A Critique of the Optimising Planning Model

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The structure and results of the linear programming model of development presented by Sukhamoy Chakravarty and Louis Lefeber in the paper, "An Optimising Planning Model", which appears in this issue, is discussed below.

An unwary reader of the paper may ignore the authors' explicit statements to the contrary and conclude that the development strategy implied in the Third Plan is faulty and that an attempt to achieve the targets of output given in the Plan will involve larger investment and less consumption than are provided for in it. Following from this it may also be believed that the model worked out by the authors will sustain larger consumption during the Plan and beyond with less investment.

It is argued here that the results of the paper by Chakravarty and Lefeber have no such policy implications. It is also argued that their Planning Model is not comparable to what they call the "Third Plan", nor can it be validly compared to the official Third Plan. This conclusion is based on the fact that the assumptions and objectives used in their model do not correspond to those implicit in the Third Plan.*

[*These comments are based on an earlier version of the paper in which the terms "Third Plan" and "Alternate Plan" were used instead of "Model with Third Plan Targets" and "Model with Endogenous Targets". The original terminology has been retained here.]

METHODOLOGICALLY very little is added by the model to the existing literature on planning techniques. It is a standard linear programming model, though unlike many of currently available models it is of an intertemporal rather than a single period kind. Also capacities in various sectors to be attained at the end of the planning horizon are determined endogenously by an artifice instead of by exogenous specification.[1] The main contribution of the model is of a quasi-methodological character viz the demonstration that a model containing a large number of constraints and of a fairly complicated structure is computationally feasible (proving the existence of a computer programme that actually works) thus opening the door for a number of useful experiments with the model. These experiments presumably will ultimately result in a framework that will be useful in clarifying policy issues.

Assumptions of the Model

The assumptions of the model are easily stated :

(0) The planning horizon is five years;

(1) The production side of the economy is described by a eleven-sector Leontief type input-output model. The input coefficients of 1960-61, describing the "average" technology of that year are assumed to prevail for the indefinite future beyond 1960-61.

(2) The only limitation other than availability of current inputs on the scale of output of a sector in any year is the capital stock in existence in that sector at the beginning of that year.

(3) The relationship between capital stock and maximal output of a sector is through a sectoral capital-output ratio fixed at the 1960-61 level once and for all.

(4) Capital stock in any sector is assumed to consist of two aggregates, "construction" and "equipment", though each sector might have different composition of the two aggregates in its capital stock.

(5) There is a fixed time-lag in creating capital stock that is independent of the particular sector in which it is created. For creating a unit of capital stock in any sector that is to be put to use four years from the present, one third of "construction' required must be put in place in each of the three consecutive years starting from the current year. Similarly, half of the "equipment" required needs to be installed in each of the two consecutive years starting from the year following the current year. In the present version of the model, there is no possibility of postponing part of "construction" or "equipment" installation. For instance, if you have done two thirds of "construction" and half of "equipment" installation as per schedule but fail to do the remaining the next year, you loose all that you have put in.

(6) On the supply side, there are domestic production and imports. Within the plan horizon imports into any sector are of two kinds. The first kind is termed "non-competitive", and forms a proportion of the sector's domestic output. The second is termed "competitive". Its level is determined by the optimisation procedure subject to the constraint that each sector does not spend more foreign exchange on this kind of imports than a specified proportion of total foreign exchange available after meeting the cost of non-competitive imports for all sectors. Beyond the five-year planning horizon, imports are assumed to grow at 3 per cent per annum, the sectoral composition being that of the terminal year of the plan as determined endogenously by the model.

(7) On the demand side, private consumption is treated as a composite commodity, a unit of which consists of the outputs of eleven sectors in proportions fixed for eternity at the 1960-61 levels. Consumption is postulated to grow at 5 per cent per annum beyond the plan.

(8) Public consumption is again assumed to have a fixed commodity composition. Beyond the plan its growth rate is assumed to be 2.5 per cent per annum, with the same commodity composition.

