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PLANNING IN INDIA

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I. INTRODUCTION

Indian planning is an open process. Much of the controversy and the debates that accompany the preparation of the plans are public. The initial aggregate calculations and assumptions are either explicitly stated or readily deducible and the makers of the plans are not only sensitive but responsive to criticism and suggestions from a wide variety of national and international sources. From original formulation through successive modifications to parliamentary presentation, plan making in India has evolve as a responsive democratic political process.

The wide political participation in the preparation of the plan is understandable if one realizes that the plan is not only intended as a set

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[1]An unusually large group of people have made major contributions to the research on which this paper is based, so much so, in fact, that the author feels he should be regarded as the rapporteur of a joint effort, especially with respect to the formulation of the model described. Yet, each individual might present and evaluate the results differently so that no one but the author is responsible for the opinions of this paper and any errors which it might contain. Credit for whatever merit there may be is shared with Professor S. Chakravarty of the Delhi School of Economics, Professor Louis Lefeber of Stanford University, and Dr. Kirit Parikh, Research Associate of the Center for International Studies, M.I.T. The author is also indebted to Professors Millikan and Rosenstein-Rodan of M.I.T. Assistance has been provided by Mrinal Datta-Chaudhuri, Dr. T. Krishnan, Dr. Jayant Shah and T. Weisskopf which has gone far beyond doing calculations to order and the author regards them as having been close associates. Professor Nino Andreatta of the University of Bologna, Dr. Ashish Chakravarti, Indian Statistical Institute, James A. Mirrlees, Cambridge University and Dr. Per Sevaldson of the Central Bureau of Statistics, Oslo, Norway were instrumental in starting the original project and their early advice has continued to be useful. The research has been financed by the India Project of the Center for International Studies, M.I.T. and the U. S. Agency for International Development, neither of which is responsible for the analysis and opinions expressed here. The M.I.T. Computation Center has been generous and cooperative in making its facilities available.

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of prescriptions for economic behavior but represents the diverse aspirations of a nation for social advancements. Yet, the nation is not a homogeneous political entity; it is composed of a variety of regional, linguistic, economic, cultural and political groups. The many particular and frequently contradictory interests of each of these groups has to be recognized and to the degree it is possible, accommodated within the framework of the Plans. The political process which leads to the formulation of the final document is undoubtedly an impressive manifestation of the workings of an open society. By its very nature it generates many problems from the point of view of mapping an optimal strategy for economic development. Though there has been a considerable amount of debate over the Plans there has been relatively little explicit attention given to alternative strategies or paths of economic growth and development. In fact the political discussions have been only tangentially concerned with questions of alternative compositions of national targets and much more with the capacity for saving and taxation, problems of direct controls and price stability. The latter are, of course, directly related to the setting of social-economic goals and to the mapping of the paths leading toward them. However, the relationships have not been spelled out and the significance of the Plan targets for current and future welfare has been left implicit.

Although participation in the debates which accompany the preparation of the Plans is widespread, unfortunately it has not been well informed either on the welfare implications of the Plan goals or on many other Plan implications. Planning efforts have been absorbed in attempting to make a single plan whose goals, resource requirements and resource availabilities were consistent. Alternative policies have received only limited

consideration in part because the alternatives remain relatively unknown. Plausible and consistent alternative plans are difficult to prepare and the enormous amount of information needed for their formulation is not readily available to individuals and organizations outside the central government. Hence, in order for a range of alternatives to be available for consideration, the Planning Commission and the concerned Ministries would have had to prepare them and this has not been done. The preparation of alternative Plans and the comparison of their implications is not advocated as a service to potential critics. It is an essential part of the planning process for only in this way can the full implications of any single plan be appreciated.

This criticism of Indian planning must be seen in proper perspective. No conceptually satisfactory techniques of planning or more generally of making economic policy for development were readily at hand when the Indian Plans were first being made. Even now, in spite of considerable progress the operational techniques are relatively crude. Among the less-developed countries the Indian approach to planning is one of the most sophisticated. It may be just because of this fact that higher standards are set in judging Indian performance than would be appropriate elsewhere.

There are many important aspects of Indian planning which will not be dealt with in this paper. In particular, issues related to implementation of the Plans will not be discussed. However, this omission should not be taken as implying that the issues of Plan implementation are unimportant. After a brief discussion of the techniques and functions of planning in India the focus will turn to a method of analyzing the implications for development of alternative targets and the significance of such alternatives.

This is, I believe, one area in which more intensive economic analysis can help improve planning procedures.

II. THE TECHNIQUES OF INDIAN PLANNING

The First Five Year Plan, though prepared in haste, embodied a projection of an aggregate growth path generated by capital accumulation and financed largely by domestic saving described by a linear savings function. The aggregate growth model was of a Harrod-Domar type, however the linearity of the savings function implied a marginal savings rate higher than the average. This in turn indicated a decreasing reliance on foreign assistance in spite of the higher levels of investment projected. This simple model, it should be noted, was a projection, not a plan which could be implemented, although it did have implications for policy with respect to foreign exchange availability and government saving. Sectoral investment allocations were determined in the public sector by the particular projects which were proposed. A glance at the First Plan will dispel, however, any notion that there was a lack of concern for the distant future. This Plan had in fact the most explicit set of aggregate calculations. Yet it is not surprising that at this early stage detailed analyses were not made of the significance of alternative future compositions of output.

In the formulation of the Second Plan a simple aggregative Harrod-Domar growth model was again used for over-all projections with parameters that were based on an optimistic extrapolation of the First Plan experience. For the purpose of answering questions about the strategy of resource allocation to such broadly defined sectors as agriculture and industry, Professor P. C. Mahalanobis, Director of the Indian Statistical Institute and member of the Planning Commission, prepared two and four sector models which may

have been influential in drawing up the Plan.[1] The two sector model reminiscent of the Feldman model,[2] was used to demonstrate the relations between the allocation of investment between the sectors and the over-all growth rate. It distinguishes consumer goods and investment goods, the latter usable to create capacity in either sector. A linear structure of production is assumed and a constant marginal utility of consumption so that future and present consumption would provide the same benefits. The model ignores foreign trade and consumption maintenance requirements for labor. Given these conditions it follows that the long run rate of growth depends on the relative allocation of investment to the capital goods producing sector. While the conclusion will not necessarily be maintained if the assumptions are modified the model did serve the purpose of emphasizing the significance of the choice of planning horizon.

Mahalanobis' four sector model was intended to indicate the investment allocations which would achieve prescribed growth rates and employment levels. Here, again, foreign trade was ignored and demand conditions for investment and consumption were taken into account only insofar as the investment allocation suggested by the two sector model could be assumed to be relevant.

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[1] "The Approach of Operational Research to Planning in India," and "Draft Plan Frame for the Second Five Year Plan," Sankhya, Vol. XVI, Dec., 1955, pp. 3-89. These models have been the subject of a number of critical analyses which will not, therefore, be repeated here. See: S. Tsuru, "Some Theoretical Doubts on India's Plan Frame," Economic Weekly. (Annual Number) Vol. V, Jan., 1957; S. Chakravarty, The Logic of Investment Planning, pp. 43-48; R. Komiya, "A Note on Professor Mahalanobis' Model of Indian Economic Planning," The Review of Economics and Statistics, Vol. XLI, Feb., 1959, pp. 29-35.

[2] See E. Domar, "A Soviet Model of Growth," in Essays in the Theory of Economic Growth, 1957, pp. 223-262.

Both models were too limited in scope to indicate the most desirable allocation of resources among interdependent sectors. No attempt was made to find optimal allocations; dynamic interrelations were not taken into account and the targets were defined in highly aggregative terms. The models were not employed to examine the significance of alternative long term programs and in fact could have been used for that purpose only with substantial modification.

The detailed program of the Second Plan consisted of a collection of particular projects including both unfinished First Plan undertakings and proposals for new ones. Though the sum total of the investment costs of these projects was subject to over-all constraints derived from the aggregate projections, there were nonetheless enough residual or "buffer" sectors to reduce the constraining influence of aggregate resource limitations on these projects. The exception was the limitation imposed by the scarcity of foreign exchange; however, this restriction operated primarily not as aggregate constraint but in terms of availability of foreign exchange financing for separate projects.

There was no explicit mechanism visible in the Second Plan for coordinating the development of the various sectors so as to avoid either bottlenecks or surpluses. To the extent that coordination and scheduling was achieved it was through the screening procedures of the interministerial committees and working groups that met with Planning Commission representatives. These committees were responsible for the setting of the detailed targets in the Plans, as well as for the approval and phasing of projects. As one of their working tools these committees apparently did prepare commodity balances for the entire Plan period, at least for particular items and sectors.

However, one must not conclude with the impression that the setting of the targets and the design of projects was or is now left entirely to the deliberations of expert working committees of the central government. The economic influence of the Indian States makes itself felt both at the highest political levels and through negotiations with the Planning Commission and the other Union ministries. The State governments come to the Center not only as petitioners but as powerful advocates backed by substantial resources. They are determined to have a voice not only in matters affecting their regional economies such as the location of new plants, but on over-all economic policy as well.

The approach to the Third Plan was similar to that taken in the preparation of the Second Plan. Again there were macro-economic projections which, though less explicit, were accompanied this time by a clearer recognition of the alternative possible values of parameters which in turn made some of the parameters themselves a matter of policy. One of the initial and continuing debates over the formulation of the Third Plan concerned the over-all magnitude of the Plan in relation to aggregate resource availabilities.[1] This time, however, there was no apparent attempt to use models such as those prepared by Professor Mahalanobis for the formulation of the Second Plan for determining sectoral priorities. Instead, the consultation and review procedures appear to have operated more intensively and the calculations of commodity balances were done more extensively, in more detail and with greater attention given to improving the basic data. It is impossible

[1] As an aspect of this discussion see I. M. D. Little, "Tax Policy and the Third Plan," in Pricing and Fiscal Policies, A Study in Method, P. N. Rosenstein-Rodan, ed., Cambridge, 1964, pp. 30-76.

for an outsider to reconstruct the procedures by which relative priorities and scheduling were established. The interplay of ministerial and state and local ambitions appear in some cases to have had as much influence as any over-all direction from the Planning Commission itself. Indeed as John Lewis pointed out, a framework was not provided by the Planning Commission or by any of the Ministries in which these various interests could be reconciled in a drive toward coordinated objectives.[1]

The detailed supervision of target setting, project choice and resource allocation by groups of experienced persons can go quite far in taking into account the most significant economic interactions. This is particularly true when the feedback effects of one committee's decisions on the work of other committees is limited. However, India is too large a country and its economy is too complex for such a condition to hold completely. Of course, where interactions exist, overlapping committee membership and pyramided committee organization can at least partially recognize and account for feedback effects. More than that, no mechanical model of planning could ever substitute for the judgment which such a system of committees could bring to bear on the formulation of policy. At the same time the system is necessarily a cumbersome one and its operation could be significantly improved by providing these committees better

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[1] See John P. Lewis, "India," in Planning Economic Development, Everett B. Hagen, ed., 1963, pp. 98-104 and also, Quiet Crisis in India, Chaps. 4 & 5 esp. Lewis' description of a "planning backward" approach in which a set of final demands are broken down by steps into specific phased projects would have provided a clearer conceptual framework than that which appears to have dominated the Planning Commission. However, the detailed means of its implementation are by no means clear in Lewis' description nor does this approach provide adequate recognition of the issues involved in setting the final demand goals, the constraints of initial conditions and the importance of generating alternative Plans.

analytical tools than are currently available.

Though Indian Planning is an open process with broad political participation, it is also true that the latter has, for the most part, made itself felt on the marginal rather than on the central issues. This is in part because the central issues which relate to questions of welfare of income distribution, time preference and the social control of economic activities have not always been adequately identified.

In addition to the Planning Commission and economic Ministries there are other groups formally charged with economic planning responsibilities: the National Development Council, the Advisory Committees on problems of individual sectors and a Consultative Committee of Members of Parliament. There are also informal groupings such as the consultative committee of the Prime Minister.[1] For various reasons including inadequate staff, limited time and, in some cases, with limited significance given to their roles, these groups have not provided guidance for informed political participation in the process of planning. As a consequence, in the procedures for formulation of the plans there has been relatively little consideration of the specific composition of economic targets in the light of social preferences concerning present and future consumption subject to resource availabilities.[2] These issues have tended to become prime subjects of political debate only

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[1] An informative description of the administrative and organizational structure of the Indian planning process is given in S. R. Sen, "Planning Machinery in India," Economic Commission for Asia and the Far East, Conference of Asian Economic Planners, New Delhi, 1961.

[2] However, this does not mean that Indian planning is particularly backward in this respect. The same criticism would be valid for most planning activities. Fundamental criticisms of the planning process have been raised in India by Prof. Shenoy of Ahmedabad University among others. Prof. Shenoy's objections are so basic, however, that they would appear to be more easily avoided than would the criticisms of persons committed in a general way to the prevailing brand of Indian socialism but skeptical of its implementation.

under the pressure of a new budget embodying substantial tax increases or under the impact of price inflation.

III. THE FUNCTIONS OF INDIAN PLANNING

The function of economic planning is to provide guidelines for the use of scarce resources and to indicate the methods of implementation. But what is the practical content of this function in the mixed government-private enterprise system of India? The aggregative growth models implicit in the Plans have not provided particulars of economic policy but rough guidelines to total resource requirements. They have had specific implications only for the government current and capital budget, over-all investment licensing, foreign exchange use, as well as fiscal and monetary policy. Although the Indian Plans encompass the entire economy, the decisions of the private sector can be only partially controlled by the government. Hence, the Indian Plans as for most mixed economies naturally speak with greater authority about the government than the private sectors. The Five Year Plans are sometimes represented as a set of detailed blueprints of a development program. It is nearer to the truth to characterize the Plans as a general statement of government intentions as to its own programs as well as with respect to those sectoral programs open to private initiative. As far as implementation is concerned, public sector projects can be carried out subject only to government financial and organizational constraints. For example, the Plans contain extensive chapters on such specific topics as community organization and development, conservation, education and training, family and health planning and scientific and technological research. All of these are important and proper concerns of development policy. At the same time, these are the programs whose precise effects on economic

development are difficult to assess. Furthermore, many of these programs are carried out by the state governments which in the Indian federal system have major responsibility for agricultural policy, education and welfare programs. Although the state governments, as was indicated above, are fully involved in the planning process, their effectiveness in implementing the Plans is often lower than that of the Union Government. This is partly due to the generally lesser administrative capacity of the local governments. In addition, and perhaps more importantly, the inevitable political differences among the States which cannot be fully resolved, manifest themselves in varying degrees of commitment to particular Plan objectives.

