omic research in the country[3] nor does it pretend to give an exhaustive picture of the policy issues that have been discussed on the Indian scene since 1947 when India gained independence.

The Survey is broadly divided into three areas: (1) planning theory and techniques; (2) agriculture; and (3) foreign trade. The vast majority of India's policy issues, and analytical literature, fall within one or more of these categories. With her programs for economic development, initiated through the First Five–Year Plan (1951/1956) and continued through two successive Five–Year Plans, the question of overall Plan formulation, and investment criteria in particular, has engaged the attention of many economists. Largely because agriculture is the overwhelmingly important economic activity in the economy, and its capacity to act as a significant brake on growth via its role as the supplier of wage goods to other sectors has been increasingly appreciated, this sector has also attracted considerable economic analysis. And finally, the foreign trade sector has been the focus of interesting debate. The questions raised by foreign aid, foreign investment, the import control regime and export subsidization have led to insights of wider interest.

Since the overall Plan formulation literature inevitably embraces some of the questions raised by agricultural and foreign trade policies, our discussion begins with the survey of the planning literature and only then proceeds to an evaluation of the literature that concerns itself with the *remaining* issues in the areas of agricultural and trade policies.

I. *Planning Theory and Techniques*

The formulation of the successive Five–Year Plans in India has led to a steady evolution of economic thinking on questions relating to planning theory and techniques. As we shall soon argue, however, the interplay between Plans and economic thinking has often been tenuous. At times there may even have been post-facto rationalization of investment decisions taken on political grounds by ingenious designing of suitable models. At other times, model–building and analysis have inevitably gone ahead of the Plans. However, it is possible to identify with each Plan certain basic model–types which have provided the intellectual backbone to that Plan and were the object of extensive economic debate.

Thus the First Five–Year Plan, which was essentially a collection of several projects, contained at the same time a Harrod-Domar type exercise which sought to examine the growth rates that would be achieved by specification of the (feasible) marginal savings rate and the resulting average savings ratio. The Second Five–Year Plan, on the other hand, marked a distinct departure in favor of the Feldman–Mahalanobis type of structural model which emphasises the *physical* aspect of investment and thus leads, subject to certain restrictive assumptions about transformation possibilities domestically and through foreign trade, to the proposition that raising the rate of investment requires increased domestic manufacture of capital goods. This shift from a Keynesian, "flow" analysis which emphasised the necessity to raise savings (and hence implicitly assumed that the savings could be transformed into required investment) to a "structuralist" view which emphasised the transformation constraint and the supply of capital goods to sustain growing investment (while implicitly assuming that the system would generate the savings to "finance" the growing supply of investment goods) was the most dramatic episode in the evolution of planning literature and debate in India. The formulation of

[3] Among useful attempts in this direction, with respect to agriculture, see Gupta [61] and Dandekar [28].

the Third Five-Year Plan, by contrast, marked a shift away from these *simple decision-models*: the achievement of inter-industrial consistency was attempted in some detail this time. As we shall soon see, the shift to interindustrial exercises not only underlay plan formulation but was also the characteristic of planning exercises undertaken by economists and teams associated with the Indian Planning Commission. These *multi-sectoral models* were also characterised by their explicit extension to questions of intertemporal choice: questions which had been raised as early as 1955 by Ragnar Frisch when he visited the Indian Statistical Institute which was the intellectual center for formulation of the Second Plan (1956/1961).

Having identified synoptically the main outlines of shift in planning techniques in India through the three Plans, we now proceed to survey the major ideas and contributions in this area, considering each of the three planning periods in turn.

The First Five-Year Plan

The first identifiable planning model used in India was developed by the authors of the First Five-Year Plan document which the Government of India placed before the country in 1951.[4] The model was not given an explicit analytical form, but was implicit in the numerical figures which constituted the perspective plan for developing the Indian economy [179, Chapter I]. It was essentially a simple variant of the growth model associated with the names of Harrod and Domar. The sole modification, but a crucial one, was the distinction between the average and the marginal propensities to save. The capital-output ratio was assumed to be the same on the margin as on the average. No gestation lags were introduced. The model was developed for a closed economy (although it can naturally be easily extended to deal with an open economy, with one part of investment being financed by import surplus). The basic equations underlying the growth process were the following:

$$(1) \qquad I_t = S_t;$$

$$(2) \qquad S_t = aY_t - b;$$

$$(3) \qquad Y_t = \alpha K_t$$

$$(4) \qquad I_t = \dot{K}_t$$

Here I_t stands for investment at 't', S_t for the corresponding amount of savings, Y_t stands for income. All the equations excepting (2) are the same as in the Harrod-Domar model. Equation (2) introduces the distinction between marginal and average propensities to save. The model leads tothe basic differential equation $\dot{K}_t = a\alpha K_t - b$ which can be easily solved to give us the time profile of capital stock and output. We get:

$$(5) \qquad K_t = (K_0 - b/a\alpha)e^{a\alpha t} + b/a\alpha.$$

Notice that unlike the usual Harrod-Domar model, the rate of growth here rises from period to period (provided of course $a > S_0/Y_0$). Thus an economy which decides to save more on the margin than on the average can hope to do better and better over time in terms of its rate of growth. The asymptotic relative rate of growth of the system is given by the expression $a\alpha$.[5]

Such Harrod-Domar type models have been explicitly used, with considerable advantage, as the framework for plan formulation in other countries (e.g. by Jan Tinbergen for the first Turkish Plan). They are useful in indicating the basic

[4] There *had* been earlier attempts at putting together "plans" for India: e.g., the Bombay Plan [169] in 1944. However, no conceptual framework, in terms of an explicit or implicit planning model, underlay any of these exercises.

[5] For any specific t, $r_t < a\alpha$ where r_t is the relative rate of growth of income at time t.

macro-economic features that any more elaborate construct would equally have to satisfy. Further, they have served as "simple" mechanisms for computing the external assistance that may be necessary for supplementing domestic savings to sustain projected growth rates in income.[6]

However, such a Harrod–Domar model obscures problems of importance. For example, concentration on the flow equilibrium, and the implicit assumption that there are no "structural" difficulties in transforming savings into (desired forms of) investment may ignore real constraints in the economy. Further, even within the framework of its assumptions, the model ignores the fundamental choice problem of planning over time, which requires a weighing of present versus future gains, by assuming a constant marginal propensity to save for the economy.

The connection between the actual First Five–Year Plan and the Harrod–Domar type model contained in the document was left vague by the planners. It appears as though the selection of projects for governmental expenditure reflected essentially the "overhead–capital" approach to developmental planning and the model was largely an intellectual appendage with little impact on actual Plan formulation, although it did serve to give some kind of longrun perspective to the Plan.

The Second Five–Year Plan

By contrast, the Second Plan pattern of industrial investment, with its marked shift in favour of capital goods industries, was deeply influenced by the two-sector growth model developed by P. C. Mahalanobis [95].[7] This model was independently developed by Feldman in the Soviet Union in the 1920s and later revived by Domar [47] in a considerably improved form. The basic model, as stated by Mahalanobis, can be described briefly.

Current investment flow I_t is divided into two parts, $\lambda_k I_t$ and $\lambda_c I_t$, where λ_k indicates the proportion going to the capital goods sector and λ_c the corresponding proportion for the consumption sector.

It is clear that

(7) $$I_t - I_{t-1} = \lambda_k \beta_k I_{t-1}$$

and

(8) $$C_t - C_{t-1} = \lambda_c \beta_c I_{t-1}.$$

Now the first equation implies that

(9) $$I_t = I_0(1 + \lambda_k \beta_k)^t.$$

Further, $C_t - C_0$ can be written as

(10) $$\sum_{\tau=1}^{t} (C_\tau - C_{\tau-1}) = \sum_{\tau=1}^{t} \lambda_c \beta_c I_{\tau-1}$$

(11) $$= \lambda_c \beta_c I_0 + \lambda_c \beta_c I_1 + \cdots + \lambda_c \beta_c I_{t-1}$$

(12) $$= \lambda_c \beta_c I_0 + \lambda_c \beta_c I_0 (1 + \lambda_k \beta_k). + \lambda_c \beta_c I_0 (1 + \lambda_k \beta_k)^{t-1}$$

(13) $$= \frac{\beta_c \lambda_c}{\beta_k \lambda_k} I_0 [(1 + \lambda_k \beta_k)^t - 1]$$

Since $I_t - I_0 = I_0\{(1+\lambda_k\beta_k)^t - 1\}$, we get by adding it to $C_t - C_0$ in the preceding equation:

[6] Suppose the planners are ambitious enough to set a target rate of growth in income which implies an investment rate in excess of the current savings rate. In an open economy, this would not raise any problem so long as the required amount of foreign aid (F_t) is available to meet the domestic resource gap. However, if the growth process is of the type described in the text (where the economy saves more on the margin than on the average) then the required amount of foreign aid would diminish from year to year, provided the growth rate is kept constant. The time t^* for which F_t vanishes may be defined as the time of attainment of self-sustained growth. This value for t^* may be compared with the value t^{**} for which the economy would reach the desired growth rate left to itself. The difference between t^{**} and t^* may be used to give one measure of the beneficial influence of foreign aid on economic growth. Thus, the simple growth process described in the text can help one to obtain answers to questions relating to the volume of external assistance that is necessary.

[7] Numerous specific criticisms of the analysis of the Mahalanobis model were made at the time, among them being Chakravarty [20], Tsuru [172] and Mitra [117].

$$(14) \quad C_t - C_0 = \frac{\beta_c \lambda_c}{\beta_k \lambda_k} I_0 \{ (1 + \lambda_k \beta_k)^t - 1 \},$$

the complete solution for output at time t, where

$$(15) \quad Y_t = Y_0 \left[1 + \alpha_0 \left(\frac{\beta_c \lambda_c + \beta_k \lambda_k}{\beta_k \lambda_k} \right) \cdot \{ (1 + \lambda_k \beta_k)^t - 1 \} \right]$$

where $\alpha_0 = I_0/Y_0$, the initial investment–income ratio.