(9) Exports again are exogenously determined for the period of the plan and are projected to grow at 4 per cent per annum beyond the plan with the same commodity composition as in the terminal year of the plan.

(10) Gross investment demand is determined in part endogenously by its relation to required capital stock through capital coefficients, lag structure of investment and fixed commodity composition of capital stock, and in part exogenously through specified replacement vectors.

(11) Inventory demand is related through a matrix of coefficients (fixed once and for all) to changes in output.

(12) The annual net foreign capital inflow during the five years of the plan is assumed to be Rs 500 crores. Given that exports and imports are assumed to grow at 4 per cent and 3 per cent per annum, respectively, beyond the plan, net capital inflow for this period is then determined by the

difference between import expenditure and export earnings.

The objective function of the model or its maximand is the discounted sum of aggregate consumption within the plan period. The constraints of the model in each year of the plan are:

(a) Supply of each sector's output should be at least as much as demand;

(b) gross domestic output of each sector does not exceed the capacity of that sector;

(c) changes in capital stock are related to investment expenditures in the past through the lag relations and replacement requirements;

(d) import surplus does not exceed the specified net foreign capital inflow;

(e) consumption grows from year to year by as much as or more than a specified minimum growth rate;

(f) consumption in the first year of the plan is at least as much as it was in the year previous to the beginning of the plan;

(g) capital stock in each sector at the end of the plan is at least as much as is needed to sustain stipulated growth of private and public consumption, exports and imports.

The numerical results reported in the paper refer to two runs of the model. The first run—called "Third Plan"—uses the framework described above except that (i) instead of deriving terminal capacities (for use in constraints (g) above) from specified post-plan growth rates of final demand, the same are derived from official targets of gross output for the final year of Third Plan. These targets are derived by aggregation from the expected rates of growth of output of various commodities in the official Third Plan taking into account the revisions of Mid-Term Appraisal. In order to derive relevant investment figures through the lag structure, intra-plan growth rates are projected beyond the plan, (ii) constraint (f) above on first year consumption is dropped. The second run—called "Alternate Plan" uses the framework described above with no changes. In both runs, the discount rate on consumption is 10 per cent per annum and minimal annual growth rate in consumption mentioned in constraint (e) above is 5 per cent per annum. We shall come back to a discussion of the numerical results after making some general comments on the structure and assumptions of the model.

Implications of the Assumptions Time Horizon

The horizon of five years used in the model has a number of implications. Given the three year lag structure in investment assumed in the model, it is obvious that the capacity that can be added in each sector in the first two years of the plan has an upper bound determined by investment starts prior to the plan. Similarly the investment starts that are to be made in the last three years of the plan reflect the assumption about post-plan growth. Thus the time path of the model economy within the plan period is severely constrained by what came before and what comes after the plan. In a way this is reflected in the fact that the optimal time path is not very sensitive to a change in discount rate on consumption within the plan from 0 per cent to as high as 20 per cent per annum. Lengthening of time horizon may destroy this insensitivity. It may happen that for sufficiently small discount rates, it may be optimal to accumulate capital faster in the initial years of the time-horizon than in the later years. This will mean that basic industries that produce capital and intermediate goods will receive more investment in initial years than previously. Thus if the horizon is extended to 15 years, and if we name the investment and outputs in the first five years of the horizon as the "Third Plan", it may happen that this new third plan will place more emphasis on basic industries in allocating investment than a similar plan if the horizon had only been five years. For a sufficiently high discount rate even a lengthening of the horizon may not alter the optimal investment pattern in the intial years. One must do a number of runs with varying discount rates and lengths of horizon to get a clearer picture of the behaviour of the model.