As mentioned above, the plans cannot be detailed blueprints for those sectors which are predominantly reserved for private initiative. In these areas the plans indicate the types and levels of activity which are considered to be consistent with the over-all targets. Control of expansion is exercised by means of investment licensing and foreign exchange quotes and other controls on resource allocation. Furthermore, guidance to private investors is provided through the publication of sectoral targets and access to the "industries officers" of the various ministries as well as by the agricultural extension members. In certain instances extension of private investment over and above the targeted levels has been permitted. This was, for instance, notably the case during the Second Plan, when the rate of expansion of coal mining scheduled for the government sector was not achieved and private mining companies made up the deficiency.

The public sector can be directed toward plan targets by administrative fiat and with the financial resources of the central and state governments. The private sector cannot be so directed but its response to economic

incentives is regulated by the extensive system of direct controls. The incentives themselves are modified by monetary and fiscal policy. However, the goals of free market forces and of plan targets do not necessarily coincide and the operations of the private sector have not always been well coordinated with those of the public sector and with plan targets. Shortfalls in production, investment licenses which are allowed to lapse and unforeseen price increases are all signs of inadequacies in carrying out this intrinsically difficult task.[1]

The function of the Plans in setting the context and climate for private activity can hardly be overemphasized. More than what can be accomplished with general statements of intent and speeches, the Plans give quantitative indications of the rate and direction in which the government intends to move the economy. The quantitative specifications of the Plans project precise relationships between activities in the government and private sectors specific. Given the natural sensitivity of private enterprise to India's avowedly socialist goals it is particularly important to have concrete and explicit statements of government policy toward private business. The Plans play an even larger role, however. To dismiss as window dressing the ringing phrases contained in the introductory chapters of the Plans would be a mistaken reaction, and more than that, it would indicate a lack of understanding of the catalytic effect of planning on Indian society. The Plans provide symbolic leadership and provide orientation to a developing society.

[1]It has been a continuing complaint about Indian planning by Indian businessmen and many foreign observers as well, that the private sector has suffered from excessive controls and inadequate incentives. This may reflect, however, a set of goals different from the plan targets as well as mistakes in calculation of what is necessary to achieve the targets. These issues will not be followed up here though they are far-reaching in their significance.

IV. DESCRIPTION OF A PLANNING MODEL[1]

Indian planning will be analyzed in this paper by means of a linear programming model in which the intertemporal relations involved in planning are treated explicitly. It is a programming model because optimization with respect to constraints is presumably what planners try to do. Linearity is an unfortunate restriction which for the present is imposed by analytical, computational and information constraints. Compared to the real world and to certain aspects of planning procedures actually in use the model is a gross simplification in a number of respects. In other aspects it is more sophisticated than methods currently used. It should be emphasized at the outset that the model is not intended nor able to produce the "best" possible plan for India. It is a device for checking consistency and exploring alternatives. After presenting the model and some of the results obtained with it the strengths and weaknesses of the approach will be evaluated.

The maximand of the model is the weighted sum of annual aggregate consumption for the entire planning period, T, which at five years is that of the Indian Plans. This is a linear objective function

$$(1) \qquad U = \sum_{t=1}^{T} w(t)C(t) \ ;$$

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[1]The model used in this study is a generalization of the model presented in R. S. Eckaus and L. Lefeber, "Capital Formation: A Theoretical and Empirical Analysis," Review of Economics and Statistics, Vol. XLIV, May, 1962, pp. 113-122 and L. Lefeber, "A Simple Optimizing Planning Model," Capital Formation and Economic Development, P. N. Rosenstein-Rodan, ed., Cambridge, 1964, pp. 83-109. It has been further developed by the contributions of Lefeber, Chakravarty, Parikh and the author. It has a clear heritage from the programming models of Chaps. 11 and 12 of Linear Programming and Economic Analysis, N. Y., 1956 by R. Dorfman, P. A. Samuelson and R. Solow. P. Sevaldson and Prof. N. Andreatta were instrumental in recommending the approach.

w(t) represents the relative weight placed on consumption in period t. The ratio between pairs of adjacent weights reflects a social discount factor. Thus, setting the weight corresponding to the first time period equal to one, the value of the objective function corresponds to the present discounted value of the stream of aggregate consumption over the entire plan period. The discount rate is assumed to remain constant over the plan horizon.[1]

Though the model is multisectoral, consumption is treated in the objective function as a single, composite commodity since it is stipulated that sectoral outputs enter consumption in fixed proportions. In equation (2) F(t) represents the column vector of sectoral outputs designated for consumption and c is a diagonal matrix whose elements indicate the composition of C(t). Although the use of a composite good as the consumption

$$(2) \qquad cC(t) \leq F(t) \; ; \quad c = |c_i| \; ; \; \sum_i c_i = 1 \, , \quad \text{for } t=1, \ldots, T.$$

variable is undoubtedly a major abstraction it has computational merit in that it avoids the non-linearities which may be associated with explicit demand elasticities and also circumvents the problem of separately weighting each good that enters consumption. This undoubted advantage has to be balanced against the damage done to reality by the imposition of a constraint which forbids substitution among types of consumption. In interpreting the significance of the assumption with respect to the computations to be presented, it should be kept in mind however that the

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[1]The assumption of constant discount rate is necessary to avoid the "regret" problem of R. Strotz analyzed in, "Myopia and Inconsistency in Dynamic Utility Maximization," Review of Economic Studies, Vol. 23, No. 3, 1956, pp. 165-180.

level of aggregation is quite high. It is unlikely that in a country like India the composition of consumption would change very much among grossly defined sectors over such a short period as five years. In any case, this is only a convenient formulation and the consumption proportions will be varied by exogenous specification, taking income levels into account, in order to explore the implications of alternative composition.[1]

Annual consumption levels provided by a plan cannot be set without taking into account socially desired levels and growth rates of consumption, such as satisfaction of "minimum requirements" and either a stable or monotonically increasing pattern. Substantial fluctuations in consumption are not likely to be politically acceptable. Yet, in this model satisfactory levels and growth rates of consumption cannot be taken for granted if they are not explicitly imposed as constraints. The behavior of consumption over time will otherwise depend on the interrelationships between the productivity of the system, the discount rate, initial endowments and terminal requirements. Depending on their relative magnitudes consumption behavior could be monotonic but concentrated at the beginning or end of the planning period or fluctuate over time.

To ensure a rising pattern of consumption over time a set of "monotonicity" constraints are added as shown in (3).

(3) $C(t+1) \geq C(t)(1+\rho)$, for $t=1, \ldots, T-1$.

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[1]Pseudo-variable proportions can be introduced into the market basket by stipulating overlapping upper and lower limits within which the proportions themselves can change. T. Weiskopf has experimented with consumption goods composed on this principle. The disadvantage is computational due to the inevitable increase in the number of inequalities.

These inequalities require that consumption in any one period must be at least as great as consumption in the previous period augmented by a growth factor $(1+\rho)$ where ρ is a politically determined parameter, which will presumably take into account the population growth rate. A lower bound is also placed on C(1) to ensure that at least a minimum level of consumption is attained in the first period. This is shown by the relationship (4).[1]

(4) $\quad C(1) \geq \overline{C(1)}$.

Turning now to the other relations which explain the availability and other uses of resources and output the products of the different sectors may be used as inputs into current production, for capital formation and for the satisfaction of government and export demand. Furthermore, these products may originate from domestic output or imports or - in some suitable combination - from both. This is described by the distribution relationships shown in (5) of which there is a set for each time period.

(5) $$aX(t)+F(t)+N(t)+Q(t)+H(t)+G(t)+$$
$$E(t)-M(t)-X(t) \leq 0 \quad , \quad \text{for } t=1, \ldots, T.$$

All terms of this sum are to be read as column vectors, the elements of which represent the different uses of the outputs of each sector. a is the Leontief matrix of input coefficients and X(t) is the column vector of the domestic outputs corresponding to all sectors. Hence, the product, a column vector, shows the sum of the intermediate demands by all sectors for the goods of each sector.[2] Other uses, i.e., consumption, new capital formation,

[1] In the computations actually carried out for this paper the constraint in (4) was frequently not imposed for reasons explained below (p. 60).

[2] The a matrix itself, of course, is a summary of many production relationships.

capital replacement, inventory accumulation, government consumption and exports are represented by the column vectors F(t), N(t), Q(t), H(t), G(t), and E(t), respectively, of which the last two will be stipulated exogenously. The two negative terms X(t) and M(t) are column vectors of supplies from domestic and imported sources respectively.

Domestic production requires only capital capacity. The production functions are described in (6).

(6) $bX(t)-K(t)\leq 0$; where $b = |b_{ij}|$, for t=1, ..., T.

b is a diagonal matrix composed of capital-output ratios. Capacity, K(t), is a composite capital which is committed to a particular sector, but which may change from period to period depending on the rate of depreciation and the investment which is carried out in that sector.

The formation of capacity in each sector is shown in (7) where Z(t+1) denotes new capacity which first becomes available for use in period (t+1). D(t+1) are the amounts of capital stock which are disabled by the depreciation of some part of it. R(t+1) is the amount of the disabled capital stock which is made productive again by the replacement of the depreciated component.

(7) $K(t+1) - K(t) - Z(t+1) + D(t+1) - R(t+1) \leq 0$, for t=1, ..., T+2.

New additions to capacity are formed by blending different sectoral outputs in fixed proportions and with specified gestation periods. Thus, in order to have the desired capacity increase in a particular sector available at period t designated parts of it must be completed in periods

t-1, t-2 and t-3.[1] p_1, p_2 and p_3 are matrices which indicate the proportions in which each sector must deliver output to form capacity which is to become effective one, two and three periods later. Thus,

$$(8) \qquad p_1 Z(t+1) + p_2 Z(t+2) + p_3 Z(t+3) - N(t) \leq 0, \quad \text{for } t+1, \ldots, T.$$

To account for depreciation a "one-horse-shay" model of capital is assumed so that productive services can flow from capital at a constant rate after its creation until the end of its lifetime at which point it loses all productivity. Capital lifetimes of twenty years for equipment and thirty-three years for construction are assumed so that within a five year planning model depreciation is exogenous. Given the different lifetimes for different components productive capacity is lost by the depreciation of only a part of a unit of capital and, likewise, may be restored by the replacement of only the depreciated part. The depreciation in each period is

$$(9) \qquad D(t) = \overline{D(t)} \ , \quad \text{for } t=1, \ldots, T+3.$$

The proportions of depreciation of each type in each sector are indicated by a square matrix r whose terms are D_{ij}/D_j. The terms r_{ij}/p_{ij} are the ratios of depreciation proportions to the proportions in which the component parts are required for capacity. Thus, multiplying $D_j(t)$ by r_{ij}/p_{ij} will

[1] Alternatively, it would have been possible to provide for deliveries of investment goods with variable gestation periods on which lower bounds would be set. This would provide additional flexibility which might in some circumstances be of particular flexibility as it would permit uncompleted investment to be carried over without penalty. This latter formulation was not chosen for several reasons. It would increase the computational burden, first of all. Secondly, on the basis of admittedly casual observation, this additional flexibility does not appear to be practically an important phenomenon.

indicate the productive capacity lost through depreciation of each component. The actual capacity lost in each sector is the maximum of $D_j(t)\ (r_{1j}/p_{1j},\ r_{2j}/p_{2j},\ \ldots,\ r_{nj}/p_{nj})$. The diagonal matrix d is formed from each of whose terms is the maximum of r_{ij}/p_{ij} for each i and j. The actual capacity lost through depreciation is then

(10) $V(t) = D(t)[d]$, for $t=1, \ldots, T+3$.

The optimizing mechanism can now decide to restore all or part of the depreciated capacity by replacing the worn-out components. Thus,

(11) $R(t) \leq V(t)$.

Like new investment, replacement requires a gestation period depending on the type of component. So deliveries for replacement must look three periods ahead to the actual replacement which the model decides to undertake, i.e.

(12) $Q(t) = r^1[d]^{-1}R(t+1)+r^2[d]^{-1}R(t+2)+r^3[d]^{-1}R(t+3)$, for $t=1, \ldots, T$.

In addition to capacity formation, capital formation takes place also in the form of inventory accumulation. Assuming that the latter is proportionate to changes in the levels of sectoral outputs, the demand for inventory increases, H(t), is described by relationship (13).

(13) $s[X(t+1)-X(t)] = H(t)\ ;\ s = |s_i|$, for $t=1, \ldots, T$.

In order to provide a basis for computing inventories in the first period an "anticipated" level of output is specified equal to $(1+\alpha)\overline{X(0)}$. Thus,

(14) $H(1) = s[X(2) - (1+\alpha)\ \overline{X(0)}\ ]$.

s is a diagonal matrix of coefficients for inventory change.

Government demands for goods and services are exogenously stipulated for each sector.

(15) $G(t) = \overline{G(t)}$, for $t=1, \ldots, T$.

Exports are also specified exogenously:

Foreign aid and long term capital movements, i.e., foreign transfers are also exogenously determined. The sum of the two, FA(t), expressed in constant domestic currency, plus exports $FA(t)+\sum_i E_i(t)$, define the availability of foreign exchange at any time period. The sum of imports by all sectors must, of course, not exceed the availability of foreign exchange. This is shown by relationship (17).

(17) $\sum_i M_i(t) \leq FA(t)+\sum_i E_i(t)$, for $t=1, \ldots, T$.

In a linear model such as that presented here the solution would necessarily involve a movement toward specialization of imports. In this case unconstrained specialization would manifest itself by allocating all foreign exchange resources so as to totally replace domestic production by imports in one or a few sectors.[1] This kind of specialization in a highly aggregated system would inject an extreme lack of realism into the solution. At the same time the model should be given some freedom to

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[1] If some foreign exchange were left over after the total displacement of domestic production in one or more sectors, it would be allocated to another sector where, as a consequence, domestic production and imports would take place simultaneously. This, of course, would not contradict the contention that the system moves towards specialization; it means only that the system, quite sensibly, would not throw away good foreign exchange resources.

allocate foreign exchange to the sectors where it is most useful. This is done by imposing both import ceilings in all importing sectors and import floors where such should be necessary. The latter consists of sectoral minimum import requirements that are "non-competitive" in the special sense that they must be satisfied before other imports are allowed. If foreign exchange is left over after these minimums are satisfied, it is allocated according to cost advantage, i.e. competitively, to other sectors.[1] But now the import ceilings become operational so that imports cannot completely displace domestic production in any one sector.