Several things are quite clear from this equation. First we note that the relative rate of growth of consumption or output is changing over time. It is also clear that the asymptotic rate of growth of the system is given by $\lambda_k \beta_k$ where λ_k is the crucial allocation ratio which indicates the proportion of capital goods output which is devoted to the further production of capital goods. Thus a higher λ_k would always have a favourable effect on the asymptotic growth rate of the system, irrespective of whether it is consumption or output. But what about its immediate effect on consumption? If $\beta_c > \beta_k$, then a higher value of λ_k would imply a lower immediate increment in consumption. Thus, there is implicit in the choice of 'λ_k' a choice of alternative time streams of consumption.[8]

It may be further noted that, while the implicit assumption underlying the aggregative model discussed earlier was that the savings rate was a reflection of the behavioral characteristics of the decision–making units such as the household, the corporate sector or the government, Mahalanobis effectively made it a rigid function of certain "structural" features such as the capacity of the domestic capital goods industry and capital–output ratios of the capital goods sector and the consumer goods sector. By making the allocation ratio of current investment going into investment goods sector the policy variable, he showed that a higher allocation would mean a higher saving rate on the margin and hence a greater rate of growth of output or consumption.[9] This can be seen readily by noting that $\lambda_k \beta_k / (\lambda_c \beta_c + \lambda_k \beta_k)$ is none other than the share of incremental investment in incremental output. Macroeconomic balancing for a closed economy would then imply that this is also the share of incremental savings in incremental income. If $\beta_k = \beta_c$, then this ratio of incremental savings to incremental income is exactly equal to λ_k. If $\beta_k \neq \beta_c$, then $\Delta I / \Delta Y$ is a more general function of λ_k, β_k, β_c but the fundamental qualitative point remains unaltered.

Despite the fact that the Mahalanobis model is a severely rigid construct, it has one important virtue. This lies in its recognition of the fact that capital equipment once installed in any specific producing sector of the economy may not be shiftable.[10] An important consequence is that changes in the savings rate, and hence in the rate of investment, are not necessarily feasible and become conditional upon the composition of the existing capital stock; hence, optimal programs of

[8] Mahalanobis did not address himself to the question of how to resolve this choice problem. He, however, pointed out that a specification of the horizon over which the planning was done was essential if any meaningful answer is to be given to the choice of λ_k. This is undoubtedly correct but, as more recent analysis dealing with this question has shown, specification of a planning horizon is only one of the many prerequisites for choosing an optimal path of development over time. We have to make some assumption regarding the nature of the intertemporal utility function as well as the terminal conditions of the problem. We shall deal with these questions to a certain extent when we come to the discussion of the more recent planning models constructed in the Indian context.

[9] In deriving this cental proposition, Mahalanobis implicitly ignored the role of foreign trade altogether and assumed that the government was in a position to control comsumption completely.

[10] Whether, however, the Mahalanobis–assumed non-shiftability from consumer goods to investment goods capital equipment is greater than that within the former group, and how important it is anyway, are matters on which *evidence* is scant and, as we shall soon argue, was in any case not sought by the Indian planners before adopting Mahalanobis' ideas.

capital accumulation worked out under the assumption of nonshiftability differ crucially from those derived from models with complete shiftability in capital stock among alternative uses.[11]

It needs to be stressed, of course, that foreign trade also can get the economy out of the problems raised by limited transformation possibilities domestically owing to nonshiftability of capital equipment: the assumption of a closed economy automatically rules out this important escape route from the problems raised by nonshiftability. Of course to escape these problems completely, we would have to assume the possibility of indefinite transformation at constant rates—the so-called "small country" assumption in trade theory. Therefore, the essential problems raised by nonshiftability will persist if the reciprocal foreign demands facing the planning country are less than perfectly elastic.

Mahalanobis, who assumed a closed economy and total nonshiftability of the capital stock from the consumption goods to the investment goods sector, appears to have used his model merely to provide the rationale for a shift in industrial investments towards building up a capital goods base. However, the *precise* choice of the proportion of investments in the capital goods sector, during the Second Plan and possibly, thereafter, appears to have been arbitrary—at any rate, if there were specific economic considerations underlying it, these were not spelled out. In any case, an optimal choice thereof would have required, at the minimum, a quantification of the transformation constraints (both domestic and foreign)—and we know that neither was attempted.

Indeed, it appears quite plausible to argue that Mahalanobis (who had just then visited the socialist countries and with whose economists he had close contacts) was impressed with Soviet thinking on industrialization, with its emphasis on the building-up of the capital goods base, without full recognition of the fact that such a strategy presupposes constraints on domestic and foreign transformation which need to be empirically verified. Further, it seems likely that, being a physicist by training and a statistician by practice, he directly identified increased investment with increased availability of capital goods, which in turn he identified with domestic production thereof, ignoring foreign trade in particular.[12] It is interesting that the Second Plan did not explicitly state the rationale of the shift to heavy industries in terms of foreign trade constraints, so that the later justification of this strategy by alluding to "stagnant world demand" for Indian exports comes somewhat close to a *ex post facto* rationalization. Indeed, the Second Plan's examination of export earnings through the Plan is so cursory that it is difficult to believe that the "stagnant world demand for Indian exports" assumption, by virtue of which the shift to heavy industries was later sought to be justified, was seriously made: such a *crucial* assumption, if made, would surely have been examined more intensively! Further it is important to note that the preceding Five-Year Plan's experience with the balance of payments *and* exports was comfortable, so that it hardly seems likely that the export prospects could have been viewed with such pessimism as has later been imagined.[13]

While, therefore, the Mahalanobis two-sector model was used to provide the rationale for a general shift in investments to building up a capital goods base,

[11] Cf. Chakravarty [22] for a detailed treatment of the analytical issues raised by planning for optimality in the context of models with non-shiftable capital.

[12] This probably accounts for his model [96] in the *Draft Frame* of the Second Plan taking no *explicit* account of savings, whereas *economists* looking at growth inevitably started from the savings end.

[13] These arguments have been developed more fully in Bhagwati and Padma Desai [14].

though the actual magnitude of this shift was otherwise determined, Mahalanobis provided yet another model, a four-sector model [96], which broke down total investment among three further sectors, in addition to the capital goods sector: (1) factory production of consumer goods; (2) household production of consumer goods, including agriculture, and (3) the sector providing services such as health, education etc.[14]

Mahalanobis assumed that all four sectors had independent output-capital and labor-output ratios. These were symbolized by β_1, β_2, β_3, β_4, θ_1, θ_2, θ_3 and θ_4 respectively. He assumed a given total of investment. The problem was to allocate the total between the sectors in such a way that specified increases in income (ΔY) and in employment (ΔN) were reached. The policy variables were the shares of investment going to each sector, denoted by λ_1, λ_2, λ_3 and λ_4.

The model was determined, of course, only if one of the three independent λ's (the policy instruments) was exogenously determined, since there were only two objectives: ΔY and ΔN. With the λ for the capital goods sector given a pre-assigned value (the reason for which was never spelled out clearly) the system was solved by Mahalanobis to assign investments among the three remaining sectors. However, as Komiya [78] pointedly noted, the Mahalanobis solution was inefficient, in that it was situated in the interior of the feasibility locus between incremental output and incremental employment. Thus, greater employment and/or output could have been obtained by merely reallocating the given investments among the three sectors, although such a solution would not assign a positive fraction of investment to every sector.

The very fact that a simple linear programming exercise by an outsider could show the inefficiency of the Mahalanobis allocations, in conjunction with the fact that Mahalanobis did not use this technique even though the planners at his Indian Statistical Institute were certainly not lacking in knowledge of these elementary techniques,[15] indicates that the four-sector model was essentially produced to impart (unsuccessfully, as it turned out) intellectual respectability to investment allocations arrived at on other, unspecified considerations. This conclusion seems also warranted by the fact that the statistical source of the parameters (relating to labor-output and capital-output ratios) was not spelled out. Nor was any attempt made to reconcile the model with the real facts of the situation, especially the presence of foreign trade.

The very limitations of the Mahalanobis two-sector and four-sector models pointed to the need for a more extensive, multi-sectoral and multi-period model for more efficient resolution of the choice problems facing the Indian economy. Such models were to be constructed during the Third Plan period and we shall go on to discuss them. However, it is pertinent to mention here an alternative approach to Indian planning, rival to that of Mahalanobis, which was put forward at the time of the Second Plan formulation by P. R. Brahmanand and C. N. Vakil [19].

Their approach constitutes in some ways the polar opposite of the position taken by Mahalanobis. While the latter's whole emphasis was on the role of fixed capital, Vakil and Brahmanand's entire emphasis was on the role of wage goods as

[14] The entire economy was supposed to be divided into these four sectors.

[15] The Indian Statistical Institute is internationally renowned for its contributions to mathematical statistics and its distinguished Faculty which currently includes two Fellows of the Royal Society in this subject. Besides, they had the benefit of visits, at the time, by Richard Goodwin, Jan Tinbergen, Ragnar Frisch and Oskar Lange.

capital. This approach was therefore related to the Marxian concept of variable capital, since in common with Marx they assumed that the wages were paid as advances in the beginning of the production period. However, the operational part of this approach was derived from the assumption that there existed massive overpopulation in agriculture. They did not subject the concept of disguised unemployment in agriculture to any critical investigation, nor did they try to measure the extent of such disguised unemployment in the Indian context. They were following the tradition set by P. N. Rosenstein-Rodan and R. Nurkse in taking it as obvious that a massive reserve army of labor existed in rural areas.[16] Further they assumed, as Nurkse did, that the disguised unemployed must possess considerable savings potential since labor could be transferred from agriculture without lowering production and kept at work producing real capital goods by the payment of wages consisting exclusively of food.

Several assumptions were made by Vakil and Brahmanand to formalize their system. First, the wage good was assumed to be exclusively food. Second, it was assumed that labor could produce capital goods without the assistance of other factors of production. Thirdly, they assumed that a mechanism existed by which average consumption on the farm could be kept constant subsequent to the transfer of labor, and the transferred labor's consumption on the farm be siphoned off to feed it while it was engaged in producing capital goods. To be sure, they recognized the possibility of leakage in this connection. They assumed that the whole of the hypothetical surplus might not be procurable and further that there might be a need to provide for slightly higher consumption levels than in agriculture to workers engaged in construction. Thus they derived a "multiplier" formula in which the multiplicand was an autonomous increase in the stock of wage goods in the hands of the planning agency.[17]

However, they did not pay any attention to the possibility that the production process may not be of the simple Austrian type that they had assumed: labor→capital goods→consumer goods. If the facts of life dictated a circular model of the sort analyzed by Marx (in the second volume of *Das Kapital*) and more recently by Leontief and others, the mere availability of labor alone would not solve the problem of greater capital formation. Extra capital equipment would be needed and would need to be either produced at home or imported, hence raising the complex of issues raised earlier in connection with the Mahalanobis model. As regards the composition of wage goods, if nonfood items were necessary and if there were no corresponding excess capacity in the domestic consumer goods industries, then once again the creation of extra capacity and its synchronization with the deployment of extra labor would be involved, thus necessitating a more elaborate approach.