The input coefficients reflect input requirements per unit of output as of 1960-61. Using these in a model whose time horizon extends to infinity has a number of consequences. For instance in agriculture, the average input structure of 1960-61 reflects the then prevailing agricultural practices—negligible inputs of chemical fertilizers and machinery and a lot of land, labour and cowdung. This naturally results in a low demand for the output of 'chemicals' sector and hence low investment in that sector. However, merely introducing a set of alternative techniques in agriculture using more chemical fertilizers and/or machinery and less land and/or labour per unit of output will not change this. For, as long as arable land and/or labour do not enter as constraints (potentially binding in the future beyond if not within the plan horizon) the optimizing procedure will choose the prevailing technique. Obviously, the fixed technology assumption has been introduced as a computationally simple device. It may be worthwhile doing another set of computations using a different input-output structure for the post-plan period at least.

The sectors of the model represent considerable amount of aggregation over commodities. If the product-mix of a sector is anticipated to change, even if the technology were to remain the same, the aggregate input-output relationship will change. There are a large number of sectors, where one can assert that product-mix changes are inevitable.

The above comments apply with equal force to fixed capital coefficients as well. In particular it is wishful thinking to assume that agricultural capacity to output relationship can be described by means of a capital output ratio fixed or otherwise. The uncertainties associated with this sector suggest that a far superior treatment of it within a model will be to treat investment inputs into and outputs from it as exogenous. Thus growth of output of agriculture will be exogenous. Then the assumption of fixed commodity composition of consumption must be modified or the maximand must be changed. For, otherwise the exogenous agricultural growth rate will place an upper bound on the growth rate of consumption.

It must be mentioned here that omission of labour as an input into production in a model which extends theoretically upto infinity does not make sense. As long as labour enters directly or indirectly as an input into the production of each commodity the long-run rate of growth of the economy (with fixed techniques of production, one or more per sector) cannot exceed that of the labour force. The specification of arbitrary rates of growth for consumption, exports, etc, is meaningless in such a context.

If one introduces (a) alternative techniques of production in each sector with varying capital intensities, (b) labour as a factor of production, its rate of growth treated as exogenous, then the techniques associated with

full employment of labour and maximum sustainable level of consumption will almost surely be different from the techniques prevalent initially. It may be that the planners do wish to include, among others, an objective of a sufficiently rapid approach to the growth path yielding the maximum sustainable level of consumption. Given that the initial picture is one of unemployment and underemployment, a move towards this path will almost surely imply move towards more capital intensive techniques. This move in conjunction with the aim of import substitution in capital goods may result in planning initially for a rapid increase in capacity of industries producing capital and intermediate goods. I shall return to this point when we discuss the numerical results.

Composition of Capital Stock

The assumption that capital stock in any sector is a composite consisting in fixed proportions the two aggregates "construction" and "equipment" is perhaps one of convenience and can presumably be relaxed in a more disaggregated version of the model. However, the assumption of fixed lag structure in investment, that too independent of sectors, is not so easily relaxed. There is a large element of choice about gestation lags. For instance, the same building may be constructed in six months or years, depending upon technique of construction used. Of course, there is a time sequence involved in the sense that one cannot install equipment before the building is ready etc. Once one poses the problem of gestation lags as one involving choice of techniques, naturally the optimizing procedure must choose the appropriate lag. However, the fixed lag assumption enables the authors to compute terminal capacities on the basis of post-terminal rates of growth of the elements of final demand. If the lag structure is itself subject to choice, this computation becomes infeasible. Even if one assumed a fixed but sectorally different lag structure, the model will require information relating to long periods before the plan and solution of difference equations of order equal to maximum lag for the post plan period. Thus if agricultural capital were to consist only of large irrigation works and these take 20 years to construct, we need to know the investment starts in irrigation for 20 years before the plan!

There is no empirical evidence one way or the other about the uniform three-year lag assumed. The results of the model are likely to be very sensitive to changes in length of lag. As mentioned earlier, a three-year lag in conjunction with a five-year horizon severely constraints the choice elements of the model. A lengthening of the lag to 4 years with the same horizon will make it more severe.