Relationship (18) describes the division of total imports into non-competitive $[\sum_i M^1_i(t)]$ and competitive imports $[\sum_i M^2_i(t)]$. These are obtained for each time period by summing over the sectoral amounts.

$$(18) \qquad \sum_i M_i(t) = \sum_i M^1_i(t) + \sum_i M^2_i(t) \quad , \quad \text{for } t=1, \ldots, T.$$

Import floors, i.e., the minimum levels of non-competitive imports are determined for each sector in terms of given proportions m^1_i of the sectoral domestic outputs. This is shown by (19).

$$(19) \qquad M^1_i(t) = m^1_i X_i(t) \quad , \text{ for } t=1, \ldots, T.$$

Whatever foreign exchange is left over after satisfying non-competitive input requirements can be distributed for competitive imports with the limitation that not more than a given proportion m^2_i of the remaining foreign

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[1] Cost advantage depends on the initial distribution of capital capacities as well as the structure of production coefficients. Therefore, the allocation of the foreign exchange resources may be dominated by the initial conditions rather than a more comprehensive interpretation of cost advantage. Furthermore, changes in foreign prices are also neglected and exports are exogenously stipulated. Hence the concept of cost advantages is different in a number of respects from a dynamic interpretation of Ricardian comparative advantage.

exchange can be spent for imports in that sector. This is described under (20). $\sum_i m_i^2$ must be chosen so as to exceed unity, otherwise the maximizing mechanism has no freedom to allocate competitive imports according to cost advantage.

$$(20) \quad M_i^2(t) \leq m_i^2(t) \left[FA(t) + \sum_i E_i(t) - \sum_i M_i^1(t)\right], \quad \text{for } t=1, \ldots, T.$$

Up to this point constraints have been described which relate to the intra plan periods. The determination of the initial and terminal conditions must now be described. The initial conditions summarize the productive capacity of the economy in existence at the start of the planning period, i.e., the initial capital stocks K(1). Furthermore since capacity increases follow a lagged gestation pattern, the incomplete projects from the pre-plan period which are available for completion during the first years of the plan must also be specified. Their completion may or may not be efficient - the decision on this is left to the optimizing mechanism. The initial conditions in the form of column vectors are shown in (21). Capacity increases maturing in the first period are not listed since they are already included in K(1) as potentially active productive capacity at the beginning of the Plan.

$$(21) \quad K(1) = \overline{K(1)}; \quad I^3(0) = \overline{I^3(0)}; \quad I^2(0) = \overline{I^2(0)};$$

$$I^2(-1) = \overline{I^2(-1)}.$$

$I^2(0)$, for example, is the investment carried out in period 0 for completion in period 2.

While the initial conditions reflect the state of the economy when the planning period begins, the terminal conditions summarize the state of

the economy to be attained by the end of the planning period. For a variety of reasons plans must be truncated at some point and it is the function of the terminal conditions to reflect the post-plan future within the planning period. Barring terminal capital requirements set so high as to be unfeasible, the planner has considerable scope for choice with respect to these terminal conditions. The issues related to this choice have received so little explicit attention in Indian planning that it is hard to avoid the belief that their significance has not been adequately appreciated. Although there are good reasons for making short plans the choice of a planning period is essentially arbitrary. Yet short plans should be consistent with both the long run and continuing goals of society as well as more immediate needs. The former objectives will include raising the standard of living of the nation; the latter, for example, may reflect urgently felt military requirements. There are a variety of techniques which can be employed to bring these post-plan considerations within the purview of a truncated planning period.

The terminal conditions will be set in two ways in the solutions which follow. First the targets of the Third Plan will be used. They will be extrapolated by means of the sectoral intra-plan growth rates as a basis for determining the investment necessary within the plan period for post-plan period growth. With such terminal conditions the model will be called the Target Model and its solutions, Target solutions. The next analysis will use a method of setting targets which makes them determined endogenously as part of the solution. The technique is a variation of

that presented by Chakravarty and Eckaus[1] and R. Stone and Alan Brown.[2] The level of composite consumption attained in the last period of planning is taken as the basis for the future growth path of consumption. Even in this case, government purchases, exports and foreign exchange reserves (exports plus foreign aid) continue to be specified exogenously. Thus, because the last period consumption is an endogenously determined variable of the optimizing system, the post-terminal sectoral output levels required to sustain a given rate of post-terminal consumption growth also become endogenously determined variables. Since in this case the model solution provides an optimal transition to exogenously specified post-terminal growth rates it will be called the Transit Model and its solutions, Transit solutions.[3]

The determination of the post-terminal sectoral output levels required to sustain a given rate of consumption growth is shown by relationships (22) and (23). Equation (22) is the distribution relationship (5) into which the appropriate growth terms have been substituted and (23) is the sum of the particular solutions corresponding to the non-homogeneous elements of the post-terminal growth: consumption, government, exports and imports. The homogeneous elements in (22) relate to inter-industry

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[1] S. Chakravarty and R. S. Eckaus, "An Approach to A Multisectoral Planning Model," in Capital Formation and Economic Development, P. N. Rosenstein-Rodan, ed., Cambridge, 1964, pp. 112-115, esp. General considerations involved in setting terminal conditions are discussed in S. Chakravarty and R. S. Eckaus, "Choice Elements in Intertemporal Planning," ibid, pp. 68-83.

[2] A Computable Model of Economic Growth, London, 1962.

[3] The nomenclature in the first version of this paper was not so specific. Originally what is now called the Transit Model was called the Basic Model and the Target Model was not given a name.

flows and to gross capital formation as well as inventory requirements. They are the terms multiplied by the b, d and s coefficients. The non-homogeneous elements are the terms indicating the growth of C, G, E and M based on the levels which they attain in the last plan period and the exogenously stipulated growth rates.

$$(22)\quad X(t) = aX(t) + b^1[X(t+1)-X(t)] + b^2[X(t+2)+b^3[X(t+3)-X(t+2)] + s[X(t+1)-X(t)] + (1+\phi)^{t-T}F(T) + (1+\delta)^{t-T}R(T) + (1+\gamma)^{t-T}G(T) + (1+\varepsilon)^{t-T}E(T) + (1+\mu)^{t-T}M(T),$$

$$\text{for } t = T+1,\ T+2,\ T+3.$$

$$(23)\quad X(t) = [I-a-(b^1+s)\phi-b^2(1+\phi)\phi-b^3(1+\phi)^2\phi]F(T)(1+\phi)^{t-T} + [I-a-(b^1+s)\delta-b^2(1+\delta)\delta-b^3(1+\delta)^2\delta]R(T)(1+\delta)^{t-T} + [I-a-(b^1+s)\gamma-b^2(1+\gamma)\gamma-b^3(1+\gamma)^2\gamma]G(T)(1+\gamma)^{t-T} + [I-a-(b^1+s)\varepsilon-b^2(1+\varepsilon)\varepsilon-b^3(1+\varepsilon)^2\varepsilon]E(T)(1+\varepsilon)^{t-T} + [I-a-(b^1+s)\mu-b^2(1+\mu)\mu-b^3(1+\mu)^2\mu]M(T)(1+\mu)^{t-T},$$

$$\text{for } t = T+1,\ T+2,\ T+3.$$

The b coefficients are defined by

$$(24)\quad b^1 = p^1 b\ ;\quad b^2 = p^2 b\ ;\quad b^3 = p^3 b\ .$$

where $p^i = \sum_j p_{ij}$

The coefficients ϕ, δ, γ, ε and μ are the specified post-terminal growth rates for private consumption, replacement, government consumption, exports and imports.

In the initial computations reported below the consumption composition has been maintained unchanged throughout the post-terminal period by projecting the sectoral components of consumption of the last plan

period with identical rates. This, of course, is not necessary; a more general framework could project the components of the last plan period's consumption with different growth rates. Thus, as post-terminal consumption levels increase, for more income elastic components a faster growth could be registered. This particular approach was chosen for its computational simplicity in the early stages of the research.

The extrapolation of imports is also based on a distribution that is endogenously determined in the last planning period. This is convenient because the post-terminal path itself has no built-in optimizing mechanism for the determination of choice variables and the alternative procedure would be an arbitrary allocation of foreign exchange. Since imports as well as exports are projected at given growth rates over the entire post-terminal path, the post-terminal levels of foreign aid (or long term capital flows) must be residually determined if a balance of payments relationship is to be satisfied. Whether the need for aid increases or decreases in the post-terminal period depends on the absolute amount of the deficit in the terminal year as well as on the growth rates at which exports and imports are projected post-terminally. Since exports and foreign aid are exogenously stated for the planning period itself, a stipulation of the post-terminal growth rates of exports and imports is sufficient to know whether the requirement for aid will increase or fall post-terminally.

The other non-homogeneous elements, i.e., government demand and depreciation, do not require explanation. Both of these are exogenously stipulated already for the plan period. The projection of government demand is exogenous for the post-terminal period also. Since the model

cannot decide for the post-terminal period what proportion of actual depreciation to replace the terminal period's level of replacement is projected.

As mentioned earlier, (23) provides the sum of the particular solutions corresponding to the non-homogeneous elements discussed above. Equation (23) expresses the post-terminal sectoral output levels required to sustain the stipulated rates of growth as a function of the non-homogeneous components from which the required terminal capacities can readily be calculated with the help of the sectoral capital output ratios. Again, because of the investment lag structure, the post-terminal output levels and capacity requirements must be determined for the first three post-terminal time periods.

The statement of the terminal conditions completes the system. The solution is obtained by maximizing the objective function, i.e., the present discounted value of the consumption stream over the plan period, subject to all the constraints. Given the parameters of the constraints, there will be a different solution for each specified rate of discount or corresponding set of W(t). These solutions will be at vertices of the feasible region in the consumption space defined by the intersection of the given sets of constraints. Of course, there may be different feasible regions corresponding to different selections of the parameters of the constraints. By varying the discount rate in combination with the parameters of the constraints it is possible to derive all portions of the social production feasibility surfaces which are relevant for economic planning. Of course, of the multifold infinity of possibilities, only the consequences of those changes in parameters which can be controlled

by economic policy makers and which are likely to be descriptive of changes in the real economy will be interesting.

The maximum solution must be accompanied or sustained by a set of shadow prices which are the choice variables of the dual minimum problem. Since the sectoral capacities and the supply of foreign exchange are the only scarce resources in the system, the dual problem must consist of imputing those rents to the use of capacities and for the use of foreign exchange which exhaust the value of the total product as well as minimize the cost of production. The shadow price of foreign exchange must always be positive since imports can be always used to increase the value of the maximand at some time. The shadow prices or rents of capacities will be positive or zero depending on whether the capacities of particular sectors are fully or only partially utilized. Because of arbitrary initial conditions as well as other rigidities such as the fixed composition of the consumption good, it is not surprising that excess capacity should exist in some time periods. Though the rents corresponding to these capacities will be zero on such occasions, the respective outputs will still be positively priced as long as their production requires inputs of scarce commodities. If all sectors deliver intermediate goods to all other sectors it follows that none of the outputs can have a zero shadow price even if all capacities but one are redundant.

The shadow price of a given sectoral output in any one time period cannot be greater than the cost of producing a unit. Neither can the arbitrarily stipulated weight or market price of the composite consumption good exceed the cost of those current outputs which are required to make up a market basket. In other words, $\sum_i c_i u_i(t) \geq W(t)$ where c_i is the

proportion of the output of sector i needed to make up a unit of composite consumption good and u_i is the shadow price of the good. When the inequality holds, the cost of putting together a market basket will exceed its current worth and production for consumption will not take place. When, on the other hand, the equality holds, part of the sectoral outputs will be used for providing consumer goods. Since the relationship between the W's of adjacent time periods embodies the social discount factor, the shadow prices of the commodities are correspondingly also discounted over time. Though the shadow prices are the analogues of competitive market prices, they cannot be adopted for the actual market implementation of a plan. They refer to broad aggregates rather than specific commodities; hence they can serve only as indicators of the relative scarcities of a composite output of each sector. Moreover they reflect the particular constraints of the model. For example, the shadow price that corresponds to the balance of payment constraints is a shadow rate of foreign exchange but one which reflects the import constraints. If the balance of payments constraint is expressed in domestic currency then it will indicate what the current domestic value of a unit worth of foreign exchange converted at some constant exchange rate should be in any one time period. The foreign exchange shadow price will not, however, reflect its value to sectors whose demand for foreign exchange is arbitrarily limited by the constraints on specialization of use of foreign exchange. In these sectors the value of foreign exchange will be greater than the dual price associated with the over-all foreign exchange constraint.

Each solution generates a complete specification period-by-period of the uses of resources for various types of production and the flows

of goods to various uses all of which are consistent with the constraints and optimize the objective function. In this paper the time paths of outputs and inputs generated by the model will not be emphasized. Attention will be concentrated on the terminal year output levels and certain overall characteristics of the solution, recognizing that they are supported by a feasible and consistent set of resource allocations in each period.

V. DESCRIPTION OF THE DATA

One of the crucial problems in implementing planning models is that of matching the information requirements of the theoretical frameworks with the limited data which are practically available. Many of the compromises which have been made between a more sophisticated theoretical structure and the practical formulation of the planning model have been due to limitations in data. In a number of cases the compromises have been necessary because the work has been carried out in a context removed from original sources of data and actual planning activities.

The Indian Third Five Year Plan period provides the basic setting for the numerical implementation of the model. The structure of the economy reflected in most of the calculations is intended to be that of India at the beginning of the Third Plan period. The magnitudes chosen for the exogenous elements in the models are based on Indian conditions expected to prevail during the Plan.[1]

The numerical solutions remain hypothetical exercises. Though a strenuous attempt has been made to provide realistic data, assumptions of

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[1]The alternative computations which will subsequently be compared are all based on the same set of data and statistical assumptions. Hence, whatever the weaknesses of the data, I do not believe it detracts from the strength of the qualitative comparisons.

convenience have been made in estimating parameters which would not be tolerable if the purpose of calculations were to make specific plans for India rather than to gain general, order-of-magnitude insights. In particular, I should like to emphasize that I do not presume to be laying down guide lines for Indian policy makers. The empirical results are intended to be illustrative rather than definitive.