[16] The early writings of Brahmanand [18] in fact anticipated the notion of disguised unemployment, although the concept was not fully developed. Brahmanand's interest in this question had arisen from a general examination he was undertaking of the applicability of the Keynesian theory to the economic situation in India. In this connection, V. K. R. V. Rao's [143] analysis of the Keynesian multiplier in the Indian situation is also of interest.

[17] The Vakil-Brahmanand approach could be readily used to provide a rationale for the policy of importing food as a means to step up capital formation and generate extra employment. It is interesting that these authors did not make any effort to link up their analysis directly with the question of food aid. Although such an approach was implicit in the early work of Dandekar [27] and others, it was only much later that Chakravarty and Rosenstein-Rodan [26] tried to develop the logic of food aid somewhat more fully in an analysis which was considerably influenced by a model similar to that provided by an economy with massive rural overpopulation.

The social welfare function implicit in Vakil and Brahmanand's approach to planning was novel at the time: they were emphasizing the need to minimize the time needed to reach full employment. Whether such an objective constitutes an adequate social welfare function is very doubtful;[18] but that it is an objective which needs very careful consideration is beyond doubt. Mahalanobis' model, at least in its formal aspects, had paid no attention to this.

Despite its limitations, Vakil and Brahmanand's attempts to build an analytical scheme which tried to tackle the problem posed by disguised unemployment in agriculture deserve emphasis.[19] In discussions subsequent to the formulation of the Second Plan, the wage goods approach has not figured prominently. Amongst eminent economists, Gadgil [55] has been the only one to draw pointed attention to the importance of mobilizing rural labor to build social overhead capital, which he did as late as 1961. In more attenuated forms, however, this aspect of the planning problem is still alive.

The Third Five-Year Plan

The Third Plan was not entirely pioneering in its attempted utilization of multi-sector balances to achieve consistency. Quite aside from Ragnar Frisch's suggestions in this respect [54], Jan Sandee [150] had actually constructed a simple linear programming model during his visit to the Indian Statistical Institute during 1957/1958, which was used to maximize aggregate consumption in a terminal year (1970) as an excess of consumption over a base year (1960), subject to maintaining intersectoral consistency conditions and feasibility conditions on the side of the balance of payments.

While the Sandee model was essentially a straightforward, *static* linear programming exercise, it had one analytically important feature which deserves special mention. This relates to his treatment of investment in the terminal year. If this year were taken really to be the terminal year of the Plan, then clearly there is no justification for having any investment at all in that year (assuming, of course, that all investments fructify beyond the one year horizon). Since no planner ever takes such a myopic point of view, it is necessary to elaborate a rationale for introducing investment activity in single-period optimization models. One can theoretically conceive of several procedures which can be used for this purpose. Sandee's procedure was to assume that, over the decade of 1960–70, investment flows should increase linearly every year. We may spell this out.

Let us denote the year 1960 by '0' and the year 1970 by T. Then the cumulated investment over the period is given by

$$\int_0^T I(t)dt.$$

Sandee assumed $I(t)=a+bt$. Then we have

$$\int_0^T (a+bt)dt = aT + \tfrac{1}{2}bT^2.$$

The proportion of total investment that must take place in the T-th year out of the total over the entire T year period is given by $a+bT/aT+\frac{1}{2}bT^2$. Now applying this factor to the investment demand for the product of the i-th sector induced by output increase in 1970 over 1960, which equals

$$\sum_j b_{ij}\Delta X_j,$$

we get the estimate for investment of the i-th type for the year for every i. Hence the vector of goods to be delivered on the investment account in the terminal year is determined. Intersectoral deliveries on the

[18] See Chakravarty [23] on this issue.

[19] On the question *whether* disguised unemployment exists, we survey the Indian literature in Section II.

current account, together with the balance of payments considerations, must be included. Sandee, then, proceeded to maximize consumption in 1970 subject to obeying a lower limit on total investment summed over all the sectors and a few other inequality constraints.[20]

The work underlying the Third Plan was nowhere as explicitly set out as in Sandee's exercise, although balances of supply and demand at a detailed sectoral level were set out. Reddaway [145], who was associated with the Perspective Planning Division of the Indian Planning Commission,[21] undertook a systematic supply–demand balance exercise, for many industries, essentially putting together different target outputs, imports and demands to test for simple consistency for the year 1965–66, the terminal year of the Third Plan. If this exercise were construed as constituting simple, *ad hoc* checks on targets supplied to Reddaway by the Perspective Planning Division (PPD) it was valuable. But construed as an attempt at devising a full–fledged Third Plan, with only partial targets of production supplied by the PPD, the exercise was less satisfactory even within the framework of testing for consistency (as distinct from optimality). This was pointed out by Padma Desai [42] who, on attempting to formalize the Reddaway exercise, found it underdetermined despite efforts at discovering (from Reddaway's work) ways in which the model might have been intended to be closed.[22] The problem clearly arose from Reddaway's omission to state his model, if any, in formal terms. It therefore throws into focus the need for stating carefully the model underlying the investment allocations and related decisions, quite aside from the theoretical elegance and scrutiny of otherwise vague assumptions that such a procedure would entail.

In fact, during the Third Plan period itself, many economists such as Alan Manne, Ashok Rudra, Sukhamoy Chakravarty, Richard Eckaus, Louis Lefeber and Kirit Parikh, turned to precisely this kind of work in connection primarily with the Fourth Plan: whereas Manne and Rudra were to build static, multi–sector consistency models, the Chakravarty–Eckaus–Lefeber–Parikh exercises were to be concerned with explicitly dynamic, multi–sector models.[23]

Before we discuss either of these two developments, both of which marked improvements over the earlier computational models of planning, we should note that the Third Plan not only marked a shift to examination of consistency at the inter–sectoral level but also incorporated some fresh, though embryonic, analytical thinking. The notion that foreign trade might be the bottleneck to increasing the rate of investment had come more sharply into focus, instead of being the implicit premise of a Mahalanobis type of investment strategy.[24] Thus, significantly more than

[20] It may be noted that, as Sandee assumed that the balance of payments in 1970 would be such as to require no import surplus, he could pay no attention to any parametric variation in foreign aid availability, a question which has been repeatedly posed by many model builders in India since then.

[21] Reddaway was on the M.I.T. Center for International Studies Program, under which several distinguished economists were associated with the Planning Commission's work. P. N. Rosenstein–Rodan and Max Millikan headed this program, which brought to India numerous economists including I. M. D. Little, Trevor Swan, Arnold Harberger, Louis Lefeber, J. Mirrlees, Richard Eckaus, and Sir Donald MacDougall.

[22] See the interchange between Padma Desai and Reddaway [146] on this issue.

[23] As it eventually turned out, the Fourth Plan was deferred by three years, largely thanks to the dislocation of aid flows following the Indo–Pakistani war of late 1965 and two unprecedented agricultural droughts in 1965–66 and 1966–67 which, in turn, led to a recession in industrial investments. The planning exercises, which had not anticipated these major disturbances, turned out to be irrelevant to the immediate situation. Whether, however, the Fourth Plan should have been postponed in consequence is a matter on which there has been much debate.

[24] This view was, at least partly, a reflection of the stagnation in India's export earnings during the decade

with the Second Plan, the investment decisions in the Third Plan were taken with an explicit attention to the role of foreign aid in breaking this bottleneck and the possible desirability of "using aid to end aid," and reach self-sustained growth at some foreseeable future date. To put it differently, the Third Plan investments, which continued the shift to the heavy industrial sector, were taken against the notion that foreign aid would enable the economy, by permitting these investments, to cross over the hump (posed by the foreign trade constraints) from a low growth rate equilibrium to a high growth rate equilibrium. This precise view was to be the basis of more formal exercises by Manne and Bergsman [100] in connection with the Fourth Plan work.

Models for the Fourth Plan

Among the detailed, *static* exercises attempted during the work on the Fourth Plan was that by Manne and Rudra [101], who were both working in collaboration with the PPD (which had put out its own "bluebook" of projections based on similar thinking).

Although their exercise was of the standard type, and related to the consistency of the terminal year of the Fourth Plan, there were certain interesting features. For example, they followed Sandee in attempting to give a rationale for investment activity in the terminal year. However, unlike Sandee, they assumed that investment would rise exponentially over the intervening years and hence the proportion of investment to be completed in the terminal year was given by

$$\gamma = \frac{e^{rT}}{\frac{1}{r}\left[e^{rT} - 1\right]} = \frac{r}{1 - e^{-rT}} \tag{16}$$

This proportion "γ" was called by them the stock–flow conversion factor. Having done this, they took the consumption vector to be given and tried to find out the gross production vector that would be needed if all the end use activities were to be satisfied at given levels, subject to the assumption of a stipulated stock flow conversion factor. Their procedure may be summarized as follows.

Let $\hat{x}$ stand for the vector of production levels in 1970 and x^0 for the vector of production levels in 1960. Then we get

$$\hat{x}_i + M_i = \sum a_{ij}\hat{x}_j + F_i + \gamma \sum b_{ij}(\hat{x}_j - \overset{0}{x}_j) \tag{17}$$

where M stands for imports, F for final demand and a_{ij} and b_{ij} are the standard current input–output and capital coefficients respectively. If M were written as $[m]\hat{x}$ where $[m]$ is a diagonal matrix of import coefficients, then we may write the solution of the above as:[25]

$$\hat{x} = (I + m - A - `\gamma' B)^{-1}[F - \gamma B x^0] \tag{18}$$

where I is the unit matrix.

Since Manne and Rudra were concerned with constructing a terminal year model for the Indian economy, they did not specify in a complete way the path the economy was to follow from a given initial

1951–1960, which made the hypothesis of a foreign exchange bottleneck to Indian development seem much more plausible. Manmohan Singh [163] was later to show that this stagnation was largely a result of domestic policies, although demand factors would have constrained significant expansion of export earnings.

[25] It is clear that the choice of 'γ' cannot be completely unrestricted. It must satisfy an upper bound restriction if $(I+m-A-\gamma B)^{-1}$ is to be non negative. From the theorems on non negative square matrices we know that this would be the case provided m were sufficiently small so that $(A+\gamma B-m)$ is non negative, and $1>r_0$ where r_0 is the Frobenius root of the matrix $(A+\gamma B-M)$. A sufficient condition for this to hold is that $\max_j \Sigma_i(m_{ij}+a_{ij}+rb_{ij})<1$ for any suitable choice of units. Hence, given the coefficients of production, the capital coefficients and a given pattern of competitive import demand, γ must have at least an upper bound.

point to the terminal configuration. Thus this model may be said to give a perspective rather than a plan. However, the construction of a terminal configuration is an essential ingredient in any finite horizon planning model so that the Manne–Rudra model did provide some guidelines for the planner, even though it did not specify a complete time phased course of action.