Exports and Imports

The introduction of a category of imports called "non-competitive" is inevitable in a short run model in the sense that it may be impossible to build domestic capacity to replace imports within the horizon of the model. In such a case one introduces a foreign exchange row in the input-output table showing the minimum expenditure of foreign exchange needed to produce a unity of output in each sector. These are comparable to the category of maintenance imports. In addition there will be "competitive imports" which are essentially additions to domestic production. These will enter as elements in each row of the input-output table. An optimizing procedure will determine in which of these sectors (or rows) there should be import of this type. In this framework, "non-competitive" imports will not enter the supply-demand balances of each sector. They will enter only the foreign exchange balance equation. However, in the Lefeber-Chakravarty model, the "non-competitive" imports are treated as additions to domestic supply except that these are rigidly related to domestic output of each sector through a fixed proportionality relationship. In a model of this sort, there are only two processes which supply each commodity—one domestic process and a "competitive import" activity. The structure and maximand of the model being linear, naturally the optimising procedure will result in only one of these processes being in use in all but one sector. That is, the model will suggest complete specialisation. This might mean that existing domestic capacity in some sectors may not be used at all. This is not very meaningful as a practical proposition, especially in view of the enormous aggregation involved in defining the sectors of the model. To avoid this, Lefeber and Chakravarty impose a ceiling on "competitive imports" into each sector. This ceiling says that at the most, a specified fraction of the available foreign exchange (after meeting "non-competitive" imports) can be spent for "competitive" imports into a sector. A perhaps superior way of achieving the same end will be to impose a ceiling on under-utilisation of capacity in each sector. For instance, we may say no more than 10 per cent of the existing capacity can be left idle in the equipment sector etc.

It must be remembered also that exports are treated as exogenously given for the plan period. In the post-plan period the assumption is that exports and imports grow at 4 per cent and 3 per cent per annum, respectively, with the same commodity composition in each case as in the terminal year of the plan. Since this composition for imports is largely determined on the basis of (a) the technology implied in the 1960-61 input-output and capital coefficients and (b) the initial capacities in various sectors, it is obvious that no long run comparative advantage or costs enter into its determination. The same argument applies to exports as well, since it is quite likely that our comparative advantage in future may not be in the same commodities that are being exported now. The planners do take a view on long run comparative advantage and on the need for rapidly reducing reliance on foreign assistance in emphasizing the development of basic capital and intermediate goods industries. Even though exports are assumed to grow faster than imports during the post plan period of the model thereby progressively reducing foreign assistance, the procedure of determination of their structure discussed earlier cannot reflect the above-mentioned objective of planners. We shall return to this when we discuss the numerical results.

Final Demand

The assumption of fixed commodity composition of consumption has very little meaning in a long-run model which tries to bring to bear on the plan the influence of the indefinite future beyond the plan. This means that the fact that income-elasticities differ from commodity to commodity is ignored. If it happens, since the initial composition of consumption is heavily weighted in terms of the output of a few sectors, maximization of consumption, *ceteris paribus*, will naturally result in an investment pattern that will put a lot of investible resources in developing capacity in these few sectors. We shall return to this aspect when we discuss the numerical results. Another unfortunate consequence of this assumption comes to light if the terminal conditions are not related to future consumption

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growth but to targets of output for various sectors with a structure radically different from that of consumption. If the initial capacities are more in line with that of the consumption structure, maximization of consumption in this case will result in excess capacity in those sectors whose outputs have large weights in consumption. This fact again will be illustrated in our discussion of numerical results.

The commodity composition of public consumption is also fixed in the model once and for all, the post-plan growth rate for this item being 2.5 per cent per annum. Some of the arguments of the previous paragraph apply here too. Further, as the government assumes greater and greater responsibilities over time in the provision of services like health, education and social welfare, it is clear that some shift in consumption from private to public sectors will take place at least in these sectors. The demand for these services is closely correlated with size and age composition of the population and the desired level of consumption to be provided by the government and one can not project this demand into future at arbitrary rates of growth. Other items in public consumption like administrative services etc may be related to growth in income.