It should also be emphasized that the numerical estimates presented are all based on secondary and public sources. No special data collection activities have been undertaken for the purpose of the computations described below, although officials of the Government of India, especially in the Planning Commission, and members of the Indian Statistical Institute have cooperated most generously.[1] Thus, all the information used for the empirical implementation of the model is an adaptation of data originally designed to serve other purposes, but it does appear to conform to those on which Indian planning was based.

Production Data

As indicated in the description of the models the Leontief input-output assumptions of "fixed coefficients" of production have been adopted to describe production conditions. The production data with which the model is provided are a set of ratios for each sector. These ratios indicate for each type of use of a sector's outputs the inputs which are required. The ratios can be changed exogenously from period to period and from one solution to the next. However, the models are not provided with technological alternatives from which to make a choice. The general structure

[1] I am particularly indebted to Prof. Alan Manne for his explanations of the background of the data in whose preparation he was a major collaborator.

and logic of input-output tables have been discussed in detail elsewhere[1] so that only a brief description will be given here of the tables used and of the adjustments which have been made in them. For complete and detailed descriptions of the tables it is necessary to apply to the original sources.

The current-flow matrices

The first input-output flow tables for India were prepared for the middle 1950's in the Indian Statistical Institute in Calcutta. Some original numerical experiments were made using an expanded version of these original tables prepared by Ashish Chakravarti, now of the Indian Statistical Institute, Delhi. However, in early 1964, two new input-output tables became available for 1959-60. One issued by the Indian Statistical Institute, Delhi, was prepared under the direction of Dr. A. Rudhra and with the cooperation of Professor A. S. Manne of Stanford University, who was then a member of the India Project of the Center for International Studies, M.I.T. The second table was estimated in the Inter-Industry Study Group of the Planning Commission under the direction of Dr. K. S. Khrisnaswamy, Chief, Economic Growth Section, and will be referred to here as the I.S.G. table. Inasmuch as somewhat more information as well as other supporting data was currently available for the I.S.I. table as compared to the I.S.G. table, the former has been used in the computational trials.

The 1959-60 I.S.I. table which has been used is basically that presented in Notes on Perspective of Development, India: 1960-61 to 1975-76.[2] It is a thirty sector table with inputs valued at producers'

[1] W. Leontief and others, Studies in the Structure of the American Economy, New York, 1953.

[2] Perspective Planning Division, Planning Commission, April, 1964, pp. 183-187.

prices. The final uses of output are for the Household, Government and Export sectors, for Stock (inventory), Gross Fixed Capital Formation and Others, a miscellaneous sector. In addition to the inputs of the intermediate producing sectors Wages and Salaries, Gross Profit and Margins are distinguished. The latter includes wholesale and retail trade margins and indirect taxes and subsidies. In this table only five sectors produce fixed capital: the urban and rural construction sectors and the electrical, transport and non-electrical equipment sectors. Such industries as cement, iron and steel, and non-ferrous metals, rather than supplying outputs directly for fixed capital formation deliver to the construction sector which in this table is a processing rather than service industry. It receives such inputs, processes them and delivers fixed capital.

Many of the special features of the I.S.I. table have been suppressed and it has been modified in several ways consistent with the objective of developing a technique of general applicability and to reduce computational requirements.[1] Although the thirty-one sectors of the I.S.I. table already

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[1] In several sectors there was a negative input entered in the miscellaneous "Others" sector as an aggregative correction to overestimation of inputs to other sectors. These negative inputs were eliminated by allocating them among the other inputs of the sector using the proportions of the positive inputs as a guide. The undistributed inputs of the rail and motor transport sections were allocated using the proportions from the I.S.G. table.

Another major change in the I.S.I. table was the creation of a Residential Housing sector which provides rental services. This sector constitutes approximately seven per cent of the consumer budget; it is also the sector with largest capital-output ratio. The original experiments with the 1955-56 I.S.I. table reinforced the view suggested by these characteristics that over-all results would be sensitive to the size and growth rate for this sector. It was, therefore, decided to isolate Residential Housing from the miscellaneous "Others" sector. In order to construct a Residential Property row, it was assumed that this sector delivers only to Private Consumption and the amount of the delivery was the 520 crores of rupees estimated as the output of the sector in the official national income accounts. This amount was subtracted from the delivery of the Others sector to Private

(continued)

represent a high degree of aggregation, preliminary trials indicated that further aggregation was necessary in order to accommodate the model to the available computational capacity. Unfortunately this aggregation could not be done in a way which would satisfy theoretical criteria which would avoid bias and misrepresentation.[1] This is due to the lack of empirical knowledge which the criteria require and the previous aggregation which has already been done on a theoretically unsatisfactory basis. Further aggregation to eleven sectors was carried out and Table 1 presents the revised 1959-60 I.S.I. table on an eleven sector basis as used in the empirical experiments.

The Fixed Capital Formation Relationships

Capital is one of the two scarce factors and its formation is the major source of growth in the planning models described above. This does not represent a refusal to grant the importance of natural resources or labor inputs or changes in technology. The obstacles to an explicit treatment of factors other than capital are partly analytical, partly computational and partly the lack of adequate empirical information. It would, for example, require only a slight elaboration of the theoretical structures of the model in order to treat labor as if it were a capital factor formed by education, health services and similar inputs. That, however, would not be completely satisfactory from a theoretical viewpoint nor are there

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Footnote continued

Consumption. The Residential Housing column was formed by allocating the row total among the input sectors using the relevant coefficients of the 1955-56 I.S.I. input-output table.

The Others sector was made into a producing sector receiving inputs as indicated by its column vector. For the corresponding row vector the Margin row was consolidated with the Others row. This treatment of Margins was to conform to the usual practice for wholesale and retail trade.

[1]See for example, A.A. Waters, "Production and Cost Functions: An Econometric Survey," Econometrica, Vol. 31, No. 1-2, Jan.-April, 1963, pp. 5-11.

TABLE 1

Revised I.S.I. Input-Output Coefficient Matrix

	1	2	3	4	5	6	7	8	9	10	11
1. Agriculture and Plantations	.080	.000	.017	.051	.131	.505	0.	0.	.043	0.	.035
2. Mining and Metals	.000	.208	.231	.025	.052	.004	.131	.041	.146	.005	.001
3. Equipment	0.	.020	.037	.016	.003	.003	0.	0.	.016	0.	0.
4. Chemicals and Fertilizers	.010	.020	.037	.199	.081	.028	.028	.185	.008	0.	.003
5. Cement, Glass and Wood	.000	.011	.005	.011	.025	.003	0.	0.	.221	.015	0.
6. Food & Clothing Manufacturers	.008	.002	.002	.034	.018	.057	0.	0.	0.	0.	.001
7. Electrical Generation	.001	.023	.013	.016	.022	.013	0.	.004	0.	0.	.001
8. Transportation	.007	.145	.073	.098	.070	.049	.118	.042	.026	.007	.021
9. Construction	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	.026
10. Housing	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11. Other and Margin	.005	.028	.135	.032	.089	.055	.068	.017	.107	.045	0.
TOTAL	.111	.458	.550	.480	.491	.718	.346	.288	.567	.071	.087

corresponding empirical relationships which are reasonably well-established.

The capital formation relationships are a kind of modified acceleration principle with a detailed breakdown of sectoral inputs. There is a rich literature on the theoretical issues raised by such coefficients and there is no point in summarizing it here. The use of the related aggregate capital output ratios for projections is well-known and also much discussed. As with so many aspects of computable multi-sectoral models, credit should be given to W. Leontief and his associates for their pioneering work on the structure of capital.[1]

Although the empirical information necessary to fill in the capital coefficients matrix is far from adequate, a substantial amount of data is available. With some major exceptions the quality of information of this type for less developed countries such as India may be superior to that for more developed economies. The relatively small size of many of the modern sectors, as well as the extent and variety of reporting required for the implementation of various government regulations should facilitate the estimation of sectoral marginal capital coefficients. The major exceptions are in agriculture and the traditional services and handicrafts which bulk large in the economy. In these sectors there is no simple and reliable relation of capital accumulation to capacity changes. These sectors could have been treated exogenously in our models and in a real planning application might be handled best in that way. Consistently with the experimental approach adopted here these sectors have been put on the same basis as other sectors with calculations being made for alternative estimates of their capital-output ratios.

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[1] Op. cit.

In order to carry out the first trial computations on the alternative models with a plausible set of numbers a complete matrix of capital coefficients for India was first estimated in the Center for International Studies, M.I.T. This had to be done in an extremely rough way, but all the various sources of information publicly available were used. The Indian Third Five Year Plan and various studies of the Indian Planning Commission were the most important of these. In 1964 a new matrix of capital coefficients was estimated in the Indian Statistical Institute, New Delhi by Vinod Prakash. These estimates appear to have been based on many of the same sources as well as other information not publicly available. A comparison of the two capital-coefficients matrices showed considerable agreement. The Prakash matrix was used as the basis of most of the computations as the most recently available authoritative estimates. The original capital-coefficients matrix was used to obtain additional detail beyond that available in the Prakash capital coefficients and as a source of the alternative estimates of capital requirements used in our sensitivity analyses. Since the Prakash estimates were presented in the thirty-one sector detail of the 1959-60 ISI matrix, they were also aggregated using the 1959 output levels as weights. Table 2 indicates the aggregate capital-output ratios for each sector.

In the model described there is scope for presenting some detail of the capital gestation process. The next step in data preparation, therefore, was the disaggregation of the capital matrix by periods. The existence of gestation periods of varying lengths is a major source of the problems of coordinating the growth of different sectors in development programs. In addition, since in the less-developed regions delays in

making capital effective have a particularly high cost, it is important to be able to analyze such delays. In India there has been particular concern expressed over this problem of planning. On the other hand, published empirical information about the gestation periods of capital projects is relatively scarce both for developed and less-developed regions. There is a substantial body of informed comment, moreover, which holds that gestation periods in the more-developed countries are quite different from practices prevailing in the less-developed areas but there is relatively little organized information. Although the existence of several studies of the time patterns of capital creation indicates the feasibility of such investigations, the secondary sources now available are completely inadequate for this purpose and no independent estimation was attempted. In these circumstances a simple arbitrary pattern which could easily be modified as more information became available was adopted to represent the gestation process. It was assumed that in order to achieve an increment of capacity in period t one-third of the total eventual contribution of the Construction sector had to be forthcoming in each of three preceding periods. For the contribution of the equipment producing sectors it was assumed that one-half of the total requirements had to be provided in each of two periods preceding the period in which capacity was to become effective. With these assumptions the matrices showing proportions of total requirements supplied by each sector at period t for investment in every other sector which will mature in periods t+1, t+2 and t+3 were estimated for India for the 1960's as shown in Tables 3, 4 and 5, respectively.

TABLE 2

Aggregate Capital Coefficients Matrix

Adapted from ISI Estimates

1. Agriculture and Plantations	1.51
2. Mining and Metals	2.42
3. Equipment	0.91
4. Chemicals and Fertilizers	0.88
5. Cement, Glass and Wood	0.89
6. Food and Clothing Manufacturers	0.55
7. Electrical Generation	6.26
8. Transportation	2.22
9. Construction	0.15
10. Housing	10.00
11. Other and Margin	0.15

The inventory investment relationships

Although in some cases there may be technical requirements which put close limits on inventories, in most sectors the stock holding decisions are subject to a variety of influences whose net effect, in developed countries, at least, is a particularly volatile type of behavior. The patterns of inventory-holding in the less-developed areas have not been studied intensively, however, and relatively little empirical information is available. Such information is notoriously difficult to collect and the statistical reporting systems of these areas have not been able to cover this aspect of investment in a thorough and continuous manner. Some data which do exist suggest that inventory accumulation may be a relatively more significant part of total investment in less-developed areas than advanced countries, however. The limitations of transport and communications and other uncertainties associated with deliveries would contribute to such a pattern.

TABLE 3

Proportions of Total Requirements for Investment in Each Sector Supplied By Each Sector at Period t to Mature in Periods t+1

	1	2	3	4	5	6	7	8	9	10	11
3. Equipment	.069	.248	.258	.245	.222	.314	.202	.442	.327	0.	.160
9. Construction	.282	.147	.139	.149	.166	.097	.181	0.	.087	.333	.213
11. Other and Margin	.009	.032	.034	.032	.029	.041	.026	.057	.042	0.	.021
TOTAL	.359	.427	.431	.425	.417	.452	.409	.500	.456	.333	.393

TABLE 4

Proportions of Total Requirements for Investment in Each Sector Supplied By Each Sector at Period t to Mature in Periods t+2

	1	2	3	4	5	6	7	8	9	10	11
3. Equipment	.069	.248	.258	.245	.222	.314	.202	.442	.327	0.	.160
9. Construction	.282	.147	.139	.149	.166	.097	.181	0.	.087	.333	.213
11. Other and Margin	.009	.032	.034	.032	.029	.041	.026	.057	.042	0.	.021
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	1	2	3	4	5	6	7	8	9	10	11
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9. Construction	.282	.147	.139	.149	.166	.097	.181	0.	.087	.333	.213
11. Other and Margin	.009	.032	.034	.032	.029	.041	.026	.057	.042	0.	.021
TOTAL	.359	.427	.431	.425	.417	.452	.409	.500	.456	.333	.393

TABLE 5

Proportions of Total Requirements for Investment in Each Sector Supplied By Each Sector at Period t to Mature in Periods t+3

	1	2	3	4	5	6	7	8	9	10	11
3. Equipment	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9. Construction	.282	.147	.139	.149	.166	.097	.181	0.	.087	.333	.213
11. Other and Margin	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	.282	.147	.139	.149	.166	.097	.181	0.	.087	.333	.213

The assumptions behind the inventory investment relations which have been used are that a certain ratio of inventories to output is maintained in each sector and that the proportions in which the individual sectors contribute to these inventories are fixed. These lead to the inventory accelerator relationships and for implementation require the projection of inventory-output ratios. An initial source of information used to implement these assumptions was the matrix of coefficients estimated for India by A. Chakravarti. The aggregate ratios in this table were compared with separate estimates prepared by Professor A. K. Sen.[1] These sources of information were complemented with scattered data more recently available. The matrix of inventory coefficients finally used, however, was based on the I.S.I. input-output table and is presented in Table 6.

Depreciation

The manner in which the productive capacity of capital stock diminishes with time and with use undoubtedly varies both with the type of capital and the purposes for which it is employed. These differences could not be taken into account at the level of detail at which these models are cast. Instead, as in other cases, a convention was adopted which would not unduly complicate the models while providing a first approximation to the effects of depreciation. The time pattern of decay was assumed to be that in which each unit of capital maintains its original productivity over its complete lifetime.

