to 8 express the constraint in equation 4.15:

$$X_t-C_t \leq o \qquad t = 3, 4, 5 \qquad (7.15)$$

This constraint ensures that adequate capacities are available to produce X_t. The constraint which checks the capacity levels from falling are expressed by the 9th, 10th and 21st rows of the table:

$$C_t-C_{t+1} \leq 0 \qquad t = 2, 3, 4$$

As the output levels, X_t, have positive values, the first five columns of Table 7.2 represent the following equality relationships:

$$p_1'(\bar{A}-I)+f_1'u'M = u'N+s_1' \quad (7.16)$$

$$p_1'W+p_2'(\bar{A}-I)+f_2'u'M = u'N/(1+d)+s_2' \quad (7.17)$$

$$p_2'W+p_3'(\bar{A}-I)+c_3'+f_3'u'M = u'N/(1+d)^2+s_3' \quad (7.18)$$

$$p_3'W+p_4'(\bar{A}-I)+c_4'+f_4'u'M = u'N/(1+d)^3+s_4' \quad (7.19)$$

$$p_4'W+p_5'(\bar{A}+W-I)+c_5'+f_5'u'M = u'N/(1+d)^4+s_5' \quad (7.20)$$

These equations represent the marginal costs and benefits of producing output in five different periods. For example, the three left-hand-side terms of equation 7.17 represent the marginal costs of X_2; $p_1'W$ the costs of inventory requirements in terms of X_1; $p_2'(\bar{A}-I)$ the costs of net requirements in terms of X_2 itself; and $f_2'u'M$ the foreign exchange costs. The marginal benefits of producing X_2 and given by the right-hand-side terms: $u'N/(1+d)$ is the increase in the objective function; and s_2' the reduction in the subsidy payments.

The capacity levels, C_t, also have positive values, so that the sixth, seventh and eighth columns of Table 7.2 also represent equalities. These equalities, given below, correspond to the capacity levels in the third, fourth, and fifth periods.

$$p_1'\bar{B}_2+p_2'(\bar{B}_1-\bar{B}_2)-p_3'\bar{B}_1-c_3'+g_4'-g_3' = 0 \quad (7.21)$$

$$p_2'\bar{B}_2+p_3'(\bar{B}_1-\bar{B}_2)-p_4'\bar{B}_1-c_4'+g_5'-g_4' = 0 \quad (7.22)$$

$$p_3'\bar{B}_2+p_4'\bar{B}_1-c_5'-g_5' = 0 \quad (7.23)$$

Equation 7.21 indicates that the marginal costs and the marginal benefits of C_3 are equal to each other. This equation can also be written as

$$p_1'\bar{B}_2+p_2'\bar{B}_1+g_4' = p_2'\bar{B}_2+p_3'\bar{B}_1+c_3'+g_3'$$

The left-hand-side terms of this equation give the marginal costs of the capacity creation in the third period: $p_1'\bar{B}_2$ are the marginal costs in terms of the construction investments made in the first period, and $p_2'\bar{B}_1$ in terms of equipment investments made in the second period; and g_4' represents the marginal costs of maintaining the capacities in the fourth and fifth periods at least at the third period's levels, which may be zero if capacities are increased in these periods.

The marginal benefits of C_3 are given by the right-hand-side terms. Any increase in C_3 reduces (C_4-C_3) by the same amount, and as a result, the investment requirements in the earlier periods which are related to (C_4-C_3) are reduced as well. $p_2'\bar{B}_2$ represents the marginal benefits in terms of the reduced construction investments in the second period, and $p_3'\bar{B}_1$ in terms of the reduced equipment investments in the third period. c_3' represents the marginal benefits in terms of reduction in the adequacy requirements as expressed by equation 7.15. The capacity levels of the second period are (at least) required to be maintained in the third period. The contribution of the extra capacity creation in the third period towards that goal is represented by the last term, g_3'.

The last five columns of Table 7.2 are similar to the last five columns of Table 7.1 and thus have similar interpretations.

The above discussion clearly demonstrates the crucial significance of shadow prices in a linear programming exercise. In conclusion, it should, however, be noted that shadow prices emerge from the solution of a linear programming model, therefore, they are sensitive to the particular specification of that model. So, while interpreting shadow prices, this connection between the shadow prices and the specification of the model from which they emerge should be kept in mind.