Gross fixed investment and inventory demand are endogenously derived. The implications of the assumptions of fixed coefficients, lag structure, etc, discussed earlier are relevant for these as well.

Numerical Results of the Model

We mentioned in the introduction that the authors report results from two runs with the model—a "Third Plan" run and an "Alternate Plan" run. It may be recalled that the "Third Plan" run uses targets and intra-plan growth rates implicit in the official Third Plan and its Mid-Term Appraisal to derive terminal capacities for use in the model. The "Alternate Plan" refers to a run with terminal capacities endogenously derived by the framework described earlier. Some readers of the paper, may incautiously make two sets of comparisons—a first set consisting of a comparison of results of the two runs of the model and the second consisting of a comparison of results of the "Third Plan" run of the model with magnitudes stated in the official Third Plan document.

We must state categorically that

Table 1 : Gross Output and Consumption Levels in 1965-66

(Rs Crores)

Sector	Output		Consumption	
	Third Plan	Alternate Plan	Third Plan	Alternate Plan
1. Agriculture and plantation	8958	'0412	5892	7476
2. Mining and Metals	1215	553	7	8
3. Equipment Manufacturing	1969	670	200	254
4. Chemicals	1078	830	323	410
5. Cement, Glass and Wood Products	712	498	—	—
6. Food and Textiles	2749	3132	1917	2432
7. Electricity Generation and Transmission	161	131	12	15
8. Transportation	1159	984	200	254
9. Construction	2816	1973	—	—
10. Housing	614	779	614	779
11. Services	5872	6754	4448	5643
Total	27303	26716	13613	17271

Table 2 : Gross Fixed Investment Expenditures and Change in Capital Stock During 1961-62 to 1965-66

(Rs Crores)

Sector	Gross Fixed Investment		Change in Capital Stock	
	Third Plan	Alternate Plan	Third Plan	Alternate Plan
1. Agriculture and Plantation	4159	5905	2955	4534
2. Mining and Metals	2819	250	2256	103
3. Equipment Manufacturing	1211	53	1011	—11
4. Chemicals	1281	154	1023	120
5. Cement, Glass and Wood Products	264	53	216	14
6. Food and Textiles	708	625	502	436
7. Electricity Generation and Transmission	1795	180	1420	119
8. Transportation	1208	588	899	354
9. Construction	153	46	139	30
10. Housing	1881	2751	1415	2176
11. Services	627	252	483	135
Total	16106	10857	12321	8010

Table 3 : Composition of Imports During 1961-62 to 1965-66

(Rs Crores)

Sector	Third Plan Total	Alternate Plan	
		Final year	Total
1. Agriculture and Plantation	1189	360	1753
2. Mining and Metals	1060	208	915
3. Equipment manufacturing	2268	381	1766
4. Chemicals	1379	297	1439
5. Cement, Glass and Wood Products	58	2	65
6. Food and Textiles	64	18	93
7. Electricity Generation and Transmission	—	—	—
8. Transportation	—	—	—
9. Construction	—	—	—
10. Housing	—	—	—
11. Services	27	—	14
Total	6045	1266	6045

neither set of comparisons is valid and no policy conclusions can be drawn from such invalid comparisons. The first set—we may call it 'optimality comparisons'—is invalid because the targets of official Third Plan are based implicitly or explicitly on (a) social objectives, views regarding patterns of consumption, future technological relationships, long-run comparative advantage in foreign trade, etc, that are different from those explicitly used in the model, (b) a more realistic appraisal of the possibilities of growth in agriculture, and (c) the political necessity of rapidly reducing the quantum of foreign assistance needed. Because of these differences, the fact that the "Alternate Plan" yields more consumption during the plan period does not imply that the strategy and hence the targets of the official Third Plan are meaningless.