The operating life of many types of capital is twenty to twenty-five years or more which is substantially longer than the planning horizon

[1] "Working Capital in the Indian Economy: A Conceptual Framework and Some Estimates," in Pricing and Fiscal Policies: A Study in Method, P. N. Rosenstein-Rodan, ed., Cambridge, 1964, pp. 125-146.

TABLE 6

Matrix of Inventory Coefficients

	1	2	3	4	5	6	7	8	9	10	11
1. Agriculture and Plantations	.315	.000	.022	.029	.094	.292	0.	0.	.007	0.	.007
2. Mining and Metals	.001	.140	.248	.018	.036	.002	.106	.011	.023	0.	0.
3. Equipment	0.	.038	.044	.052	.002	.002	0.	0.	.003	0.	0.
4. Chemicals and Fertilizer	.040	.012	.045	.377	.058	.017	.023	.008	.001	0.	.001
5. Cement, Glass and Wood	.002	.012	.007	.007	.018	.002	0.	0.	.035	0.	0.
6. Food & Clothing Manufacturers	.031	.004	.003	.022	.012	.039	0.	0.	0.	0.	0.
7. Electrical Generation	.004	.033	.015	.024	.016	.008	0.	.001	0.	0.	0.
8. Transportation	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9. Construction	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10. Housing	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11. Other and Margin	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	.393	.240	.384	.528	.237	.361	.129	.020	.068		.008

of the short-term models. The pattern of capital decay chosen for the model means, therefore, that depreciation is exogenous to the plan period, being determined by the investment which took place in years previous to the start of the plan. With this approach it became necessary to estimate investment during the early post war years for which relatively little statistical information existed. The actual amounts of depreciation specified exogenously for the five year model starting in 1960-61 are shown in Table 7.[1] Since there was relatively little investment in the 1940's, the assumption of a constant amount of replacement requirements in each period was considered not unrealistic. The replacement requirements to restore the depreciated capacity are shown in Table 8 and the proportions for restoring depreciated capacity in Tables 9, 10 and 11.

Imports

It is desirable to provide empirical information on the basis of which the planning models can assist in decisions on the type and quantity of goods to import rather than produce domestically. For this purpose, it is important to distinguish non-competitive imports from competitive imports. The former are imports for which no domestic capacity exists or can be created, while the latter represents sectors for which a "make or buy" decision is relevant. Strictly speaking, non-competitive imports cannot be fitted within the classification scheme for the domestic economy and recognition of each type would require creation of a separate sector. Likewise the requirements for each type of non-competitive imports should

[1] These estimates are different from those used in the initial version of this paper. Re-examination indicated those initial estimates were likely to be substantially too low and it appeared to be preferable to accept the I.S.I. estimates. As will be pointed out below, this change has had significant effects on the Third Plan Target solutions in particular.

TABLE 7

Depreciated Capacity by Sectors in Rs. Crores

	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
1. Agriculture and Plantations	277.4009	281.6406	285.8804	290.1202	294.3599	298.9025	303.4451
2. Mining and Metals	71.4057	72.4970	73.5884	74.6798	75.7711	76.9404	78.1097
3. Equipment	16.0887	16.3346	16.5804	16.8263	17.0722	17.3357	17.5992
4. Chemicals	50.7788	51.5549	52.3310	53.1071	53.8832	54.7147	55.5462
5. Cement, Glass and Wood Prods.	16.1588	16.4058	16.6527	16.8997	17.1467	17.4113	17.6759
6. Food and Clothing	32.7314	33.2316	33.7319	34.2322	34.7324	35.2684	35.8044
7. Electricity	48.3195	49.0581	49.7966	50.5351	51.2736	52.0648	52.8561
8. Transportation	84.5926	85.8855	87.1784	88.4713	89.7642	91.1494	92.5347
9. Construction	1.5697	1.5936	1.6176	1.6416	1.6656	1.6913	1.7170
10. Housing	186.8442	189.6999	192.5556	195.4113	198.2670	201.3266	204.3863
11. Other and Margins	136.8277	138.9189	141.0102	143.1015	145.1927	147.4333	149.6740

TABLE 8

Replacement Requirements by Sectors in Rs. Crores

	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69
1. Agriculture and Plantations	143.6563	145.8519	148.0475	150.2431	152.4388	154.7912	157.1437
2. Mining and Metals	65.8512	66.8577	67.8642	68.8706	69.8771	70.9554	72.0338
3. Equipment	14.6194	14.8428	15.0662	15.2897	15.5131	15.7525	15.9919
4. Chemicals	47.9160	48.6483	49.3806	50.1130	50.8453	51.6300	52.4146
5. Cement, Glass & Wood Products	13.0896	13.2897	13.4898	13.6898	13.8899	14.1042	14.3186
6. Food and Clothing	30.2738	30.7365	31.1992	31.6619	32.1246	32.6203	33.1161
7. Electricity	40.5330	41.1525	41.7720	42.3915	43.0110	43.6747	44.3385
8. Transportation	84.5926	85.8855	87.1784	88.4713	89.7642	91.1494	92.5347
9. Construction	1.2641	1.2834	1.3027	1.3220	1.3414	1.3621	1.3828
10. Housing	186.8274	189.6828	192.5382	195.3937	198.2491	201.3085	204.3679
11. Other and Margins	134.1757	136.2264	138.2771	140.3278	142.3786	144.5758	146.7730
12. TOTAL	916.0000	930.0000	944.0000	958.0000	972.0000	967.0000	1002.0000

TABLE 9

Proportions for Restoring Depreciated Capital in (t+1)

	1	2	3	4	5	6	7	8	9	10	11
3. Equipment	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9. Construction	.233	.130	.119	.138	.126	.077	.216	0.	.027	.333	.217
11. Other and Margins	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	.233	.130	.119	.138	.126	.077	.216	0.	.027	.333	.217

TABLE 10

Proportions for Restoring Depreciated Capital in (t+2)

	1	2	3	4	5	6	7	8	9	10	11
3. Equipment	.133	.269	.284	.259	.275	.339	.156	.442	.406	0.	.154
9. Construction	.233	.130	.119	.138	.126	.077	.216	0.	.027	.333	.217
11. Other and Margins	.017	.035	.038	.034	.036	.045	.021	.057	.054	0.	.020
TOTAL	.383	.435	.441	.431	.437	.461	.392	.500	.487	.333	.391

TABLE 11

Proportions for Restoring Depreciated Capital in (t+3)

	1	2	3	4	5	6	7	8	9	10	11
3. Equipment	.133	.269	.284	.259	.275	.339	.156	.442	.406	0.	.154
9. Construction	.233	.130	.119	.138	.126	.077	.216	0.	.027	.333	.217
11. Other and Margins	.017	.035	.038	.034	.036	.045	.021	.057	.054	0.	.020
TOTAL	.383	.435	.441	.431	.437	.461	.392	.500	.487	.333	.391

be related separately to its uses in the producing or final demand sectors. The treatment of competitive imports should provide for the decision between domestic production or import and take into account the changing basis for such decisions as domestic capacity changes.

A rigorous distinction of competitive and non-competitive imports and the adjustment of import requirements with the development of domestic capacity was not possible within the limitations of the model structure, computational capacity and data availability. Non-competitive imports were treated as fixed fractions of the total output of the sectors in which they were assigned. The ratios of non-competitive imports to output were calculated from the I.S.G. matrix mentioned above and used as non-competitive import coefficients. Table 12 lists these coefficients by sector.

As noted previously, in order to handle competitive imports within the model structure ceilings were set on the use in each sector of the foreign exchange left over after the satisfaction of non-competitive import needs. These ceilings were in the form of ratios to sectoral output of uncommitted foreign exchange. The ratios were based on the import information in the ISI and ISG tables with some adjustments based on judgment as to the sectors in which government policy would be more or less restrictive in permitting import substitution for domestic production. These ratios are shown in Table 12.

TABLE 12

Import Coefficients by Sector

	Non-Competitive	Competitive
1. Agriculture and Plantations	.01600	.301
2. Mining and Metals	.14500	.199
3. Equipment	.23500	.348
4. Chemicals and Fertilizer	.26100	.162
5. Cement, Glass and Wood	.00400	.020
6. Food & Clothing Manufactures	.00008	.027
7. Electrical Generation	0.	0.
8. Transportation	0.	0.
9. Construction	0.	0.
10. Housing	0.	0.
11. Other and Margin	0.	.020

Exports

The exogenous treatment of this use of output is justified on the argument that the satisfaction of foreign demands is not affected by domestic policy. This is only partly true, of course. Export duties or subsidies and exchange rate policy can certainly change relative prices but these influences are not within the structure of the model in any case. Although for most of the major export sectors the domestic use of output is not a major alternative, the choice between exporting and using output domestically is significant for a number of sectors. No attempt was made to bring this choice within the framework of the model either, although it might be possible to do so in some cases.

The practical problem is the choice of methods for extrapolation of exports in each sector. The technique used here is a simple one. The initial level of exports was estimated from pre-plan years and an average growth rate was projected for all exports. This is an arrangement of convenience which could be refined. The export levels projected are listed for each sector in Table 13.

TABLE 13

Export Levels Projected for the Third Plan Period

(In Rupees Crores)

	1960-61	1962-63	1963-64	1964-65	1965-66
1. Agriculture and Plantations	198.188	206.370	214.552	223.037	231.826
2. Mining and Metals	40.090	41.745	43.400	45.117	46.894
3. Equipment	4.336	4.515	4.694	4.880	5.072
4. Chemicals and Fertilizer	15.088	15.711	16.334	16.980	17.649
5. Cement, Glass and Wood	2.793	2.908	3.023	3.143	3.267
6. Food and Clothing Manufactures	215.656	224.560	233.463	242.696	252.259
7. Electrical Generation	0.	0.	0.	0.	0.
8. Transportation	0.	0.	0.	0.	0.
9. Construction	0.	0.	0.	0.	0.
10. Housing	0.	0.	0.	0.	0.
11. Other and Margin	177.836	185.178	192.519	200.133	208.019
12. TOTAL	645.000	681.000	708.000	736.000	765.000

Government

The government sector in the planning models is assumed to consist entirely of "public consumption" so that resources delivered for this purpose do not contribute to productive capacity nor act as intermediate inputs to producing sectors. Again there is a substantial literature on the extent to which these assumptions are justified for various types of expenditure and so the issues will not be reviewed here. The problem becomes one of finding a reasonable basis on which to project an exogenous sector.

Considerable detail is available on the uses of funds in the budgets of the union government and less detail for the state government budgets. For neither type of budget was it possible to find the detail on function re-classified according to types of inputs used. The ISI table provides such a breakdown in the year for which it was estimated. With this information and the Third Plan projections to aid establishing growth rates, future deliveries to the government sector were estimated exogenously. Table 14 presents these estimates.

TABLE 14

Government Expenditures by Sector

(In Rupees Crores)

	1961-62	1962-63	1963-64	1964-65	1965-66
1. Agriculture and Plantations	0.	0.	0.	0.	0.
2. Mining and Metals	0.	0.	0.	0.	0.
3. Equipment	97.596	101.204	104.993	108.601	112.209
4. Chemicals and Fertilizer	28.402	29.452	30.555	31.605	32.655
5. Cement, Glass and Wood	0.	0.	0.	0.	0.
6. Food and Clothing Manufactures	109.120	113.154	117.389	121.423	125.457
7. Electrical Generation	4.923	5.105	5.296	5.478	5.660
8. Transportation	0.	0.	0.	0.	0.
9. Construction	108.200	112.200	116.400	120.400	124.400
10. Housing	0.	0.	0.	0.	0.
11. Other and Margin	192.758	199.884	207.367	214.493	221.619
12. TOTAL	541.000	561.000	582.000	602.000	622.000

Foreign Aid

This is truly an exogenous element. For the purpose of the basic model net annual foreign aid was set at $500 million. As noted above the allotment of foreign aid on an annual basis will lead to different results than specification of a total amount to be available over the entire plan in whatever annual pattern desired.

Consumption

The models require specification of the proportions in which the total consumer budget is allocated among the output of the producing sectors. These proportions in actuality depend on the incomes achieved and the patterns of relative prices and the price and income elasticities associated with the products of the various sectors. In this case the constraints of the analytic framework are more severe than the data constraints. Estimates of price and income elasticities are available for many of the sectors, especially the more significant ones, though there are high levels of

variance associated with the estimates and for some sectors there is almost no information. On the assumption that, for sectors defined as grossly as those in this paper, consumption proportions would not change markedly in a short period, the distribution of consumption was specified in advance.

For the purposes of the models computed here initial consumption proportions were calculated from the ISI transactions tables for 1959-60. These are shown in Table 15.

TABLE 15

Consumption Proportions Based on 1959 ISI Table

1. Agriculture and Plantations	.42941
2. Mining and Metals	.00048
3. Equipment	.01471
4. Chemicals and Fertilizer	.02384
5. Cement, Glass and Wood	.00501
6. Food and Clothing Manufactures	.14101
7. Electrical Generation	.00087
8. Transportation	.01476
9. Construction	0.
10. Housing	.04516
11. Other and Margin	.32475

Initial capacity and uncompleted capital

The endowments of capital stocks with which the Plan period starts are initially the only productive resources available. These endowments are the result of events in the pre-Plan period and exogenous to the Plan itself. Likewise, the amounts of uncompleted capital whose construction had started prior to the Plan period with a view of completion during Plan are exogenous. A rational planning procedure would coordinate the end of one Plan and beginning of another. In actuality, however, the Indian Five Year Plans have suffered somewhat from a lack of coordination between the

Plans. The Third Five Year Plan though referring to projects started during the second Plan and to be completed during the Fourth Plan does not provide a detailed description of the degree of completion of such projects at the beginning of the Third Plan nor a detailed sectoral classification. There were no other sources of public data from which such information could be extracted. It was assumed, therefore, for the purposes of our trial computations that the Indian Planning Commission had attempted to schedule investment activity to provide a smooth transition between the Plans. The growth of capital estimated for each sector in the Third Plan was extrapolated backwards in order to estimate the amounts of investment which would have taken place in the pre-Plan period under this assumption to achieve the desired capital formation. The capital coefficient matrices described previously were used for this latter purpose. In order to establish the initial capital stocks the sectoral output levels in the year immediately prior to the Plan are multiplied by the aggregate capital-output ratios. These totals were then adjusted for depreciation. The capital in process at the beginning of the Plan is described in terms of the maximum amount of capital which could be formed in each sector in the first and second Plan periods, as this is determined by Pre-Plan investment activity. The major source of information for these calculations was a report prepared by M.R. Saluja as part of a joint project of the Indian Statistical Institute and the Center for International Studies.[1] It was also assumed that all sectors were operating at full capacity in the initial period.[2]

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[1] "Methods and Sources for Output Levels, 1960-61 and 1965-66," ISI, Delhi, August 3, 1964.