FOOTNOTES

CHAPTER 7

1. See Taylor (1975).

2. In the case when the upper bounds are binding, s_i' can be interpreted as rent. In that situation, s_i' should be included among the cost factors.

CHAPTER 8

CONCLUSION

8.1 INTRODUCTION

The role of heavy industries in Indian industrial development has been the subject of a major controversy both in and outside the context of planning. At the heart of the debate about the heavy industries strategy are the contentions that this strategy does not accord adequate importance to the agricultural and/or consumer goods sector, and that the import-substitution policies implied by this strategy have been very costly. The justification for one more study on this subject is predicated on the realization that most of the preceding studies were lacking in the following respects: (a) implications of the heavy industries strategy were not explicitly formulated and studied, (b) treatment of the issues of limited land availability and the use of modern technology in agriculture was cursory and inadequate, and (c) choices implicit in the heavy industries strategy between present and future consumption streams were not properly followed up.

In this study, an attempt is made to reassess the implications of the heavy industries strategy, by giving proper consideration to these desiderata. The study has been conducted within the framework of a five-year plan using a dynamic multisectoral linear programming model. In this chapter, we summarize the main features of our model and the main results of our research. Some possible future modifications and extensions to our model are suggested later in this chapter.

8.2 THE MAIN FEATURES OF OUR MODEL

Our model was designed to provide a framework within which the implications of an industrial policy emphasizing the capital goods sector could be examined. An essential imperative of the heavy industries strategy is that the economy's output capacity should expand during the plan period. In such a strategy capital is not considered malleable which could be easily transferred between sectors and periods. The capacity constraint in our model is designed to ensure such non-transferability of capital. This constraint ensures that there is non-negative investment in each sector in each period. Failing to introduce capacity constraint leads to the absurd possibility of eating capital even before it existed. Such restrictions should be explicitly put in the planning models if the models are to effectively grasp the nature and intensity of the problems associated with the growth of capital goods industries.

Unlike other sectors of the economy, the agricultural sector may be inhibited by the limits of the country's natural resources, especially by the limited availability of land. To capture this land constraint, we exogenously specified upper limits to the agricultural sector's output levels in some of our experiments.

Significant growth in agricultural output can be achieved despite the land constraint if modern technology is used in agriculture. The impact of such a technological transformation on the economy is studied by replacing the Indian agricultural technology with the Japanese technology. This transformation is accomplished in two stages: in the first stage, the agricultural sector's input/output co-efficients are replaced; in the second stage, the capital/output coefficients are replaced as well. In some experiments of our model (the hybrid cases) a simultaneous application of both Indian and Japanese technology is allowed.

The objective function most used in our experiments is the present discounted value of consumption over the plan period. There are, however, two other objective functions which are also used in simulations of the model. To study the issues related to the choices implicit in the heavy industries strategy between present and future consumption streams, some simulations of our model are performed with an objective function which includes both consumption stream of the post-plan period and the plan-period consumption. Another objective function which gives equal attention to consumption and investment is also used to study the issues related to the choices between present and future consumption.

8.3 THE MAIN CONCLUSIONS OF OUR STUDY

In the following section, the main conclusions of our study are summarized. When a reference is made to a particular case, the objective function should be taken to be consumption over the plan period, unless mentioned otherwise.

The results of our study show that the capacity constraint significantly strengthens the equipment sector. The deliveries made by the equipment sector for the purpose of investment increase as a result of the capacity constraint. In the cases with the capacity constraint, the equipment sector even surpasses the consumer goods sector in terms of production.

The effects of the capacity constraint on the construction sector are generally not favourable. But the two capital goods sectors, viz., the equipment and construction sectors, as a whole, benefit from the capacity constraint.

The burden of the growth in the equipment sector caused by the capacity constraint is generally borne by the services sector. This is especially the case when the agricultural sector uses traditional technology. If an industrial strategy which emphasizes capital formation in the economy is pursued, some sacrifice will need be made in terms of output of some non-capital-goods sector(s). The results of our study in this regard suggest that the sacrifice is generally made by the service sector.