The second set of comparisons—we may call it 'consistency comparisons' for such a comparison, if valid, will mean testing internal consistency of the official Third Plan—is invalid because some crucial assumptions of the model such as lag structure of investment, fixed commodity pattern of consumption forever, ceilings on competitive imports, etc, have no exact counterparts in the official plan. There is also the somewhat less consequential fact that the targets used in the "Third Plan" run of the model involve some manipulations and extensions of official targets to fit to the particular framework of the model. Hence some of the results of the "Third Plan" run of the model such as Gross National Product, Gross Investment, Gross Domestic Ratio, etc, should not be compared with their corresponding values implied in the official Third Plan.

Having stated that the results of the model have no valid policy implications we could have ended this paper. Nevertheless we shall discuss here some of the numerical results[2] with some comments, mainly to indicate the differences between the two plans and to illustrate the implications of some of the differences in objectives (implicit or explicit) underlying them.

Tables 1-8 give the numerical values of some important variables of the two runs of the model. From Table 1 we note that "Third Plan" run yields larger gross outputs for sectors producing capital and intermediate goods such as ores, metals, equipment, chemicals, electricity, transport and construction than the "Alternate Plan." This is to be expected since official Third Plan targets for these sectors implied rapid growth over the plan and these have been used for the model. Besides the structure of consumption, exports, etc, used in the model are heavily weighted by agriculture and such other sectors the prevailing techniques of production of which do not require very much by the way of inputs form the above-mentioned sectors producing basic goods. Also there are no explicit constraints in the model requiring that foreign assistance be reduced to some specified level by a specified time. An extrapolation of the results of the model suggests that if everything goes according to the assumptions of the "Alternate Plan" it will take 52 years from 1965-66 for India to reduce the trade deficit to zero.

Lower gross outputs in "Third Plan" for sectors producing consumer goods

Table 4 (a): Some Macro Economic Magnitudes — Third Plan

Items		61-62	62-63	63-64	64-65	65-66
1. Consumption	(Rs crores)	12333	12641	12957	13281	13613
2. Government Expenditure	,,	541	561	582	602	622
3. Gross Fixed Investment	,,	2345	2679	2816	3736	4530
4. Change in Stocks	,,	229	236	517	637	1023
5. Foreign Trade Deficit	,,	—500	—500	—500	—500	—500
6. Gross National Product (GNP)	,,	14948	15617	16372	17756	19288
7. Gross Domestic Saving	,,	2074	2415	2833	3873	5053
8. Gross Domestic Saving/GNP (%)		*13.9*	*15.5*	*17.3*	*21.8*	*26.2*
9. Total Gross Investment (Rs crores)		2574	2915	3333	4373	5553
10. Total Gross Investment/GNP(%)		*17.2*	*18.7*	*20.4*	*24.6*	*28.8*
11. Gross Fixed Investment/GNP (%)		*15.7*	*17.2*	*17.2*	*21.0*	*23.5*
12. Growth of GNP over Previous Year (%)		—	*4.5*	*4.8*	*8.5*	*8.6*
13. Growth of Consumption over Previous Year (%)		—	*2.5*	*2.5*	*3.0*	*2.5*

Table 4 (b): Some Macro Economic Magnitudes — Alternate Plan

Item		61-62	62-63	63-64	64-65	65-66
1. Consumption	(Rs crores)	13005	13883	14603	15904	17273
2. Government Expenditure	,,	541	561	582	602	622
3. Gross Fixed Investment	,,	2090	2117	2159	2257	2234
4. Change in Stocks	,,	248	297	449	398	329
5. Foreign Trade Deficit	,,	—500	—500	—500	—500	—500
6. Gross National Product (GNP)	,,	15384	15858	17293	18661	19358
7. Gross Domestic Saving	,,	1838	1914	2108	2155	2063
8. Gross Domestic Saving/GNP (%)		*11.9*	*12.1*	*12.2*	*11.5*	*10.7*
9. Total Gross Investment	(Rs crores)	2338	2414	2608	2655	2563
10. Total Gross Investment/GNP	(%)	*15.2*	*15.2*	*15.1*	*14.2*	*13.2*
11. Gross Fixed Investment/GNP	(%)	*13.6*	*13.3*	*12.5*	*12.1*	*11.5*
12. Growth of GNP over Previous Year	(%)	—	*3.1*	*9.0*	*7.9*	*3.7*
13. Growth of Consumption over Previous Year	(%)	—	*6.8*	*5.2*	*8.9*	*8.6*