[2] An attempt was made to adjust for the extent of initial idle capacity in the various sectors but the data were not available in a form which would make this possible. The adjustment for less than full use of capacity in

(continued)

Table 16 presents the initial conditions as computed above. The annual availability of foreign aid was set at five hundred crores of rupees. This, with the projected exports, determines the total availability of foreign exchange.

TABLE 16

Pre-Plan Output Levels and Capital in Process
(In Crores of Rupees)

	Pre-Plan Outputs	Maximum Capital Formation in Period 1	Maximum Capital Formation in Period 2
1. Agriculture and Plantations	7577.0	798.75	825.73
2. Mining and Metals	462.0	293.24	332.02
3. Equipment	670.5	158.49	186.67
4. Chemicals and Fertilizer	612.5	147.68	163.60
5. Cement, Glass and Wood	450.6	58.21	62.46
6. Food and Clothing Manufactures	2442.0	99.83	103.53
7. Electrical Generation	108.0	162.29	180.50
8. Transportation	779.0	245.51	260.58
9. Construction	1617.0	30.76	33.89
10. Housing	579.8	399.98	410.40
11. Other and Margin	5854.6	191.78	196.99

VI. ANALYSIS OF THE INDIAN THIRD FIVE YEAR PLAN PERIOD

The analytic framework for planning presented in Part V above is certainly an over-simplification of the real world and the problems of economic development. Likewise, the brief description of the data inputs cannot do full justice to their inadequacies. Yet the framework is more

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Footnote continued

order to determine initial effective capital endowment is a significant one since even small errors here may correspond to a substantial portion of the annual amounts of investment. The well-known problems of defining capacity occur in an aggravated form in such sectors as traditional agriculture.

sophisticated than that of other formal models currently employed and the data are not substantially different from those actually in use. Formal sophistication, however, is not itself, an adequate criterion for judging planning methods. Less sophisticated techniques may be more realistic and more flexible, for example, in not being constrained to linearity in production relations and other constraints and in balancing a variety of objectives. Fortunately a choice need not be made and a variety of approaches to economic policy can be used simultaneously and consistently. The scope and comparative advantage of the approach described here may be appreciated better after an application to the Indian Third Five Year Plan is described. In using the model to judge the consistency, feasibility and optimality of the Third Plan, criteria and constraints are applied which are believed to be reasonable. However, the caveat must be registered that these are not necessarily the criteria and constraints implicit in the Third Plan itself. The issues involved in this point will be discussed in greater detail below.

The application is in two stages. The first application is that of the Target Model to the exogenously specified Third Five Year Plan targets and the results are examined for a number of alternative specifications of parameters and constraints. Secondly, the Transit Model is solved with terminal conditions endogenously determined, using equations (22) and (23), also for alternative parameters and constraints. The results of the two types of solutions are compared and finally an appraisal is attempted of the model and its results.

The full solution of the model indicates not only the value of the maximand but all the allocations necessary to achieve it: the capital

formation in each sector in each period, the intensity of use of capital and foreign exchange and the distribution of output for its various uses. The solutions will not be presented here in their full detail but the values of the maximands and some of their other major features will be compared, especially the general nature of the resource uses and scarcities in each solution.

The Third Plan Target Solutions

The over-all growth rate implied in the Indian Third Five Year Plan was about five per cent. As one would expect the growth rates projected for specific sectors varied quite substantially from this average figure. Table 17[1] indicates the 1960 gross output levels, the projected 1965 levels and the implied average annual growth rates for the thirty sector detail of the ISI input-output table. In inspecting the table it is useful to recall that only the construction and equipment sectors in this classification are capital creating sectors.

Growth rates can be misleading as to the relative emphasis of the Plan since the initial output levels in some cases are so low. This is the case in both the crude oil and fertilizer sectors to some extent. In addition, these are levels and growth rates of gross output and do not in themselves indicate the planned growth of the Indian economy as measured by final output or capital accumulation. Yet the over-all picture is

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[1] It is difficult from the Third Five Year Plan itself to construct a detailed yet comprehensive breakdown of sectoral targets. W. B. Reddaway in his book, The Development of the Indian Economy, London, 1962, provides a substantial amount of detail as does the publication of the Planning Commission, Selected Plan Statistics. A recent study by M. R. Saluja, of the ISI, Delhi, "Methods and Sources for Output Levels, 1960-61 and 1965-66," is the source of the data reproduced here. The "Others" sector is omitted as are Margins so the total is not equivalent to gross output of the economy.

TABLE 17

Third Plan Targets
Compared to Pre-Plan Output Levels

(in Crores of Rupees)

	Sector	1960-61	1965-66	Growth Rate (Average Annual)
1.	Construction--urban & industrial	1201.0	1980.0	10.5
2.	Construction--rural	416.0	436.0	0.8
3.	Electrical equipment	126.0	362.0	23.5
4.	Transport equipment	201.0	417.0	15.7
5.	Non-electrical equipment	343.5	888.0	20.7
6.	Iron and steel	269.0	909.0	27.6
7.	Iron ore	7.8	22.0	23.1
8.	Cement	52.6	88.0	10.8
9.	Other metals	32.0	80.0	20.0
10.	Other minerals	45.4	77.0	11.1
11.	Plantations	196.0	250.0	5.0
12.	Leather and leather products	189.0	220.0	3.1
13.	Animal husbandry	1130.0	1323.0	3.2
14.	Food industries	1323.0	1733.0	5.5
15a.	Food grains	3751.0	4767.0	4.9
15b.	Grain milled	223.3	279.0	4.5
16.	Cotton and other textiles	800.0	1093.0	6.5
17.	Jute textiles	130.0	165.0	4.9
18.	Other agriculture	2097.0	2571.0	4.1
19.	Chemical fertilizers	20.7	166.0	51.7
20.	Glass, wooden and non-metallic mineral products	398.0	620.0	9.3
21.	Forestry products	180.0	262.0	7.9
22.	Motor transport	325.0	580.0	12.3
23.	Petroleum products	237.1	659.0	22.6
24.	Crude oil	3.2	46.0	70.3
25.	Rubber products	67.5	127.0	13.5
26.	Rubber--synthetic	-	17.0	-
27.	Chemicals	284.0	742.0	21.2
28.	Railways	454.0	640.0	7.1
29.	Electricity	103.4	286.0	22.6
30.	Coal	109.0	206.0	13.6

relatively straightforward. With the exception of fertilizers the highest growth rates in the table are in the capital producing sectors, their most important suppliers and in several import substituting sectors. The sectors supplying consumer goods, which in India include relatively small amounts of consumer durables, on the whole had lower growth rates projected for them. The rationalization of this relative emphasis would presumably be based on two related arguments. First, capital is needed to provide the means with which to increase output in the consumer goods sector and the well-known "accelerator effect" accounts for the more rapid growth of the capital goods sector itself. Secondly, capital is also needed to provide import substitutes to reduce the reliance on foreign aid and, again, the capital equipment sectors must grow more rapidly than the sectors which they are supplying. Of course, the relative emphasis as between capital and consumer goods production, the planned import substitution and, therefore, the requirements of foreign exchange reflects decisions as to the growth rate of the economy and the distribution of the benefits of the growth both in the intra-Plan and post-Plan periods.

Although aggregate projections were made in the Plan itself for the post-Third Plan Period no set of detailed sectoral post-Plan growth rates was presented. Since short-term planning requires this specification it was assumed for the purpose of the Target Model calculations that the intra-Plan sectoral growth rates would be carried into the future. This amounts to saying that no substantial changes in the composition of output would be expected in the early post-Plan years.[1] Otherwise the Target

[1]It should be recalled at this point that the amounts of unfinished capital carried into the first years of the Plan are set in the calculations by assuming that the last years of the Second Five Year Plan were phased to provide smooth growth of capital and output to the Third Plan targets.

Model was solved with the data inputs of Part V.

For the purposes of the solution condition (4) which specified a minimum initial level for consumption was omitted in order to reduce the possibility of finding that all the requirements could not be met. This change now permits the optimization procedure to reduce the consumption levels in the initial plan year as low as necessary in order to meet the consumption growth constraint of later years. The feasibility issue in this respect thus becomes one of political acceptability of the solution unless, even with zero consumption, no economically feasible solution can be found.

In fact, with the specified parameters and constraints no feasible solution could be found which was consistent with the Third Plan targets. Even with the maximand reduced to zero, that is, with no consumption at all permitted in the plan period, there was no allocation of available resources which would meet the constraints and achieve the targets. The point made above about the absolute inflexibility of the constraints must be constantly kept in mind, however. It is possible that these constraints create some small bottleneck which if relieved ever so slightly would permit the achievement of the targets with a substantial and generally satisfactory level of consumption for the maximand. To investigate this possibility the constraints limiting the use of foreign exchange for competitive imports were, first of all, removed completely. It had been found from previous experience that this would often result in a substantially improved performance.[1] In this case it was still not possible to achieve a feasible solution. At this point, rather than to continue

[1]The parameters of the non-competitive import constraints were based on data from the I.S.G. table. The significance of this result will be discussed below.

to search blindly for some way of obtaining a feasible solution, the targets were reduced across-the-board, one percentage point at a time until a feasible solution was achieved. With a feasible solution there are shadow prices and other indicators of relative scarcities which help indicate the reasons for the infeasibility of the full targets.[1]

A feasible solution was found when the targets were reduced by four per cent. If an average annual rate of growth of five per cent had been postulated for the Third Plan, a reduction in target year outputs and capital stocks of four per cent corresponds to a reduction in the average annual growth rate to 4.15 per cent. It is this 96 per cent level of the Third Plan targets which will now be the subject of further analysis here and which will, hereafter, be referred to as the Target solutions.

The value of the maximand or discounted value of consumption over the Third Plan period, with a social rate of discount of 10% and at the 96%

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[1]Since, in the version of this paper originally presented, a feasible solution was presented with the Third Plan targets, it appears desirable to explain this new result. Subsequently to those calculations a number of minor changes have been made in the coefficients. The major change, however, and that responsible for this new result was in the method of treating depreciation and the magnitude of the depreciation estimates. The total and sectoral depreciation estimates used originally were revised using the methods described briefly above. The new annual total of depreciation is about 500 crores above the original estimate. It is interesting to quote the Third Plan on meeting depreciation requirements: "The estimate of investment on replacement shown (150 crores for industry only) falls short of the minimum requirements of the cotton textile, jute textile and woolen textile industries in regard to which special studies have been made recently. The backlog of replacements in these three industries alone has been estimated at about Rs. 169 crores. The estimate that investment on replacement account in the Third Plan will be of the order of Rs. 150 crores is more or less a projection of the actual performance during the Second Plan. Even so it is on the optimistic side in view of (a) the pressure on available resources of private enterprise and institutional agencies for new investment and (b) the fact that mills with large backlogs of replacement are in no position to provide resources for renovation commensurate with needs and (c) the small allocation made in the Plan to enable the N.I.D.C. to assist these programs financially." (Third Five Year Plan, p. 460.)

level of targets, was Rs. 24,710 crores. The corresponding undiscounted value of consumption was Rs. 32,712 crores. While this is feasible in the sense of being consistent with a solution to the linear programming problem, certainly no plan for which this was a true implication would be regarded as politically acceptable. The average annual level of consumption in this solution of only Rs. 6,542 crores at the 96% level of targets compares with the level of consumption in 1959-60, prior to the beginning of the Third Plan of approximately Rs. 12,600 crores. In the solution the 1961-62 level of consumption was only 2,347 crores of rupees and it grew at the minimum permissible rate until the fourth and fifth year when a total of Rs. 25,300 crores of consumption was permitted.

In spite of the low level of the maximand in this target solution there were substantial amounts of idle capital throughout the plan period. Examination of the sectors in which this occurred, of the relative amount of investment in the various sectors and of the shadow prices will help in appreciating the kind of strain which the targets impose on the system. The largest amounts of idle capital relative to availabilities occur in the consumers goods sectors and their major suppliers. In the first period only Construction capital is used to its fullest extent and after that full capacity is reached in only the Equipment and Mining and Metals sectors until the last and post-terminal periods when there is virtually full capacity operation in all sectors. This idle capacity is the result, again, of all the constraints but in this case it is probably the fixed input proportions and fixed consumption proportions which are mainly responsible. Since only the Construction sector in the first period is a bottleneck and that sector is, in reality, relatively easily expanded, a

slight relaxation of input proportions or an increase in the productive capacity of that sector might substantially improve the maximand. For example, Housing requires little in the way of current inputs yet its capacity is kept idle in the early periods because its proportion of consumption is fixed and capacity is a limitation in other sectors. Similar adjustments to improve the maximand for the second, third and fourth periods in the Equipment and Mining and Metals sectors, where capacity is formed less easily, would be more difficult to justify. While a reduction in the consumption proportions of these sectors might increase the maximand, these consumption proportions are already small. A further reduction would probably imply price increases in these sectors or the use of price controls to avoid such an eventuality.[1]

An additional calculation was made on the Target Model solution in order to test the significance of the rigidities in input proportions and in consumption proportions. For this purpose it was assumed that output in the major consumer goods sectors could be produced in these sectors without any current inputs whatsoever beyond those provided in the solution and by the sector itself. Using the idle capacities generated in a Target Model solution the additional potential output was computed and allocated to various uses on the basis of the Model's allocations in the fifth period when capacity was being utilized almost fully. The addition to consumption under these generous assumptions was roughly Rs. 32,500 crores and, with the amount produced otherwise, the total consumption would be roughly Rs. 65,000 crores during the five years. That would not be enough to

[1]There were, in fact, substantial price increases in coal in the early years of the Third Plan.

maintain a constant per capita level of consumption given a population growth rate of at least two per cent, even if the total could be distributed at will over the five year period.

The real limitation on the level of consumption in the Target Model solutions is the size and composition of the Third Plan targets. These do not allow enough of current inputs and new capital to be diverted into the consumption goods sectors and their major suppliers to produce acceptable levels and rates of growth of consumption.