It is also to be inferred from these results that the agricultural sector generally need not bear the burden of the growth in the equipment sector, especially in the circumstances when this sector predominantly uses traditional technology. The assertion that lack of agricultural growth is caused by the heavy industries strategy is thus, in general, not supported by our findings. The findings do, however, indicate that the agricultural sector can play a crucial role in generating income and consumption demand.

The changes in the composition of imports brought about by the capacity constraint are in accordance with the import substitution policies implied by the heavy industries strategy. The imports of equipment are almost stopped and are replaced by the imports of services. The economy thus produces most of the required capital goods domestically and meets part of the demand for other industrial goods by imports.

One other outcome of the imposition of the capacity constraint is that the (general) price level in the last three periods as reflected by the shadow prices of different sectors' products is considerably higher in the cases with the capacity constraint than in its absence. The capital goods strategy thus creates upward pressure on the prices in the later part of the plan. In the later periods, foreign exchange also becomes scarcer and more expensive as reflected by the shadow prices of foreign exchange in the cases with the capacity constraint.

The results of our study show that the land constraint in our model reflects the land-scarcity aspect of Indian agriculture. Without the land constraint, the agricultural sector experiences unrealistically rapid growth. The cases without the land constraint thus underestimate the importance of contributions from the non-agricultural sectors. The results of the cases with the land constraint show that it is mainly the capital goods sectors which benefit from the assumption of limited land availability. The equipment sector reaches its highest levels (in terms of sectoral share) in the cases with the strictest land constraint. Our findings thus provide a justification for the heavy industries strategy in the Indian case where the assumption of limited land availability is very reasonable.

The price level in the later periods is considerably lower in the cases with the land constraint than in its absence. This drop in prices consequent upon the reduction in the agricultural sector's demand for other sectors' products as inputs, and the reduction in income generated within the agricultural sector, is another important effect of the imposition of the land constraint.

That agricultural output can be raised by using modern (Japanese) agricultural technology is verified by the results of our study. The results show that the growth in agriculture occurs more in the second stage of the technological transformation than in the first stage.

The first stage technological transformation, by raising the agricultural sector's demand for all sectors' products (except services') as inputs, increases the cost of production of agricultural goods. One effect of this increase in cost, as shown by the results, is that it considerably reduces the value of the objective function, in other words, it reduces total consumption of goods and services in the economy. Our findings in this regard support the assertion that technological transformation in the agricultural sector will not be costless: a price in terms of lower consumption will have to be paid in order to modernize agriculture.

One interesting result of the first-stage technological transformation is that both capital goods sectors generally benefit from this transformation. That is, however, not the case in the second stage of the transformation.

As the capital requirements of the agricultural sector in the Japanese technology are relatively lower than in the Indian technology, the agricultural output increases at an extraordinarily high rate as a result of the second-stage transformation: In Case (J), for example, agricultural output grows at an average rate of 19 per cent per year in the initial four years.

One other outcome of this second-stage transformation is that the lower capital requirements of the agricultural sector cause the gross outputs (and sectoral shares) of capital goods to be significantly lower. The equipment sector reaches its lowest level in Case (J) as a result of this transformation. The diminution of the equipment sector as a result of the use of modern technology in agriculture is arrested with the imposition of the capacity constraint as shown by Case (JC).

These extreme results must, however, be qualified because they are consequent upon the lowering of capital/output coefficients as a result of the introduction of the Japanese technology. In fact, these Japanese coefficients used in our study are marginal coefficients: given the highly developed infrastructure in agriculture in Japan, they represent the additional investments required to raise agricultural output. Raising agricultural output in India will require much higher levels of investment in agriculture, not lower as suggested by the Japanese coefficients. The demand for capital goods in agriculture will rise as a result; that, most likely, will effect substantial growth in the capital goods sector. The results of Case (J) and of like cases thus underestimate the importance of capital goods in the process of modernization of agriculture.