Models which give some guidelines regarding the phasing of investment can be usefully divided into two categories.[26] One of these categories may be described as giving us intertemporally consistent planning models. The other category, somewhat more ambitious in scope, deals with optimization over time, and has been experimented with by Chakravarty, Eckaus, Lefeber and Parikh.

Chakravarty and Eckaus [24] first outlined the logic of an intertemporally consistent multisectoral planning model and pointed out the basic difficulties. They did not, however, compute numerical growth paths. It is of some analytical interest to give a brief summary of their arguments.

For the sake of simplicity, let us ignore temporarily all the non-homogeneous elements of a Leontief dynamic system other than consumption. Then, we have a dynamic system characterized by the following equation:

$$X(t) = AX(t) + B\dot{X}(t) + C(t) \tag{19}$$

where $X(t)$ stands for the vector of output levels, $\dot{X}(t)$ for its rate of change, $C(t)$ for the vector of final consumption, and A and B are the standard Leontief matrices. The complete solution of the dynamic system assuming $C(t)$ to be growing exponentially over time is given,[27] using the notation of a matrix exponential, by the following expression:

$$\begin{aligned} X(t) = {}_e[B^{-1}(I - A)^{+}] \\ + (I - A - rB)^{-1}Ce^{rt} \end{aligned} \tag{20}$$

where P is a vector of arbitrary constants and C represents exogenous levels of consumption to be determined through policy considerations. The advantage of using this matrix exponential notation is that it shows the analogy with the ordinary scalar case involving one variable quite explicitly.

The above equation holds provided B has an inverse, a condition which is often not satisfied. The solution for more general time paths of $C(t)$ may also be worked out, either in an analytical form or through numerical approximations.

Now if $X(0)$ and $X(T)$ are both given, in the first case from history and in the second case from the planner's specifications, then we have $2n$ equations to determine the unknown P and C's. This is the logic of the consistency models. However, difficulty arises in so far as the matrix

[26] The Mahalanobis model, through possibilities of variation in the choice of λ_k, was also in principle capable of generating alternative time phased programs. The Mahalanobis model was further elaborated, by disaggregation with respect to intermediate goods (where the Mahalanobis model had been vertically integrated) and via the explicit assumption that capital goods producing the consumer (and intermediate) goods could not be shifted to producing capital goods (which *in any case* was implicit in the Mahalanobis model and indeed provided its basic economic rationale). This was done by Raj and Sen [140]. They produced a number of illustrative time paths whose value consisted in reemphasizing that an intertemporal choice had to be made, although no attempt was made by them to indicate how this might be done. Besides their model, while set in the context of an open economy, ignored the possibilities of trade offs between domestic production and imports for supplying any given bundle of goods at a point of time, as pointed out by Bhagwati [6]. For other comments, see Prasad [129].

Mention should also be made of a more novel, exploratory paper by P. N. Mathur [109] which gave a computational, time-phased solution to investment allocation decisions. Mathur, writing in 1962, explored the consequences of transforming an initial technological matrix for the Indian economy into technology of the U. S. type within a specified planning horizon. He used a linear programming formulation to discriminate between alternative transformation paths.

[27] See the article by S. Chakravarty and R. S. Eckaus [24].

$B^{-1}(I-A)$ may not be well behaved: thus there is no guarantee that the dynamic system which is governed by the matrix will ensure nonnegativity of the relevant variables over time. Hence, one cannot be sure that consistency necessarily implies viability. On the other hand, one could also work recursively backwards from an assumed terminal condition by using the finite difference version of Leontief's structural equations. The advantage of this procedure is that it would not require the B-matrix to be invertible. However, in all probability, we would fail to tally exactly with the initial conditions. If the magnitude of the difference between the historically given initial situation and the desired initial situation (thus worked out) was not large, then one could argue that the model provided some sort of a time-phased plan. But there is no a priori guarantee that the difference would not be significant; nor can we assume that the deviations would be found only in the sectors producing 'tradeables,' and hence be remediable by international trade.

Unlike the procedure discussed by Chakravarty and Eckaus, Manne and Bergsman [100] used a different method which gave what they called an "almost consistent model." In working out this almost consistent model, they did not rely on the complete solution of the non-homogeneous dynamic Leontief system. They computed a set of terminal output levels of $X(T)$ based on the need to reach specified levels of final consumption in the year T and to sustain growth in gross output at specified levels beyond the horizon T. This part of the exercise was therefore based on different assumptions from those underlying the determination of terminal investment levels used by the other models. Once $X(T)$ was determined, Bergsman and Manne obtained the timepath of $X(t)$ starting from $X(0)$, by log linear interpolation. Hence they had a unique planned output trajectory $X(t)$. As for the demand side, the timepath of final demand for year 0 to T was assumed to be given exogenously. But induced investment in both fixed capital and inventories was determined by planned output increases. Now, if we denote the planned requirements trajectories over time by $D(t)$, clearly $X(t) \neq D(t)$ for every t (and for every industry). Such differences were to be met by so-called "shock absorbers." These shock absorbers were either imports of producer's goods, or changes in projected consumption of food and fabrics and the domestic output of service sectors. Since construction, which was treated as a domestic service, turned out to be too severe a bottleneck for the initial year, they called their model an almost-consistent model.

The planning model first developed by Chakravarty, Eckaus, Lefeber and Parikh and later extended by Eckaus and Parikh [51], and hereafter described as the "CELP model," was formally the most detailed of all the models so far developed in the context of Indian planning.[28] This is not to suggest that it was completely adequate for the purpose of generating development plans for the Indian economy. But within the limitation of a linear model, the structure had sufficient flexibility to handle a number of important planning questions.

The model constructed by the above authors is best described as a finite horizon, linear optimization model involving explicit intersectoral and intertemporal relationships, which satisfies boundary conditions relating to the initial year as well as to the terminal year of the plan. This description indicates that the CELP model formally subsumed the structural features of the preceding models. In addition it provided an intertemporally optimal path of development which brought the economy from the initial situation to the

[28] This model has been described and discussed by Eckaus [49] and by Chakravarty and Lefeber [25].

desired terminal situation. It also distinguished between investment starts, investment in execution and completed investment.

The linear maximand used in the CELP model was the discounted sum of consumption over a five year period. The relative rate of discount over time was assumed to be constant to avoid 'regret' phenomena of the type discussed in the theoretical literature by Robert Strotz [167]. Consumption in each period was assumed to be of constant composition. In other words, there was no substitution allowed between the different items of consumption in one single period. This is an assumption of the Leontief variety on the side of consumption. These assumptions could be formally stated as follows:

$$(21) \qquad \text{Maximize } \sum_{t=1}^{T} W(t)C(t)$$

where $W(t)=(1+r)^{-t}$ and $[c]\ C(t) \leqq F(t)$ where $[c]$ is a diagonal matrix of proportional consumption coefficients with $\sum c_i = 1$. Clearly, r is the social rate of time discount whereas $F(t)$ is the vector of sectoral outputs designated for consumption. The authors expressed their unhappiness over their extremely rigid assumption with respect to consumption but justified their procedure on the ground that, for an economy such as India, the low level of per capita income did lend some credibility to the assumption of a fixed composition consumption basket.[29]

To make sure that consumption did not fluctuate from period to period, a linear model such as this required an explicit monotonicity constraint: $C(t+1) \geq C(t)(1+n)$ where 'n' is a predetermined growth rate. Further, consumption in year 1, denoted by $C(1)$, was assumed to be greater than $\bar{C}(1)$, a predetermined amount. On the side of the structural relations, the CELP model specified interindustry relationships both on the current and on the capital account. The model differed from the traditional treatment on the side of capital formation by introducing a gestation lag of 3 years coupled with the assumption of an exogenous pattern of investment buildup. The model permitted the authors to assume that the pattern of buildup in investment was either uniform or different between sectors. These restrictions on the structure of the economy were described by the following set of relationships:

$$(22) \qquad AX(t) + F(t) + N(t) + H(t) + G(t) + E(t) - M(t) - X(t) \leqq 0.$$

$F(t)$, $N(t)$, $H(t)$, $G(t)$ were vectors of consumption, capital accumulation, inventory accumulation and governmental expenditure respectively. $E(t)$ was the vector of export levels and $M(t)$ was the vector of import levels.

With regard to capital formation the CELP model used the following set of relationships:

$$(23) \qquad bX(t) - K(t) \leq 0, \quad \text{where } [b] = \begin{bmatrix} b_1 & & \\ & b_2 & \\ & & b_n \end{bmatrix}$$

a diagonal matrix of sectoral capital-output ratios.

$$(24) \qquad K(t) - K(t-1) - Z(t) + R(t-1) \leqq 0$$

$$(25) \qquad q^k Z(t) = I^t(t-k); \quad \sum_k q^k = 1, \qquad k = 1, 2, 3.$$

$$(26) \qquad \sum_k p_{ij}^k I_j^{t+k}(t) - N_{ij}(t) = 0; \quad \sum_j N_{ij}(t) = N_i(t).$$

[29] Clearly the assumption of a fixed-consumption pattern, in turn, implies the CELP model assumed identical, constant returns to scale tastes for each individual, thus ruling out explicit consideration of the qvestion of the effects of changes in income distribution on consumption patterns.

Equation (23) states that total demand for fixed capital must be less than the capital stock currently available. Equation (24) states the balance relationship for net capital formation. $Z(t)$ is gross new capacity available in 't' and $R(t-1)$ shows the replacement requirements computed on any reasonable basis. Equations (25) and (26) describe certain structural aspects of the process of capacity creation. These consist of the assumption that additions to capacity consist of the blending of different sectoral outputs according to given proportions and at given moments of time. In other words, capacity additions are produced by outputs devoted to capital formation with a distributed lag structure. A well defined part of the intended capacity increase must be completed at $t-3$, $t-2$, $t-1$ periods in order to have the desired capacity increase available at period t.