are again not surprising. For, the only constraints on the expansion of output are capacity and foreign exchange. A unit of consumption requires 0.43 units of output of "agriculture", (see table 7), 0.33 units of "services" and 0.4 units of food and clothing. This, combined with the naive assumption that expansion of agricultural output is related to investment through a fixed capital output ratio of 1.50 and the fact that "services"[3] and "food and clothing" have very low capital output ratios result in larger consumption and lower investment for the "Alternate Plan". The fixed commodity composition of consumption contributes to the difference in another way also. This results in the following rather peculiar result: even if all sectors contributing to consumption but one were to have either excess capacity or possibility of competitive imports, and that one sector has reached the ceiling with respect to both capacity utilisation and competitive imports, there is no possibility of increasing total consumption. This fact comes out clearly when we look at the idle capacity figures of Table 6. It shows that in all the five years of the plan, the "Third Plan" run shows excess capacity in three or more of consumption sectors like Agriculture, Food and Textiles, Housing, and Services. We shall discuss later in detail the idle capacity figures of Table 6.

Table 2 gives gross investment expenditures and change in capital stock during the five years of the plan for the two runs. The latter figures are less than the former both because they are net of replacement and because part of investment expenditures in the last three years of the plan relate to capacity to be realised after the plan. The differences in the two plans with respect to investment are also not at all surprising in view of the various differences in objectives, etc, which we have already discussed. Thus the "Alternate Plan" puts roughly 54 per cent of total gross investment in Agriculture, with 25 per cent going to Housing and 6 per cent going to Food and Textiles manufacturing. It involves also an actual decrease in capacity of the sector manufacturing equipment and negligible increase in basic sectors like Mining and Metals, Chemicals, Electricity generation and transmission, etc. The "Third Plan" run places roughly 26 per cent of total investment in Agriculture, 12 per cent in Housing and 4 per cent in Food and Textiles. It also expands capacity substantially in basic industries, reflecting implicitly objectives such as import substitution in basic goods dictated by considerations of long run comparative advantage, and a rapid approach towards an economy of full employment with techniques of production appropriate to long run growth. At the risk of repetition, we must mention that the "Third Plan" run here is not comparable to the official plan. The large gross investment figure of roughly Rs 16,200 crores given in Table 2 for the "Third Plan" may be in part due to the procedure of extrapolation of official intra-plan growth rates adopted by the authors to derive investment starts that have to be made during the plan for capacity to be realised in the immediate post-plan years. Thus the pre-plan

Table 5 (a): Gross Fixed Investment Expenditures — Third Plan

(Rs Crores)

Sector	61-62	62-63	63-64	64-65	65-66	Total
1. Agriculture and Plantation	749	812	735	1038	825	4159
2. Mining and Metals	366	540	560	481	872	2819
3. Equipment Manufacturing	235	367	300	69	240	1211
4. Chemicals	91	78	163	386	563	1281
5. Cement, Glass and Wood Products	58	59	48	35	64	264
6. Food and Textiles	118	53	47	208	282	708
7. Electricity Generation and Transmission	113	66	231	574	811	1795
8. Transportation	154	119	244	349	342	1208
9. Construction	42	57	40	2	12	153
10. Housing	347	491	360	408	275	1881
11. Services	72	37	88	186	244	627
Total	2345	2679	2816	3736	4530	16106

Table 5 (b): Gross Fixed Investment Expenditures — Alternate Plan

(Rs Crores)