The results of our study show that inclusion of the consumption stream of the post-plan period in the objective function generates a temporal shift in production away from the earlier periods to the final period. This consideration of the post-plan consumption provides a significant stimulus to the equipment sector. The strengthening of the equipment sector comes mainly at the cost of the agricultural sector. By showing that the objective of long-run consumption maximization, in contrast to consumption in the short-run, requires a strong equipment sector, these results provide a validation for the heavy industries strategy. Finally, our results show that inclusion of investment in the objective function also results in a strengthening of the equipment sector. In this situation, the other capital goods sector, the construction sector, is also benefitted. By substantiating the assertion that, when the short-run objectives of planning are broadened to include increase in investment in addition to increase in consumption, strong capital goods sectors are required, our results provide a further validation for the heavy industries strategy.

The results of our study clearly show that our model provides many interesting insights into the intricate issues and problems associated with a development plan. The results are however subject to major qualifications. Some of these qualifications originate, in general, from the use of linear programming techniques in planning exercises.

Both quantities and shadow prices which emerge from the solutions of a linear programming problem are very sensitive to changes in objective function. A multiple objective function which includes many socially desirable goals would be ideal in this regard, but here again, the problem of assigning appropriate weights to these goals remains.

Ad hoc restrictions such as the ones to prevent flip-flop behaviour of consumption or production quite often shape the solutions in a way which can hardly be said to be an outcome of an optimal process. The shadow prices associated with these restrictions can be interpreted as taxes and subsidies. But it will be hard to find any resemblance between them and actual prices, and for that reason, their practical significance will be very limited.

The purpose of our study has been more experimental and illustrative than to provide a blue-print for an Indian plan. The rather simple structure of our model reflects that focus. Some of the qualifications (of the results) can directly be attributed to the specific nature of our model.

The present discounted values of consumption and investment were calculated using a particular discount rate. Some simulations of the model with other discount rates or without discount rate are required to see if the model solutions are sensitive to discount rate or not.

Our sectoral classification is of a highly aggregative nature. The shadow prices emerging from such a system can only have a "broad" meaning, and should be interpreted as such. In a similar way, the imports should also be interpreted in a broad sense.

The assumption of no output growth in the two post-terminal years dispenses with investments in the last year(s) of the plan, and, thus, circumvents capital formation. Impact of this assumption can be assessed by performing simulations of the model with alternative post-terminal growth assumptions.

Finally, our model offers no possibilities of substitution in final demands. The assumption of fixed proportionality in consumption is not realistic and needs to be improved upon. Our model allows alternative processes (process substitution) in the production of agricutural goods. Similar substitution possibilities could be introduced in the other sectors also.

8.4 SUGGESTIONS FOR FUTURE RESEARCH

Our study has attempted to explore the implications of an industrial strategy which emphasizes capital formation in the Indian economy. However, as noted above, the post-terminal growth assumptions of our model undermine that emphasis. It will be interesting to find out what new emergent patterns of development would be if some assumptions requiring a specified growth in capital stocks in the post-terminal years were made. The objective function can also be modified to include some explicit target of capital formation.

Our model assumes that the Indian economy does not face a shortage of labour. Given the level of unemployment in the economy, this assumption is quite realistic. However, an ambitious plan which targets high growth in capital goods sectors might not be feasible due to lack of supply of skilled labour. Extension to our model can be made to include labour constraints which can take into account the availability of labour by different skill categories. The model can also be used to assess the employment creation potential of modern agricultural technology. This will, of course, require detailed information of labour/output co-efficients for all sectors of the economy including separate coefficients for modern agriculture.

The assumption of free disposal of surplus output which underlies the surplus output created in the various sectors in the solutions is unrealistic. Agricultural surpluses could possibly be exported to earn foreign exchange, as might consumption goods, equipment and construction. However, it is unlikely that surplus output of services could be exported so that an equality in the material balances constraint would be more appropriate. Future work can experiment with alternative ways of eliminating surplus output.

Private consumption requirements in our model are related to distribution of income which is given exogenously. In future work, income distribution can be made endogenous by making it dependent on the sectoral composition of value added. This will, in effect, make marginal propensity to consume also dependent on the sectoral composition of value added.

The purpose of our study was to reassess the Indian heavy industrialization strategy. Despite some limitations discussed above, the dynamic multisectoral linear programming model developed in our study was quite successful in accomplishing that task.

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