Anything which increases resource requirements for growth when resources are scarce will obviously reduce the level of performance as measured by the maximand. Anything which reduces resource requirements when resources are scarce or loosens a binding constraint will improve the maximand. A number of such changes and other modifications have been tested in alternative solutions. The results are summarized in Table 18.

The first column of Table 18 lists the value of the maximand, i.e. discounted consumption, for each of the alternative solutions. Undiscounted consumption over the five years is presented in the second column. The third and fourth columns list the net investment and replacement investment required by the targets. Since in some cases when only one type of capital input is required the model is indifferent between carrying out net new investment and replacement, some small amounts can be shifted between these two categories without affecting the results in any way. Column 5 contains the net domestic savings estimate obtained by subtracting the net foreign capital inflow from the calculated net investment requirements. Terminal year gross domestic product and gross domestic output are listed in columns (6) and (7) and the ratio of net domestic savings to NNP in

the last year of the plan is in column (8).[1]

The target solutions can be envisaged as taking place in three steps. First, the investment requirements of the targets are calculated from the stipulated initial and terminal conditions and using the specified capital-output ratios. Secondly, the model decides whether or not those requirements can be met given all the other constraints. Finally, it utilizes whatever freedom it has to distribute the investment over the plan period in order to maximize consumption. Only in the last step is the optimization feature called upon.[2] The first step is really a straightforward calculation with capital-output ratios but it is a comprehensive calculation. The calculated initial conditions are the capital capacities at the beginning of the plan period which are greater than the capacities which produced the output of the pre-plan year by the amount of capital which matures in the pre-plan year. The targets are not the outputs of the last plan year but the capacities with which the plan ends for the capacity maturing in the last plan year, though it does not contribute to output, requires investment and saving. Moreover, in order to insure post-terminal growth some investment and saving is required within the plan period for investment which will mature after the plan. The investment assumed to have taken prior to the plan period for the plan period can be subtracted, however. Inventory investment for all sectors must be added. All these calculations are performed as part of the target

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[1]This table contains more information than was originally presented at the Conference. Perhaps if it had been included originally it might have prevented some misunderstandings.

[2]In some situations the model might as a result of the optimization provide more capacity than called for by targets. This is not the case in the present circumstances, however.

solutions.

The estimate of investment requirements in run 4 shown in column (3) of Table 18 provides additional insight as to the reasons for the character of the Target solutions. It indicates that for the 96% level of Third Plan targets adjusted as explained above over Rs. 16,000 crores of net investment would be required as compared to the Rs. 10,000 crores estimated in the Third Plan itself. While some part of the discrepancy may be due to differences in capital-output ratios and other parameters, I do not believe such differences would account for the very sizeable discrepancy. Rather it seems likely that some part of the necessary components of investment were omitted or underestimated in the Third Plan preparations.

In runs (5) and (6) the discount rate applied to consumption in each period in the maximand was changed with negligible results for the value of consumption and the allocation of resources. This is due in part to the shortness of the planning period and the constraints on output which operate from both ends of the period. All subsequent trials were made with a discount rate of 10.0% in the maximand.

In runs (7) and (8) the growth constraints on consumption were successively reduced and each time only a modest change resulted. This suggests that the natural tendency of the model to shift consumption toward the beginning or end of the plan period was not important, probably because of all the other constraints imposed.

In solution (9) the initial capacity in Construction, the bottleneck sector at the outset of the plan period was increased by 5%, resulting in a substantial increase in the maximand. A 10% across-the-board increase

TABLE 18

A Summary of Target Model Solutions with Third Plan Targets[1]

	1 Maximand	2 Undiscounted consumption	3 Total net investment over the Plan	4 Total replacement over the Plan	5 Total net domestic savings over the Plan	6 GNP in the last year	7 Gross domestic product in the last year	8 Net domestic savings/NNP in the last year
1. Third Plan Targets				infeasible				
2. Third Plan Targets, net foreign capital inflow increased by 100%				infeasible				
3. Third Plan Targets, net foreign capital inflow increased by 100%, no competitive import ceilings				infeasible				
4. 96% of Third Plan Targets, Reference Solution	24,710	32,712	16,076.8	3,253.5	13,576.8	21,320.2	28,591.3	.191360
All the following solutions are with 96% level of Third Plan Targets								
5. Social discount rate, $W(t)/W(t+1)-1,=0.0\%$	32,713	32,713	16,076.8	3,253.5	13,576.8	21,325.3	28,601.3	.191125
6. Social discount rate, $W(t)/W(t+1)-1,=20.0\%$	19,387	32,712	16,076.8	3,253.5	13,576.8	21,320.2	28,591.3	.191360
7. $C(t+1) \geq 1.025C(t)$	24,851	32,849	16,077.0	3,253.3	13,577.0	21,320.6	28,592.0	.191377
8. $C(t+1) \geq C(t)$	25,002	32,996	16,077.1	3,253.3	13,577.1	21,320.9	28,592.7	.191394
9. Initial capacity in construction increased by 5%	31,490	39,547	16,064.7	3,225.4	13,564.7	21,158.5	28,286.4	.183393

TABLE 18 (continued)

	1 Maximand	2 Undiscounted consumption	3 Total net investment over the Plan	4 Total replacement over the Plan	5 Total net domestic savings over the Plan	6 GNP in the last year	7 Gross domestic product in the last year	8 Net domestic savings/NNP in the last year
10. All initial capacities increased by 10%	64,996	78,732	13,243.1	2,722.9	10,743.1	22,203.5	29,113.1	.115798
11. All initial capacities reduced by 10%				infeasible				
12. Capital output ratio in agriculture increased to 2.5 from 1.5				infeasible				
13. Capital output ratio in housing reduced from 10 to 7.5	32,612	40,841	16,143.0	3,163.1	15,643.0	21,164.0	28,295.3	.183646
14. No competitive import ceilings	31,177	40,482	16,399.3	2,878.4	13,899.3	21,344.0	28,642.5	.191706
15. Net capital inflow increased by 25%	28,068	37,178	16,197.6	3,115.5	15,573.6	21,339.9	28,601.8	.186896
16. Net capital inflow increased by 50%	28,378	37,563	16,189.6	3,125.6	15,438.6	21,347.0	28,595.6	.182694
17. Net capital inflow increased by 100%	28,948	38,264	16,176.3	3,139.1	15,176.3	21,354.9	28,569.2	.174373
18. Net capital inflow increased by 100%, no import ceilings	36,291	46,253	16,204.4	3,106.5	11,204.4	21,427.4	28,710.6	.173393

TABLE 18 (continued)

	1 Maximand	2 Undiscounted consumption	3 Total net investment over the Plan	4 Total replacement over the Plan	5 Total net domestic savings over the Plan	6 GNP in the last year	7 Gross domestic product in the last year	8 Net domestic savings/NNP in the last year
19. Net capital inflow reduced by 25%	19,750	26,107	15,657.6	3,744.6	13,782.6	21,352.8	28,645.6	.188254
20. No net capital inflow				infeasible				
21. Intra Plan export growth rate at 3%	24,445	32,355	15,797.8	3,579.1	13,297.8	21,349.8	28,621.7	.184108
22. Intra Plan export growth at 5%	25,194	33,360	15,655.3	3,746.8	13,155.3	21,349.7	28,620.0	.184773

[1]Since replacement in some sectors requires the same type of capital inputs as new net investment the model is indifferent in these cases as to the classification of the investment. This accounts for most of the small variations in the totals of net investment and replacement.

in initial capacities in run (10) breaks many bottlenecks and the value of consumption rises beyond that which a 5% growth rate would produce, as is confirmed by the fact that the consumption growth constraints are not binding. A ten per cent increase in capacities has the effect of putting the system almost half way toward achievement of the 96% level of targets. Presumably with a somewhat lower value of maximand the degree of achievement of the targets could be raised. Of course, while all the additional capacity is eventually useful, the most important effect of such a change is to break the bottlenecks. If initially available capacities were reduced by 10% as in trial (11), the 96% level of Third Plan Targets becomes infeasible.

The agricultural sector bulks large in the Indian economy and the expansion of its output has posed especially difficult problems. The sensitivity of the model to success in this field is only indirectly and very partially tested by changing the capital-output ratio in this sector. This was tried, however, in solution (12) in which the capital-output ratio was raised to 2.5 from 1.5 with the result that the 96% level of targets became infeasible again.

The housing sector though not so large in terms of output has the largest capital-output ratio of any sector. This was reduced in run (13) from 10 to 7.5 with substantial effects on the maximand as compared to solution (4) as it reduced the requirements for inputs from the construction sector in particular.

In solutions (14) through (22) various conditions relating to imports, exports and foreign assistance were modified. In run (14) the constraints were eliminated on the use of the foreign exchange left over

after satisfying the non-competitive imports. This resulted in a substantial increase in the value of the maximand. The implication is that a relative use of foreign exchange by the various sectors which was different from that which had prevailed at the end of the Second Plan, at least, would improve the performance of the system. In runs (15) through (22) the availability of foreign aid is varied. When foreign aid is increased in run (15) by 25%, a total of Rs. 625 crores, the value of consumption rises by more than seven times that amount as compared to solution (4). The successive increases in runs (16) and (17) have a much smaller effect as the bottleneck of domestic resources remains intractable. When a doubling of foreign aid is combined with greater freedom in the use of foreign exchange in solution (18), another substantial increase in the maximand takes place. In run (19) the reduction of foreign aid by 625 crores over five years reduces the available consumption almost ten times. With no foreign aid, as shown in target solution (20), the 96% targets become infeasible.

It is interesting to note that reducing the growth rate of exports during the plan period actually reduces the value of the consumption available in spite of exports being a drain on domestic resources. As shown in runs (21) and (22), at the level at which the system operates in the Target Model solutions the domestic resource requirements for increasing exports do not clash directly with the resource requirements for reaching the targets and the increased exports do provide additional foreign exchange.

During the Third Plan period there have in fact been general shortfalls with respect to the Plan targets. The reasons for these are certainly more complex than can be explained by a linear programming model. Yet it

is worth noting that the Target solutions can be interpreted as being consistent with the shortfalls and with the manner in which they occurred. The model produces a "feasible" solution only by scaling down the Third Plan targets and by reducing per capita consumption levels. Since in actuality consumption could not be so constrained, resources would be pulled into agriculture and the other consumer goods sectors to such a degree that targets could not be achieved elsewhere. Yet the government's commitment to the targets was sufficiently strong that resources were not shifted wholesale to the consumption-supplying sectors, and per capita consumption has risen only slightly. A set of alternative -- or aggravating -- explanatory factors for the Third Plan period are the bad monsoons and the increase in the military budget in reaction to the Chinese border invasion. Further study would be necessary to put each of these influences and explanations in proper perspective.

The Transit Model Solutions and Comparisons with the Target Solutions

The second stage in applying the model to the data was the computation of a number of alternative solutions with terminal conditions set endogenously by means of equations (22) and (23). These will be called the Transit Model Solutions. In these solutions the targets reflect the conditions that consumption, government expenditures, exports and imports grow at rates which are specified exogenously in this set of solutions at five per cent, two and one half per cent, four per cent and three per cent respectively. The Plan targets are now determined as part of an optimal solution and are only one aspect of the solution. There are a number of reasons why none of the Transit Model Solutions may represent the best possible "plan" for India. These will be described in detail in

the last section of the paper and at this point the caveat will only be registered.

Table 19 summarizes some features of the solutions for alternative specifications of the parameters and constraints. The differences between the Target solutions and the Transit Model solutions are striking. The values of the maximand of the Transit Model solutions are higher in every case. On reflection, however, it is not completely surprising that it should be so. The Transit Model is optimizing the weighted sum of aggregate consumption and also ensuring the capability for post-terminal growth of which consumption is the largest component. The composition of consumption is not allowed to change within or after the plan period nor is the composition of the government and export demands. Thus, the Transit Model maintains a substantial degree of consistency between the orientation of the economy during and after the Plan. Investment is provided in the Transit Model solution in proportions and amounts completely consistent with the exogenous specifications on the pattern of consumption, etc. and with the intra-Plan optimization of the consumption maximand. It is interesting to note that the total amount of net investment in the Transit Model solutions is usually close to the Rs. 10,000 crores originally estimated for the Third Plan. The Third Plan targets are apparently not in the same way compatible with the maximand and the Third Plan Target Solutions reflect this fact. The shadow prices of output and capital and the distribution of idle capacities in the Transit Model solutions reflects this different orientation. In the Transit Model solutions there is less idle capacity overall and it is concentrated in the capital goods producing sectors and their major suppliers. The shadow prices also reflect the emphasis on capital formation in the consumer goods sectors.

TABLE 19

Transit Model Solutions for Third Plan Period

	1 Maximand	2 Undiscounted consumption	3 Total net investment over the Plan	4 Total replacement over the Plan	5 Total net domestic savings over the Plan	6 GNP in the last year	7 Gross domestic product in the last year	8 Net domestic savings/NNP in the last year
1. Reference Solution, social discount rate = 10%	59,435	72,034	9,822.4	2,963.6	7,322.4	20,210.1	26,054.8	.079201
2. Social discount rate, W(t)/W(t+1)=1=0%	72,034	72,034	9,826.4	2,963.6	7,326.4	20,214.1	26,061.0	.079300
3. Social discount rate, W(t)/W(t+1)=1=20%	50,674	72,007	9,304.2	2,979.0	6,804.2	19,975.5	25,744.3	.079005
4. $C(t+1) \geq 1.025C(t)$	60,009	72,641	9,863.7	2,894.3	7,363.7	20,184.1	26,030.9	.079924
5. $C(t+1) \geq C(t)$	60,009	72,641	9,863.7	2,894.3	7,363.7	20,184.1	26,030.9	.079924
6. All initial capacities increased by 10%	65,009	79,402	10,900.1	2,787.2	8,400.1	22,022.3	28,425.9	.078865
7. Post-terminal consumption growth rate reduced to 2.5%	59,997	72,820	7,861.0	2,419.4	5,361.0	19,579.1	25,563.3	.029871
8. Post-terminal consumption growth rate increased to 7.5%	58,258	70,507	12,096.4	2,852.3	9,596.4	20,448.4	26,852.8	.130031

TABLE 19 (continued)

	1 Maximand	2 Undiscounted consumption	3 Total net investment over the Plan	4 Total replacement over the Plan	5 Total net domestic savings over the Plan	6 GNP in the last year	7 Gross domestic product in the last year	8 Net domestic savings/NNP in the last year
9. $C(1) \geq 1.05\bar{C}(0)$				infeasible				
10. No competitive import ceilings	59,949	72,724	10,135.3	2,912.1	7,635.3	20,221.0	25,888.7	.077516
11. Net capital inflow increased by 25%	59,785	72,496	9,834.7	2,951.9	7,334.7	20,239.6	26,059.1	.073079
12. Net capital inflow increased by 50%	60,034	72,832	9,839.3	2,956.4	7,339.3	20,099.3	25,816.1	.063780
13. Net capital inflow reduced by 25%	59,118	71,547	8,848.4	2,931.5	6,348.4	19,647.3	25,317.4	.081237
14. Net capital inflow eliminated	57,684	69,811	8,887.6	3,291.9	6,387.6	19,794.2	25,672.6	.107955
15. Intra-Plan export growth rate at 3%	59,475	72,066	9,658.2	2,942.9	7,158.2	20,112.5	25,911.1	.077773
16. Intra-Plan export growth rate at 5%	59,445	72,021	9,671.3	2,898.1	7,171.3	20,082.1	25,871.6	.079556

The growth rate for consumption associated with solutions (1) and (2) with a 10.0% and 0.0% rate of discount in the maximand, respectively, is 10.2%. The monotonicity constraint is binding only between the second and third and the third and fourth periods. It is not binding at all when the constraint is reduced to 2.5% in solution (4) in Table 19 so its complete elimination in solution (5) does not further affect the maximand.