If q^k denotes the proportion of total capacity increase that must be completed k periods in advance ($k=1, 2, 3$), then in order to have a unit of capacity increase in t, $I^t(t-k)$ must represent that part of $Z(t)$ that has to be completed in period $(t-k)$. This is shown by the equation (25)

$$q^k Z(t) = I^t(t-k); \quad \sum_k q^k = 1, \quad k = 1, 2, 3.$$

The lagged investment components $I^t(t-k)$ have their fixed coefficient production functions, one for each lagged period. In any one time period t, a given sector is going to contribute inputs for producing $I_j^{t+1}(t)$, $I_j^{t+2}(t)$ and $I_j^{t+3}(t)$. These inputs at time 't' are additive whether or not they are provided for capacity intended for $t+1$, $t+2$ or $t+3$. When summed, they make up the sector's contribution to gross investment in t. This is described in equation (26) where p_{ij}^k is the fixed production coefficient. Thus,

$$\text{(27)} \qquad \sum p_{ij}^k I_j^{t+k}(t) - N_{ij}(t) = 0$$

$$\text{(28)} \qquad \sum_j N_{ij}(t) = N_i(t).$$

In addition to capacity formation, there is also the equation for inventory accumulation, which is indicated by the following equation:

$$\text{(29)} \qquad H(t) = S[X(t+1) - X(t)]$$

where $S=[S_{ij}]$ is the diagonal matrix of inventory requirements.

Foreign trade problems were introduced in the model in a "complete" way, but not necessarily in a very satisfactory way. Export demand levels were assumed to be given exogenously. Hence no optimization was introduced there. Imports were divided into two categories: competitive imports and noncompetitive imports. Noncompetitive imports were related to sectoral production levels by fixed proportions. Competitive imports were related to the sectoral production levels through the device of import ceilings. Formally the competitive imports of the i-th type of commodity were given by the following inequality:

$$\text{(30)} \qquad M_i^2(t) \leqq m_i^2[FA(t) + \sum E_i(t) - \sum M_i^1(t)]$$

where $M_i^2(t)$ was competitive import of the i-th type at time 't', $FA(t)$ was the foreign aid availability at 't', $E_i(t)$ was exports of the i-th commodity at time 't', $M_i^1(t)$ was noncompetitive import into the i-th sector, m_i^2 was an import ceiling. This meant that, after deducting from the total amount of foreign exchange earned at time (t) the total bill of noncompetitive imports, no more than m_i^2 times the residual could be allocated for competitive imports of the i-th type. This device of handling competitive imports through introducing boundary relationships was important in avoiding a pattern of complete specialization to which a linear model would otherwise gravitate. Hence, despite the awkwardness of the procedure, it served an important purpose in view of the procedure of linear maximization adopted in the CELP model on the assumption that $\sum_i m_i^2 > 1$.

The manner in which the investment figures for the terminal year were derived in the CELP model was different from that employed by Sandee, or Manne and Rudra.[30] The CELP model brought the post plan future into focus in terms of investment in the terminal year. This had some conceptual advantage over the converse procedure used by the earlier authors in as much as the growth rates were applied to the terminal year consumption component directly rather than to investment figures. This is readily seen as follows. From the purely mathematical point of view, the terminal configuration is merely the sum of the particular solutions corresponding to the nonhomogeneous elements of an open dynamic Leontief model. If we write the sectoral balance equations in the compact vector matrix form, as

$$X = AX + B\dot{X} + C + E + G - M \tag{31}$$

where X is the vector of gross output level, C the vector of consumption, E the vector of exports, M the vector of imports and G the vector of government expenditure, then the sum of the particular solutions corresponding to C, E, M and G gives the terminal configuration. Investment is treated here completely endogenously, since we assume $I = B\dot{X}$. The complete solution to the nonhomogeneous part of the above differential equation is given by

$$\begin{aligned} X &= (I - A - rB)^{-1}Ce^{rt} \\ &\quad + (I - A - \lambda B)^{-1}Ee^{\lambda t} \\ &\quad + (I - A - \mu B)^{-1}Ge^{\mu t} \\ &\quad - (I - A - vB)^{-1}Me^{vt}. \end{aligned} \tag{32}$$

[30] This procedure has been used independently by Manne. Also see Frisch [53].

Here r, λ, μ, v are the growth rates of C, E, G and M respectively.

We should note that since the CELP model assumed a fixed consumption basket, only the scale of consumption of the composite good was left to be determined by the logic of the optimizing mechanism. The items for the terminal year such as exports, government expenditure and imports were exogenously determined. Given these exogenous items, $K(T)$, which stands for the terminal vector of capital stocks, was expressed in this model as a function $f(r; T)$ where f is a vector function of the vector of the post Plan growth rates 'r' and the length of the horizon T; 'f' was determined implicitly by the solution of the optimizing mechanism.

Given the information on post terminal growth rates, the length of the planning horizon, the initial conditions, the structural equations, and the inequalities on the side of competitive imports, the model could work out a complete time path for all the variables such as production, consumption, and investment levels. (The model can, of course, be analyzed from the dual angle, e.g., in terms of the shadow prices of the relevant scarce factors. These shadow prices are the optimal rentals of different types of equipment as well as the price of foreign exchange. It is interesting to note that the shadow price of foreign exchange was always positive in this model since imports could always be used to increase the value of the maximand.)

The model as developed by the above authors was the subject of a critical appraisal by Srinivasan [165]. Many of Srinivasan's criticisms[31] were directed at the degree of weight to be placed on the numerical solutions thrown up by the model in some preliminary runs as well as

[31] For these comments, which are of considerable relevance to an evaluation of the Third Plan targets, Srinivasan [165] should be consulted. We turn to these questions shortly.

on the comparability of the solution to the model with the actual Third Five-Year Plan figures. Srinivasan, however, raised a *conceptual* question of general importance. This question related to the way in which the terminal conditions were specified in the CELP model. This model had envisaged terminal conditions as a way of sustaining post terminal rates of growth of consumption, where the composition of consumption was given exogenously but the scale was left to be determined by the optimizing mechanism. There are two limitations to this procedure. In a model involving an infinity of time, no indefinitely sustainable growth rate can exceed the growth rate of the labor force. Further, the composition of consumption, which in this model was pegged till eternity, could be expected to change if, as planned, income levels were going up year by year. Srinivasan, therefore, expressed a preference for setting terminal conditions in a way which would maximize indefinitely sustainable consumption per capita. This, of course, is none other than the disaggregated version of the so-called golden rule of accumulation. The terminal capacity vector in this case would be a function of the rate of growth of the labor force, and the production relationships of the system. Coupled with the assumption of full employment and a given time horizon, this would give the planner a vector of absolute levels of capacity needed at the end of the planning period. The method of setting terminal conditions along the lines suggested by Srinivasan has both conceptual and policy determination merits, especially in the context of a country like India with a massive and rapidly growing population.

Since the original form of the above model was published, moreover, Eckaus and Parikh [51] have done further work within the framework of the CELP model. While the conceptual structure of the model used by Eckaus and Parikh is essentially the same as that of the CELP model, the introduction of longer time horizons and also of new techniques in the agricultural sector by Eckaus and Parikh constitute important improvements.

Having stated the formal properties of the CELP model, and argued for its superiority over earlier efforts at operational planning models in the country, we now proceed to comment further on the analysis of the CELP model, indicating the areas in which further research is necessary and thereby highlighting some additional limitations of the CELP approach. We then conclude our survey of Indian planning models and techniques by discussing the precise manner in which the experiments with the CELP model were actually designed to throw light upon the important policy questions which Indian planners were concerned with at the time.

Possibilities of Further Improvement in Model-Making. The first important improvement in designing computable planning models would be to relax the assumption of linearity by introducing a nonlinear maximand. This is because linear maximization problems over time are known to display the so-called "flip-flop" behavior in consumption and investment levels, which is certainly very awkward for realistic planning models. If this "flip-flop" behavior is then sought to be corrected through the imposition of additional constraints, the constraints become more important than the optimization procedure, and hence the problem is not really solved. In the context of a multisector, intertemporal maximand, it is necessary to distinguish between two types of nonlinearity. First, there is the possible nonlinearity of a one-period utility function involving different types of consumer goods. Such a utility function would be an improvement upon the fixed coefficients approach. Secondly, the aggregate utility function over time could be nonlinear bringing in considerations relating to the diminishing marginal utility of consumption as the consumption vector rises over time. Maximization of a nonlinear maximand however would raise many problems of a computational nature which may yet take time to solve but, with a Leontief type technology, the problem does not seem to be by any means hopeless.

Secondly, the foreign trade problem requires a more satisfactory treatment. Changing comparative advantage positions with respect to different commodities should be reflected more adequately in the structure of the model. On this point also, progress would require solving intricate questions of nonlinearity in somewhat the same way as in connection with the preceding objective.[32] However, in one respect, the nonlinearities relevant to an open economy would be somewhat more intractable to handle. These nonlinearities would arise when some learning phenomenon is operative or some other form of economies of scale is relevant, rendering the classical convexity property of the feasibility surface inapplicable. The programming problem in this context would then have a mixed integer form, for which no very suitable algorithm yet exists.

In addition to all these questions, we should also note that the structure of consumption and the techniques of production in the model are quite rigid and that this certainly restricts its empirical relevance. Further it may be valuable to introduce an explicit savings constraint, as political factors may impose a ceiling on the capacity to raise savings.

An additional feature which planning models devised specifically in the Indian context ought to take into account is the phenomenon of massive unemployment, disguised and open. No formal planning model developed in the Indian context *fully* takes into account the problem posed by such unemployment. The only way unemployment is reflected in these models is through the assumption that labor is free, thus enabling one to focus attention on scarce resources such as capital and foreign exchange. Since the clear implication of these models is that full employment can be reached only over a relatively long period of time, important questions arise regarding the way unemployment is to be handled in the intervening period. This not only raises problems of distributive justice, which are very considerable, but may also raise serious problems relating to economic efficiency if one remembers that, given suitable organizational efforts, unemployed labor may be put to creating extra social overhead capital, which would largely involve redistribution of aggregate consumption. We have noticed that this aspect of planning received considerable emphasis in the work of Vakil and Brahmanand which we discussed earlier. But we have also seen that the linkage between the deployment of labor in such labor intensive rural construction activities is not entirely independent of the decisions taken elsewhere in the economy with respect to the use of scarce resources including wage goods. This is because we do not have many cases in real life where labor can produce capital goods unassisted by capital goods, and further, there is no automatic mechanism through which potential savings of the agriculturists could be transferred into consumption of labor working on construction projects. Thus, there is always some linkage between labor used on social overhead projects and the pattern of industrial development that is envisaged. Thus, what is necessary is an

[32] On the problem of planning India's trade pattern within the context of linear one-period maximization models, one can refer to the thorough work done recently by T. E. Weisskopf. Weisskopf [175] does not consider the choice of export levels; instead he assumes these to be given.

explicit analysis of a planning model which would incorporate this important structural feature of the Indian economy and explore fully its implications. The models which have been developed so far, while they range considerably in their sophistication from simple to very elaborate constructs, have, however, been essentially concerned with the implications of the shortage of capital and foreign exchange, rather than with a full analysis of the abundance of one important factor of production, e.g. unskilled human labor.

Empirical Applications of the CELP Model. Despite these limitations, and essentially on an experimental basis, the CELP model was utilized to analyze certain important, policy questions.

Two essentially important problems were explored with the aid of the CELP model, which appeared contemporaneously with the execution of the Third Plan. (1) Suppose that the Third Plan terminal year (1965/66) capacity targets were accepted, and the initial conditions and structural coefficients also accepted as implicit in the Third Plan, was there a feasible timepath from the latter to the former? Further, aside from feasibility, was the implicit timephasing in the Third Plan "optimal" if the preference function involved a discounted sum of consumption over the five year period (1961/1966)? (2) Moreover, the CELP model was also used to generate an optimal timepath of investments and outputs, while replacing the exogenous terminal year capacity targets of the Third Plan and instead allowing endogenous determination of these targets via specification of the rates of post-terminal growth in different items of final demand. This latter trial run, therefore, raised the question of the optimality of the actual Third Plan in a more comprehensive manner.

The first set of questions was analyzed on the assumption that an annual aid flow of Rs.5000 million would be available through the Third Plan—an assumption shared by the actual Third Plan. Further, the targeted rate of growth of consumption was specified alternatively at $2\frac{1}{2}\%$ and 5% per annum; the rate of time discount was set at 10%. With these specifications and the structural coefficients assumed to be those implicit in the Third Plan, the actual Third Plan turned out to be feasible. However, it turned out that the *optimal* timepath solution for going from the initial to the terminal year capacity levels, under either assumption with respect to the growth of consumption,[33] required a lowering of consumption in the first year of the Third Plan as compared with the actual consumption that obtained in the year 1960/61 which preceded the Third Plan. Thus the crucial question on the feasibility side, if one were considering an optimal transition path from initial to terminal capacity levels (as defined in the Third Plan), was whether the planners were willing to be very austere in the beginning of the Third Plan. The optimal timephasing of the Third Plan, therefore, was not merely at variance with that implicit in the Plan itself[34] but, furthermore, it seemed unlikely to be feasible in practice.[35] Furthermore, quite aside from optimality, if the capital coefficients matrix used by CELP was indicative of the structural relationships in the Indian economy, then the investment figures in the Third Plan represented a serious underestimate.

The optimality exercise which allowed the terminal year targets to be endogenously determined, however (and which

[33] The difference between the two alternative growth rates with respect to consumption showed itself more in the derived figures for the first year consumption levels than in the maximum value achieved by the objective function over the planning period.

[34] Since the possibility of such a reduction in consumption in the first year was certainly not envisaged in the Plan document.

[35] It should be noted that varying the discount rate from 10% to 20% hardly changed the solution, especially with respect to the reduction in first year consumption

therefore envisaged the possibility of an investment allocation different from that in the Third Plan itself), threw up a solution which was considerably different from the official Third Plan. First, the total discounted sum of consumption was considerably higher. The average annual rate of growth of consumption was considerably higher than the figure officially assumed for the Third Plan. Furthermore, the major constraining factors in this modified growth process turned out to be the consumption goods sectors rather than the sectors producing capital goods. Such a striking dissimilarity between the optimizing planning model and the official Third Plan was the subject of extensive comments by CELP [25] and by Srinivasan [165]. Clearly several important factors were responsible for this difference. One was the assumption of a fixed-composition consumption basket which was heavily weighted in favor of food, the chief consumer good. Secondly, agriculture was treated in the model as some sort of a "bargain" sector with highly favorable capital-output ratios and relatively small requirements for flow inputs of industrial raw materials. Furthermore, the length of the gestation lag of three years, which involved a substantial amount of investment in the pipe line so far as the capital goods sectors were concerned, together with a horizon length of five years, also affected the numerical results substantially. In the subsequent exercises done by Eckaus and Parikh [51], most of these assumptions were modified; the revised results showed a narrowing of the difference between the CELP results and the official Third Plan allocations, although the difference continued.[36] We might note here that the CELP results, pointing to a shift in investment allocations away from the capital goods sectors to the consumer goods sectors (primarily agriculture) became available at the same time as the new Indian Prime Minister, Lal Bahadur Shastri, was expressing views to the same effect and recommending publicly a shift in investments and policy attention to the agricultural sector. In view of the practical importance, therefore, of the issues raised by the CELP work, there ensued a lively debate. As it happened, the shift towards the agricultural sector was to come largely as a result of two successive droughts during 1965/66 and 1966/67,[37] which underlined the inadequate growth of agricultural output in relation to the growth of population and income, the consequent reliance of the economy on P. L. 480 imports and the necessity to push more systematically on the agricultural front. Further, the relative investments in the capital goods sector were to slacken off during this period (and until the moment of writing this Survey) owing to the significant decline in the availability of project aid for fresh projects and the slow completion of those in execution, and also the fact that the governmental investments were constrained by the shortage of wage goods owing to the two successive droughts.

Having discussed the general area of planning theory and techniques,[38] and analyzed the interplay between planning models and actual planning within the country, we now proceed to two related

[36] For further points on this difference, including the possibility that the official Third Plan might have had a different objective function implicit in its targeted allocations (even though no evidence of explicit and coherent argument on this question could be found in the Plan document) and that the Third Plan might after all make sense in terms thereof, see the original papers by Chakravarty and Lefeber [25] and Srinivasan [165].

[37] The resulting economic difficulties were to be accentuated by the Indo-Pakistani war of late 1965 and the concurrent stoppage of aid.

[38] By way of completion, we may also refer to the very recent work of Alan Manne and T. Weisskopf [102] which represents a dynamic, intersectoral model for India, 1967–1975, and is an extension of the CELP type research. Also, we should refer to two papers of interest, by A. Ghosh [58] and K. N. Raj [134], which survey the literature on Indian input-output research and planning models from different points of view.

questions that have led to extended discussion in India and have produced ideas of interest. These relate to (1) the choice of techniques and evaluation of investment projects, and (2) the issues of "financial" versus "physical" planning, "Keynesian" versus "quantity theory" approaches to planning without inflation, short term planning and spatial planning.

Choice of Techniques and Investment Criteria

The question of the choice of appropriate technology has been extensively discussed in India. The debate grew out of the preoccupation of Gandhians with the protection of traditional modes of production such as handweaving and home spinning in the cotton textiles industry (from elimination by competition in the market from modern techniques).[39] Much of the debate on this issue occurred concurrently with the formulation of the Second Plan. With its emphasis on the buildup of the capital goods sector, and also its concession to the demands for protecting the traditional forms of production, the Second Plan represented a curious blend of Soviet and Gandhian economic philosophies—consistent with the reputed Indian genius for reconciling the irreconcilables!

The economic discussion of the issue was largely centered around comparisons among three alternative techniques of weaving, representing different degrees of mechanization.[40] Raj [130, 131] whose pioneering discussion of this question was to prove fruitful, attempted to show that the rate of return on capital invested in any technique, if the capitalist rules of the game were followed, might not give a 'true' indication of the social rate of return on capital. He obviously had in mind the argument, earlier raised by Tinbergen [170] and others outside India, regarding the possible differences between 'accounting prices' and market prices in many underdeveloped economies. Raj also wanted to take into account the dole to be paid to the unemployed as a part of the cost of using the more mechanized technique, and to include the cost of social overhead involved in setting up highly mechanized new units, which could be largely avoided by sticking to more traditional techniques.

Raj's paper, which was published in the *Economic Weekly*,[41] generated an extensive debate in that journal, with both Indian and foreign economists participating therein.[42] The main thrust of the controversy that followed related to the question of how labor cost should be evaluated from a social point of view. The answer to this question turned, quite naturally, on how the social objective before the planner was defined. If, as Sen [153] noted, the objective was to maximize current output, "surplus" labor was "free" in terms of opportunity cost. If, however, the objective was to maximize the rate of growth of output, then the wage bill represented a

[39] Indeed, economic policy was to be deeply influenced by such political thinking, supported at times by economic argument. See Manmohan Singh [163] on this question, in the context of its impact on India's export performance in cotton textiles. As we will note later in the text, the Indian economic discussions ignored the effects on foreign trade, via quality effects, although these appear to have been empirically quite significant.

[40] We may also note here the interesting work of Dhar and Lydall [45] and Lakdawala and Sandesara [88] on the economics of small scale industries, which explored the problem of choice of technique, in this context, in a systematic manner.

[41] *The Economic Weekly*, now continuing as *The Economic and Political Weekly*, has occupied a unique place in Indian economic journalism. Founded and edited by Sachin Chaudhari, it has served as an outlet for tentative, economic ideas for many economists in the country, and with its semi-academic nature, it has helped to focus attention on many of the interesting problems facing the country. Among its contributors can be counted practically all the major economists, sociologists and political scientists in the country.