The 10% increase in capacities substantially improved the consumption goods output in the Transit Model solution (6) but by no means as radically as in the Target Solution. This corresponds to a result achieved when the Target solution was run for 80% level of the Third Plan Targets. In both the former and the latter case the targets become relatively easy to achieve and the model can concentrate on producing as much consumption as possible during the plan periods so that the Target solution comes to resemble the Transit Model solution.

A reduction in the desired post-terminal growth rate of consumption by 2.5% in solution (7) amounts to about 400 crores in the first post-terminal year, for example. This change increases the value of consumption available in the plan period by about twice that amount. But an increase in the post-terminal consumption growth rate to 7.5% in solution (8) reduces the availability of consumption by 1,500 crores. The terminal years capital stock goes up by 500 crores. The increase is relatively small because the model is still free to set the initial level of consumption and tries to "cheat" on the constraints of meeting terminal requirements by reducing initial levels of consumption by 169 crores. The rate of growth of consumption in this latter case is still 4.2%. If the level of consumption in the initial period were fixed at 5% above that of the pre-plan period, a Transit Model solution became infeasible as shown in (9) in Table 19.

Elimination of the import ceilings for competitive imports in solution (10) increases the amount of consumption available by about Rs. 500 crores and the terminal capital stocks by about Rs. 200 crores. The improvement in the corresponding Target solution when this change was made was much more dramatic. This was partly because in that solution there was more idle capacity which could be used if the various constraints permitted it and partly because there was more imbalance between capacities and targets which increased the significance of foreign exchange and the ability to use it freely. On the other hand, the difference between the solutions also suggests for further research the possibility that the Indian foreign exchange controls were not so compatible with their targets as they would be in achieving a different set of targets.

As could be expected from the above discussion a 25% increase in the availability of foreign exchange in solution (11) in Table 19 makes less difference than in the case of the Target solution, permitting only Rs. 489 crores of additional consumption. The next 25% increase in foreign aid in solution (12) has a slightly bigger pay-off in terms of additional consumption in the plan period for the Transit Model solution than the Target solution. Likewise, reducing foreign aid had a smaller impact on the Transit Model solution as shown in its runs (13) and (14). The reduction in the capital stocks at the end of the fifth period from Rs. 31,863 crores to Rs. 31,077 crores was much less than the reduction in consumption during the plan period as a result of the complete elimination of foreign aid.

When the stipulated rate of growth of exports is reduced by 1% in solution (15), increased resources become available for domestic use

but foreign exchange available is also reduced. The net effect of such a change or a 1% increase in the rate of growth of exports in solution (16) is relatively unimportant.

It is instructive to compare typical national income accounts associated with the Target and Transit Model solutions. This is done in Table 20 for solution (4) in Table 18 and solution (1) in Table 19. The first year of the Target solution puts a great deal of effort into breaking the bottlenecks and keeps all other activities at a low level, partly because of the fixed consumption and input proportions. It also does this in part because a higher first year consumption would, because of the consumption growth constraints, only increase the consumption requirements in future years. The domestic savings rates in all years after the first are in the Target Model solution at levels which would generally be regarded as infeasible.[1]

The national income accounts associated with the Transit Model solution look more conventional. On the other hand the domestic savings rate is substantially lower than that which has been actually achieved. This suggests as indicated earlier that the economy could achieve a higher growth rate in capital stock if it so desired. The savings rates associated with Transit Model solution (9) in fact run up to 15.6% in the last period.

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[1]This is, by no means, a new criticism of the Third Plan, although it has taken different forms depending on the analytical framework used and individual judgment as to the parameters which are within government control. Thus, P. N. Rosenstein-Rodan thought the over-all capital-output ratio implicit in the Plan was too low ("Alternative Numerical Models of the Third Five Year Plan of India," Capital Formation and Economic Development, P. N. Rosenstein-Rodan, ed., pp. 23-33, Cambridge, 1964). Other commentators, while accepting the implicit capital-output ratio, have considered the implicit domestic savings rates as too high.

TABLE 20

National Income Accounts

Target Model Solutions with Third Plan Targets

Targets Reduced to 96.0% R=10.0

	1961-62	1962-63	1963-64	1964-65	1965-66
Consumption	2346.95	2464.31	2587.52	10181.89	15131.30
Inventory Change	-2965.95	788.60	2284.87	1536.94	723.98
Fixed Investment, Net	1952.21	2403.09	2572.89	3031.39	3748.74
Total Investment	-473.55	3804.52	5433.57	5147.25	4952.25
Government Expenditure	540.99	560.99	581.99	601.99	621.99
Value Added by Govt.	899.75	933.01	967.94	1001.20	1034.46
Exports	653.98	680.98	707.98	735.98	764.98
Imports	1153.98	1180.98	1207.98	1235.98	1264.98
Gross National Product	2814.15	7262.85	9071.04	16432.34	21240.02
Replacement	540.19	612.83	575.80	578.90	479.52
Net National Product	2273.96	6650.02	8495.24	15853.44	20760.50
Savings	-973.55	3304.52	4933.57	4647.25	4452.25
Gross Nat. Output	5476.27	9956.23	12406.36	22046.08	28511.14
Intermediate Product	2206.80	3470.85	4145.37	6454.70	8143.01
Cons./Gross Nat. Prod.	.83	.33	.28	.61	.71
Total Invst./Gr. Nat. Pr.	-.16	.52	.59	.31	.23
Savings/Gr. Nat. Prod.	-.34	.45	.54	.28	.20

TABLE 20 (continued)

Transit Model Solutions for Third Plan Period

	1961-62	1962-63	1963-64	1964-65	1965-66
Consumption	12929.92	13576.41	14255.23	14978.98	16293.47
Inventory Change	4.30	189.84	318.65	464.44	341.18
Fixed Investment, Net	1803.86	1776.32	1637.95	1583.04	1702.76
Total Investment	2232.81	2426.79	2411.39	2632.82	2657.56
Government Expenditure	540.99	560.99	581.99	601.99	621.99
Value Added by Govt.	899.75	933.01	967.94	1001.20	1034.46
Exports	653.98	680.98	707.98	735.98	764.98
Imports	1153.98	1180.98	1207.98	1235.98	1264.98
Gross National Product	16103.48	16997.22	17716.57	18715.01	20107.50
Replacement	424.63	460.62	454.77	585.33	613.62
Net National Product	15678.85	16536.60	17261.79	18129.68	19493.88
Savings	1732.81	1926.79	1911.39	2132.82	2157.56
Gross Nat. Output	20786.62	21959.49	22844.25	24160.85	25952.13
Intermediate Product	5429.68	5739.74	5937.73	6286.81	6716.52
Cons./Gross Nat. Prod.	.80	.79	.80	.80	.81
Total Invst./Gr. Nat. Pr.	.13	.14	.13	.14	.13
Savings/Gr. Nat. Prod.	.10	.11	.10	.11	.10

The differences in savings rates result in a greater accumulation of total capital stock in the Target Solutions as would be expected. The total stock is 7.5% higher in Target Solution (4) than in Transit Model Solution (1) in the fifth year of the plan period. In the post-terminal years the differences are even larger. As would be expected it is in the capital goods sectors and their major suppliers that the Target solution provides for a larger accumulation and for a smaller accumulation in the consumer goods sectors.

An Appraisal of the Model and Its Application

The lack of realism in the assumptions of the model were obvious when they were made. The consequences of those abstractions in the solutions are less obvious, and the final task is to try to assess these consequences and, therefore, the usefulness of the method. The application of the model to the Indian Third Five Year Plan period provides a concrete context for the discussion. To summarize, the results of that application: there are no economically feasible solutions to the Target model with the Third Five Year Plan targets inserted. Economically feasible solutions were obtained only when the targets were reduced by 4%. Even these would not be politically feasible, however, as they require a reduction in per capita consumption during the Plan. To put the matter another way, these solutions are not consistent with other Plan goals of increasing per capita consumption. The solutions of the Transit Model with endogenously determined terminal conditions provide uniformly larger levels and growth rates of consumption. The differences between the solutions are due to the size and composition of the investment and output targets. The Third Plan targets require much more investment and place relatively greater stress on investment and output

of the capital goods sectors and their major suppliers as compared to the Transit Model solutions.

In actual planning situations the objective function and the constraints are never so simple as those stipulated in the model. Increased employment and improved income distribution are examples of the many goals which have had an important place in development debates but which are not explicit in the model. If additional constraints or multiple objectives could be taken into account, what would be the effect on the solutions? The answer cannot be given in detail, of course, without solving the broader problem but the general nature of the consequences are clear. If the additional constraints are binding, i.e., make any difference at all in the solutions, the maximand in both the Target solutions and the Transit Model solutions would be reduced and, in other than exceptional circumstances, by different amounts. Thus, adding realism by adding employment constraints, for example, might or might not diminish the difference between the Target and Transit Model solutions but it would certainly not help with respect to the question of feasibility of the Third Plan Targets. Moreover, the fact that employment and other goals have not been treated explicitly in the model does not mean that the results are without implications for these goals. The usual way of computing the employment implications of a plan is to divide output by some productivity coefficients and that could easily be done for both the Target and Transit Model solutions if data were available on productivity. Likewise, if it is possible to associate changes in income distribution with relative sectoral changes, these implications could also be worked out.

The planning horizon for the model is short, the five years corresponding to the Indian Plans. No detailed plans have been prepared by the

Planning Commission which cover a longer period but long run strategies of development have been enunciated such as "import substitution," "balanced development of agriculture and industry" and so on. Unfortunately, even the most fully elaborated strategies do not provide the concreteness of quantitative projections so it is impossible to determine the consistency of any particular set of plan targets with longer run goals. In any case, having a longer horizon for the model would again not make any difference as far as the Third Plan Target solutions are concerned. Resources cannot be transferred from the future to the present and a longer planning period would not help in achieving the Third Plan Targets. The implications of the Transit Model solutions for the future are fully revealed in the post-terminal conditions maintained and thus provide an explicit basis for judgment. However, it cannot be presumed that the Transit Model Solutions for the Third Plan period would be identical to optimum solutions obtained for a longer planning horizon. In fact, that is almost certainly not the case. Having a longer horizon provides added flexibility in a number of respects and general considerations suggest that the solutions will be sensitive to the length of the planning horizon.[1] It is impossible to predict in this short term model the effects of lengthening the planning horizon. In models such as that used here the solutions are of the "flip-flop" type, meaning, in this case, that consumption, if unconstrained would tend to be concentrated at either the beginning or end of the plan. Due to the three year gestation periods, the initial and terminal conditions create direct constraints on each period's outputs. In addition, the growth

[1]See S. Chakravarty, "Optimal Savings with a Finite Planning Horizon," International Economic Review, Vol. 3, No. 3, Sept. 1962, pp. 338-355.

constraints on consumption help prevent the flip-flop tendency. Further work is in progress to explore the significance of extending the planning horizon. Meanwhile, one can only say that the Transit Model solutions are optimal with respect to the objective function, all the constraints and the time period. They help indicate in a rough way the kind of changes which would have been necessary to create a set of feasible Third Plan targets. It is not suggested, however, that these solutions provide the best of all alternative paths. For example, some of the Third Plan objectives, such as creating the capacity to produce import substitutes, transcend the plan period itself. The Transit Model solutions for five years cannot give an answer to the question of optimal import substitution policy, though the performance of any particular solution in this respect can be gauged through the post-terminal conditions which are stipulated for export and import growth.

The model is unsatisfactory in its production technology, omitting any possibility of diminishing returns or externalities or the contribution of any other factor but capital and foreign exchange. Less sophisticated formal analyses can take such influences into account in detailed sectoral studies. Unfortunately, the integration into over-all plans of sectoral studies which embody either increasing or diminishing returns, for example, has not yet been accomplished though work is proceeding in that direction.

Technical coefficients can be changed exogenously in the models when such changes are known to be happening. In a practical application further disaggregation would help in dealing with some of the problems associated with changing coefficients. It is particularly important to extend the model structure to embody such changes since the creation of

new sectors and the transformation of traditional sectors is of essential importance in the growth of less-developed areas.[1]

Agriculture provides, perhaps, the prime example of a sector whose technology is being transformed with the absorption of increasing amounts of inputs from the industrial sectors. If such changes had been taken into account the values of the maximand would have been reduced in both the Target and Transit Model solutions and, probably, by greater amounts in the former due to the greater strain imposed there on industrial capacity.

Other qualifications have been mentioned earlier and, with additional time and space, still more could be described. It is important to have them always in mind as they condition all the interpretations of the results. Finally, however, in judging the model the real issue is not whether it is a perfect and completely comprehensive approach, for no one would argue that, but whether it can do its particular job better than other approaches which are available.

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[1]Technical coefficients were not changed in the model solutions presented above due to the relative shortness of the time span covered and lack of knowledge of what could be expected. Since in the Transit Model solutions the shadow prices tend to be lower than in the Target solutions changes in technical coefficients are likely to be of less importance in the former.