[42] Among the Indian economists in the debate were Ashok Rudra [149], Ajit Biswas [16, 17] and A. K. Sen [155]; the foreign economists were Joan Robinson [147], Charles Bettelheim [3] and Jan Tinbergen [171]. There were also several other contributors: [59].

social cost—provided we could assume that wages would be spent and would thus represent incremental consumption.[43]

However, the following comments on this position are warranted. (1) The conflict between current output and the rate of growth of output arises from the implicit assumption that the rate of savings is a function of the choice of technique and cannot be varied by fiscal policy to desired levels.[44] (2) Furthermore, from a policy point of view, we would have to assume that the government has adequate control machinery for fully regulating the choice of technique but not for varying the savings rate to any desired extent. (3) The argument that the wage bill represents the social cost of consumption must also be modified, as Raj had already noted, by the saving in consumption, if any, in the sector from which the labor "emerged." (4) Also, the formulation of the two objectives, maximization of current income and maximization of the rate of growth, involves juxtaposing two extreme forms of social preferences. The problem could instead be posed, following Ramsey, as one involving the evaluation of the entire streams of consumption associated with the choice of alternative techniques. This is, in fact, how Sen [156] proceeded later to look at the problem although his formal analysis emphasized the possibility of alternative timepaths and the necessity to choose therefrom, rather than formal optimization procedures.[45]

Furthermore, in the attempted application of these ideas to empirical problems such as the choice of technique in weaving, two major defects were evident. (1) The fact that alternative techniques may have different impacts on quality, and hence also on export performance, was not seriously considered. (2) Moreover, while computations of "reinvestable" surplus were made for each technique, it was forgotten that similar computations would have to be made all the way "backwards" to get a complete answer: the reinvestable surplus may be higher in technique A than in technique B if we take only the final stage of production into consideration, but the ranking may reverse if *both* direct and indirect reinvestable surpluses were taken into account.[46]

Finally, if we are to evaluate the entire debate as conducted at the time, it is indeed surprising that while the "true cost" of labor came in for a good deal of discussion, the associated concept of the "true cost" of capital did not figure much in the Indian discussion. It was, of course, mentioned from time to time that the market rate of interest did not reflect the true scarcity of 'capital' but it was not quite clear what was meant by such an expression. Some people argued that the current rate of return on capital invested by the companies for which balance sheet data were available constituted the index of scarcity of capital. But there were two difficulties in this case, one due to the unreliability of the estimate of capital as measured by the information given on bookvalues, and the other due to the difference that would normally exist between the average return and the marginal return. However, the question remains as to the relevance of the return on the capital even when one is referring to the marginal return.[47] Such a marginal rate of re-

[43] Little [93], writing independently later, formalized the arguments relating to the "real cost" of labor in the context of well defined models.

[44] This point was strikingly made in the early paper by F. Bator [2] on the subject of choice of techniques.

[45] Sen indicated however the resolution of this choice by maximizing the sum of consumption over a finite planning horizon: this would, however, amount to assuming implcitily a constant marginal utility of consumption. Subsequent attempts at dealing with this class of questions have recently been made by Dixit [46] and Marglin [104]

[46] The fallacy consisted in carrying over an argument, worked out at the macro level, to the evaluation of a micro industry.

[47] For an empirical attempt at estimating such a marginal return, see Eckaus and Lefeber [50].

turn would be an appropriate interest rate for discounting future benefits only insofar as we could assume that the capital market was perfect and hence society was equating the marginal rate of return on cost (in the Fisherian sense) with the marginal rate of substitution between consumption at two consecutive time points. In the absence of such assumptions being satisfied, the appropriate social rate of discount would diverge from the marginal rate of return, the degree of divergence depending upon what time profile of consumption is regarded as optimal by society.[48]

From the foregoing survey, it is clear that the Indian discussion of the choice of techniques was concerned primarily with the selection of an appropriate social rate of return on a unit of invested capital.[49] This problem came to be directly confronted eventually in connection with the cost/benefit analysis of the multi-purpose river valley projects, to which many economists turned their attention.

It would be tedious to attempt a detailed survey of all the studies; besides, their conceptual framework is largely identical. Hence we concentrate on three major analyses of investment projects, to illustrate the full range of methodological issues that were raised in the Indian context. These were the work of K. N. Raj [133] who dealt with some aspects of the Bhakra–Nangal project in the Panjab, of N. V. Sovani and N. Rath [164] who examined the economics of the Hirakud dam, and of Paul Rosenstein–Rodan [148] who analyzed the economic worthwhileness of nuclear prower production in India.[50] Rosenstein–Rodan's analysis differed from that of Raj and Sovani–Rath, in having *preceded*, rather than followed, the execution of a project.[51]

Raj's analysis was particularly acute in its discussion of the employment aspects of the project, and of its spillover effects in the form of indirect demands for consumption. Among the interesting conclusions he reached was that labor could *not* be drawn away in unlimited amounts at a given real wage rate: more labor could be had only by incurring higher costs to secure the migration of labor from more distant areas. Raj also found that the marginal propensities to consume of labor which migrated to the project site and of labor which came daily from rural households were different, the former having shifted to superior grains. He further noted several areas where the project design had ignored possibilities of substituting labor for capital, thus resulting in unduly high capital and import intensity. The design of the power project also suffered from not taking into account the time and the location pattern of the demand for power which was likely to arise: as a result, substantial investment in transmission lines, among other things, was made which could have been saved by building cheaper sources of power supply.

While, however, the analysis made by Raj clearly indicated that the time factor

[48] In fact, the social rate of discount, the "true cost" of labor and the optimal rate of consumption are all interdependent elements in a single, intertemporal optimizing problem. Hence, it would be inappropriate also to go about setting up numerical values for these magnitudes in an unconnected fashion, as is sometimes done. In this connection see the recent work of Dixit [46] and Marglin [104].

[49] The notion that the shadow foreign exchange rate may be higher than the parity also became more prevalent in the later stages of the discussion, although it had been obscured or omitted from many early analyses, both theoretical and empirical.

[50] Rosenstein–Rodan's analysis was essentially a critique of an earlier memorandum, advocating nuclear power production in India, by Homi J Bhabha, the late Director of the Indian Atomic Energy Commission.

[51] Indeed, one of the major deficiencies in Indian planning has been an inadequate appreciation of the need to analyze critically the economics of major investment projects prior to their approval and execution; there are indications, however, of forthcoming change in this respect. There is also considerable interest now among economists in conducting such studies of industrial plants and projects.

was crucial in evaluating an investment project like the Bhakra Nangal, which locked up an enormous amount of resources over a very long future, he did not make any attempt to compute the present-value estimates of benefits or costs associated with the project. Raj's reluctance on this point was understandable in view of our inability to say anything numerically very firm as to the social rate of discount which could be used to convert benefits and costs accruing at different points of time to commensurable units. But even the use of alternative sets of notional estimates would have been worthwhile to indicate the different margins of choice which existed in designing and implementing the project.

The analysis of Sovani and Rath corresponded to the usual type of cost/benefit analysis. Instead of computing an overall present value, however, they computed an annual cost/benefit ratio on the assumption of a given constant interest rate and a given depreciation flow every year. The interest rate was assumed to be 10%, on grounds which were not spelled out. The relative abundance of labor as a factor in the project design was not discussed; nor were the indirect effects of the project examined. Instead the authors concentrated on computing intensively what they considered to be the direct benefits associated with greater irrigated facilities and greater availability of hydroelectric power. While the use of the apparatus of cost/benefit analysis was a welcome feature of their exercise, the assumptions made with regard to the estimation of benefits and costs were somewhat drastic and could be questioned.

The substantive issues raised by Rosenstein–Rodan, by contrast with the exercise of Raj and Sovani–Rath, included the question of the suitable rate of discount. His calculations, based on data partly supplied to him by Ian Little, showed that the estimated unit cost of electricity generation was highly sensitive to the choice of the discount rate, because the capital costs of setting up nuclear power plants are extremely high. Further, Rosenstein–Rodan raised an interesting question with respect to the social, as distinct from the market, cost of inputs such as coal, which is an exhaustible asset with a highly uneven geographical distribution in India (implying significant transportation costs). Moreover, if a nuclear power plant were to be built, it would have necessitated heavy imports in the early stages. Thus the scarcity value of foreign exchange had to be guessed if the official exchange rate could not be regarded as an index of "true" scarcity.

Aside from all these considerations, there were uncertainties regarding technological progress, which might reduce the costs significantly in the future: the question of the optimal timing of the project was therefore equally important in this case and the possible postponability of the project was an additional factor to be considered. Even leaving out uncertainty, however, any answer relating to timing would require both an explicit assumption relating to the future demand and specification of the discount rate, even when the cost profile is known accurately: however, such an analysis was not undertaken by any of the participants in the debate.[52]

[52] In a nonstochastic context, this question of the optimal timing of a project has been analyzed by Marglin [103] [105]. He shows that the optimal time for construction occurs when the marginal loss in benefits from further postponement just equals the marginal savings in interest costs. Since this rule is too general, Marglin shows that under certain additional assumptions, the above rule could reduce to a simpler rule which says if we assume that the immediate benefit rate from a project will continue over its finite lifetime (whatever that may be), then the optimum time for construction is when the present value of benefits is not less than the cost of the project for the first time. Unfortunately, this simple rule, as Marglin is well aware, cannot be applied to situations involving increasing returns to scale. Since the argument for the nuclear power station was partly

Thus, while the discussion on investment projects which took place in India raised a number of important questions, no specific study of any investment projects undertaken so far can be said to have provided anything like a complete analysis in terms of the social cost–benefit calculus.

Other Issues Pertaining to Planning

Among the interesting debates in India, relating to planning, has been that associated with the notion of "physical" planning as contrasted with "financial" planning.

The phrase "physical" planning, attributed to Mahalanobis, was put forth as a counter to those who wished to opt for a smaller level of financial outlay on the ground that larger outlays would lead to inflation. The argument of the physical planners at the time was that if a set of investment targets was internally consistent and feasible in the sense that enough capacity and labor were available to produce it and the draft on foreign exchange did not exceed export earnings plus committed foreign aid, then there should not be any problem in generating enough "financial" resources to undertake the acts of investment.

But this contention, if taken at its face value, was spurious (despite the fact that it played a major role in getting policymakers converted to larger outlays on investment). At its essence, the argument presupposes that if, "structurally" or "physically," we can raise the proportion of investment in national income, the necessary *ex ante* savings can be found to make the program "feasible" without inflationary effects. While this is a tautology at one level, its implication that policymakers can therefore raise as much savings as are necessary to support the planned investments is clearly untenable.[53] There is no escape from having to investigate separately the problem of generating enough savings to support the projected investment, if inflation is to be avoided. Direct measures controlling the level and composition of consumption may be sometimes called for if the physical planning targets are to be implemented, a fact which was not fully emphasized by the 'physical planners'.

A related fallacy was the tendency, at the time, to argue that if India went in for capital goods production, it would not merely be *possible* to raise the savings–investment rate (by getting over the postulated transformation constraints) but that this would also *ensure* that the savings–investment rate would automatically be stepped up. The basis for this assertion was that "no one can consume capital goods so the only choice would be to have the higher savings–investment rate." It was forgotten that the effect could well be, for example, excess capacity in the capital goods sector or cutting into exports of (traditional) consumer goods (which could reduce imports of capital goods) *unless* fiscal policy was used to raise the savings rate to match the projected increment in the rate of investment.

While the notion of "physical" planning was used by the "big planners" (who favored larger investment outlays) against the more cautious "small planners," the actual fixation of the overall investment targets appears to have been more in the nature of a compromise between these

based on increasing returns through time, one could not therefore discuss its timing on the basis of the Marglin theorem. The resolution of the question requires an explicit intertemporal analysis of the particular investment projects in question, which was not undertaken by those engaged in this controversy.

[53] In a corn economy, for example, it may be possible to put all corn back into the ground and raise the ratio of investment to national income to 100%; but it would be patently absurd to argue then that, because this is technically or "physically" feasible, the necessary "financial" resources (i.e. savings) can therefore be found!

rival groups.[54] It has further been alleged by some critics that the savings–investment balance worked out in the Plans suffered from an inherent inflationary bias even when the numerical projections looked quite safe on paper. These biases arose from (1) exaggeration of productivity estimates (especially in agriculture), (2) liberal guesses at the 'safe' limits to deficit financing, (3) underestimation of investments in private agriculture and small industry (which generally were 'cut' by the big planners to reduce the total investments, in full knowledge that no reduction would *actually* follow as these were mere estimates and fairly beyond policy control), and (4) failure to make allowance for additions to inventories, not to mention (5) the 'uncovered gap' in the resource balance exercise which was actually published in the Second Plan document.[55]

In this context of fiscal policy programing, which examines whether *ex ante* savings would match the projected investments, we may note that the "Keynesian" approach has now come to stay in India. It has become customary for the Plan documents to present fiscal policy in the context of an overall savings and investment exercise, rather than purely in budgetary terms. This has been the case despite a tendency toward thinking in quantity–theoretic terms on the part of some economists in India.[56]

The question of fiscal policy also raises the entire question of *short–term* (or annual) *planning* in India. There is little doubt that short–term planning, which takes a narrower horizon than the Five Year Plans, is essential in a country such as India where (i) agriculture plays an important role (in exports, industrial production and consumption) but is subject to wide fluctuations in performance—as was brought home to Indians during the two successive and serious droughts during 1965/66 and 1966/67; and (ii) foreign aid also is crucial (in project investments and utilization of industrial capacity). The need to adapt planned expenditures, and economic policies in general, in the light of fundamental revisions relating to critical assumptions, is certainly obvious.[57]

Unfortunately, there has been no serious attempt so far at building a relevant short–term model for the Indian economy, which would permit the policymakers to take informed decisions—a lacuna which became only too obvious when the recent

[54] The cautious groups have belonged to the Finance Ministry whereas the big planners have been associated with the Perspective Planning Division of the Planning Commission.

[55] Pointing to these factors which build into the Plans a systematic tendency towards price inflation, despite the apparent balancing of *ex ante* savings and investment, Bhagwati [10] has observed that such "over-extended" planning is likely to have led to too many starts and too few completions of projects, thereby leading to a serious decline in the overall level of productivity. He has also argued that the protagonists of such a strategy may have thought that, "getting exaggerated Plan targets accepted by the Government would push it into the extra effort (via domestic taxation) which otherwise would not be forthcoming. This strategy presumably relied on the built–in creation of a mildly inflationary situation to put pressure on the Finance Ministry to tax even more than its Plan commitments, quite ignoring the fact that the resulting unrest in the urban areas could possibly prevent the Finance Ministry from taxing even as much as they would have (if the inflation had *not* been deliberately built in) and thus reducing the resultant level of real investments as also their efficiency."

[56] On this issue, see Little [92], Chakravarty [21] and Padma Desai [43]. Further, Little's [94] systematic work on taxation for the Third Plan, for the PPD, was one of the first attempts at conducting the overall savings–investment exercise in some detail, although the Second Plan did contain the rudiments of essentially the same type of exercise. Coming from the side of the big planners, Little's work appears to have had an influential role in the favorable outcome for the big planners.

[57] In this connection, it is interesting that there has been no extended discussion of suggestions such as the "rolling plans" discussed in the Swedish literature. However, the question *has* led to demands such as, for example, having a "core" of "basic" projects and expenditures which would be carried through in any case, with more being done if aid comes through. However, there has been no systematic exploring of these issues.

industrial recession, in 1967, left the policymakers in a position where action had to be taken without any systematic knowledge of key relationships (such as the effect of corporate taxes on savings, pricing policies of corporations etc.).[58] We should note here, however, an interesting, early attempt towards building an econometric model for India, by Narasimhan [122]. Narasimhan constructed an econometric model roughly on the same lines as Tinbergen's pioneering model for the United States and the United Kingdom. Narasimhan's model had 18 equations, of which 7 were definitional, one was institutional and the remaining were behavior equations. While Narasimhan's was a pioneering attempt, he appears to have paid insufficient attention to adapting the Tinbergenesque models to the very different structural features of the Indian economy. These would relate, for example, to the distinction between urban and rural propensities to save, the elasticity of the marketable surplus in agriculture, the distinction between factory employed labor and self employment, and so on. In view of these limitations, therefore, Narasimhan's exercise is best regarded as an exploration of the question of building a suitable, short–term econometric model for India, rather than as a realistic and usable model.[59]

Finally, it is interesting to note that, while Indian planning models have become fairly sophisticated in relation to intertemporal phasing and perspective planning, there has been no comparable extension of analysis to questions of *spatial* planning. This is somewhat surprising in a country with a federal setup and where the constituent States have come to follow increasingly inward looking policies.[60] An important consequence of the lack of spatial planning of industrial targets has been the tendency for the targeted industrial capacities in each industry to be competed for by numerous claimant States, thus resulting in the allocation of plants with uneconomic scale to as many States as politically necessary.[61] While it would certainly be naive to expect that efficient allocation of industrial targets among different States, consistent with the satisfaction of constraints with respect to *aggregate* levels of industrial investments in each State on political grounds, would necessarily be accepted as a politically satisfactory method of spatial planning, it is nonetheless true that few economists gave serious attention in India to this question. An important, recent departure in this respect is the work of Srinivasan and Manne [99] which has brought original analysis to bear upon the policy question of optimal location, size

[58] We may record, however, that in this area as well, more systematic work is beginning to emerge. An example is the detailed study of inventory holdings in the large scale, manufacutring sector by Krishnamurty and Shastri [85] which illuminates an otherwise obscure area of the Indian economy.

[59] In this connection, we may also refer to a short-term policy model built by Padma Desai [41] for India, which was of an illustrative nature. Her model was based on a (3×3) input–output table which was closed with respect to consumption. The exercise was interesting because of the way in which she determined consumption endogenously via the assumption that the propensities to consume of workers in different industries were different. The model could thus predict the effect of changes in exogenous items of final use on sectoral output levels more completely than the input–output models discussed earlier in the text. However, the model did not specify how the instrument variables at the command of the government were related to the exogenous variables in the input–output sense, so that it was not sufficient for generating a shortterm plan in a complete way.

[60] We take up this question again in the next section, when we discuss the food zones that have operated in India.

[61] This process has been noted, and the lacuna in Indian planning techniques criticized by several economists: see Bhagwati [9] and Hanson [62], in particular. Bhagwati [9] has also emphasized that the uneconomic scale plants may well be economically justified if the spatial distribution of demand and transport costs, for example, make centralized production uneconomic, and that it is the lack of economic analysis of this issue, rather than the actual solutions implemented, which is unsatisfactory.

and expansion of industrial capacities.[62]

Having then discussed the principal issues and models which have emerged in relation to Indian planning, we now proceed to the Indian analyses that bear on questions of agricultural policy.

II. *Agriculture*

Indian agricultural policy discussion has taken place against the background of a trend rise in agricultural production, especially of foodgrains, which has fallen sufficiently short of the growth in demand arising from income and population growth to require continual and significant import of foodgrains under the P.L. 480 program. In consequence, economic analysis has largely been concerned with questions relating to agricultural price and distribution policy, and also the economic efficiency of alternative forms of land tenure and agrarian organization.[63]

In turn, these questions have led to analytical work on a whole range of problems with a direct bearing upon policy decisions.[64] Prominent among these studies have been the analysis of (1) the economic "rationality" of farmers, (2) the response of marketed surplus and production to price changes, (3) the relationship of land tenure systems and agrarian organization to the efficiency of factor use and to the elasticity of marketed surplus, production and investment to price change, and (4) the question of the existence and measurement of disguised unemployment.

Furthermore, Indian economists have also turned increasingly to efficiency questions relating to public agricultural investments. Economic analysis has been increasingly deployed, principally by Minhas [114] and Minhas–Srinivasan [115] to examine problems such as the efficient allocation of irrigation water and fertilizers,[65] although the choice between alternative ways in which farm output may be raised (e.g. land reclamation *versus* intensive cultivation) has not yet been fruitfully explored at an empirical level.

Agricultural Performance

At the outset, we may note that the production performance of Indian agriculture has been the subject of lively debate.[66] Pointing to India's continued reliance on P.L. 480 imports, economists such as Dandekar [33] have tended to dismiss India's agricultural performance as dismal. On the other hand, Raj [135] and Dantwala [34], while conceding the inadequacy of this performance, have attempted to put it into perspective by noting that the annual, compound rate of growth of production of foodgrains at 2.98 per cent and all commodities at 3.19 per

[62] For general work on "regional" models in India, the survey by Ghosh [58], which we have referred to earlier, is a valuable reference. Aside from the many references there, work on transportation and regional planning models has been done in India by several other economists, including M. Datta-Chaudhuri [39] and K. Sundaram [168].

[63] With respect to agrarian organization, the *social* aspects of alternative policies have also claimed equal attention in the Indian discussions. Cf. Dantwala [35]: "It may be pertinent to enquire as to what has provided the main inspiration for the proposal to impose a ceiling on individual ownership of land: the urge for distributive justice or the necessity of a more rational use of the land surface? The impromptu answer would perhaps be: both. But it would be honest to admit that the prime motivation is distributive justice. In the context of the acute land hunger and millions of dwarf farms, ownership of large areas of cultivated land by a few is considered highly inequitable, justifying the imposition of an upper limit to individual ownership."

[64] *The Indian Journal of Agricultural Economics*, currently in its 22nd volume, is an excellent guide to the full range of problems that Indian agricultural economists have considered from time to time. As already noted earlier, our survey is necessarily selective.

[65] We may also recall here the cost-benefit analysis of Sovani and Rath [164] and Raj [133] which we have surveyed in Part I. See also the excellent review of the literature on application of economic theory to Indian agricultural policy discussion by Khusro [76].

[66] We may note here the important work of Minhas and Vaidyanathan [116] in measuring the rate of growth of Indian agriculture, by 268 districts, for the aggregate output of 28 major crops for 1951–54 to 1958–61. For their method of measurement, including their decomposition of this growth into crop pattern change, productivity and acreage "effects," as also a valuable survey of other work in this area, see Minhas [113]. Parikh's work [127] in this area is also noteworthy.