Sector	61-62	62-63	63-64	64-65	65-66	Total
1. Agriculture and Plantation	1144	1253	1271	1157	1080	5905
2. Mining and Metals	4	12	46	87	101	250
3. Equipment Manufacturing	—	—	2	14	37	53
4. Chemicals	17	10	32	50	45	154
5. Cement, Glass and Wood Products	8	1	6	15	23	53
6. Food and Textiles	136	100	102	148	139	625
7. Electricity Generation and Transmission	17	12	35	58	58	180
8. Transportation	236	116	—	79	157	588
9. Construction	24	8	—	2	12	46
10. Housing	477	584	613	567	510	2751
11. Services	27	21	52	80	72	252
Total	2090	2117	2159	2257	2234	10857

capacity was low in a sector and a rapid growth was planned for it in the official documents, the same high rate gets extrapolated whether the planners did have such growth in mind for the future or not. This may be especially true in some investment and intermediate goods sectors. Tables 5(a) and 5(b) give year by year details of the gross fixed investment expenditure for the plan as a whole given in Table 2.

Table 3 gives the commodity composition of imports for the two runs of the model. Since exogenous export earnings and foreign assistance were the same for both runs, the figure for total imports is the same. Again, the "Alternate Plan" involves larger import of Agricultural Products, and Food and Textiles. Also, in relation to a smaller total of gross investment the imports of metals, equipment, chemicals, etc, are larger than in the "Third Plan". This again is not at all surprising, given that future consumption in the "Alternate Plan" is projected at 5 per cent growth rate with fixed commodity pattern of the type discussed already. This results in not much capacity being built during the plan in the basic goods sectors and whatever is needed of these goods is imported.

Table 3 also points to one other unfortunate feature of the model. The 'Alternate Plan' projects imports into the future at 3 per cent per annum with the commodity composition as that of final year of plan. Thus substantial volume of supplies from imports are made available in basic goods sectors. This blunts the need for import substitution through a build-up of capacity in these sectors. The "Third Plan" run does not require such an extrapolation of imports.

Tables 4(a) and 4 (b) give some macro-economic magnitudes associated with the two runs. The "Third Plan" run implies lower gross national product and consumption and larger investment than in the "Alternate Plan", though GNP is almost the same in the two runs for the final year. The "Third Plan" involves a gradual step-up over the plan in domestic savings and gross investment as proportions of GNP while the "Alternate Plan" involves a decline! Again, high values of the savings or investment ratios of the "Third Plan" run should not be compared with the corresponding magnitudes in the official Plan. In fact, if the commodity composition of consumption were flexible the result may have been greater consumption with very little change in investment thereby increasing GNP and reducing the saving ratio.

Annual investment expenditures for the two runs reported in Tables 5(a) and 5(b) need no comments in addition to those made when discussing Table 2.

Table 6 gives the story of excess capacity in various sectors. Both runs involve excess capacity in a large number of sectors in the first three years of the plan. This is because of the fixed lag structure of investment assumed in the model. As we mentioned in the introduction, the change in capacity during the first three years of the plan is pretty much decided by initial capacity and what investment starts' were made prior to the plan. Because of the assumption that investment once started, has to adhere rigidly to the lag structure if one is not to loose what was already put in, in the initial years investment was made to complete investment started earlier. The capacity thus added is not for immediate use but for use during the final years of the plan and beyond. This results also in a bunching of capacities becoming available yielding wildly fluctuating idle capacity ratios as one notices from table 6. Some of the excess capacities get corrected during the final year of the plan. Those that still remain are indicative of the nature of the two runs. Thus the "Third Plan" run ends up with excess capacity in Agriculture, Housing and Services while the "Alternate

Table 6 : Idle Capacity as Per Cent of Total Capacity

Sector	1961-62		1962-63		1963-64		1964-65		1965-66	
	Third Plan	Alternate Plan	Third Plan	Alternate Plan	Third Plan	Alternate Plan	Third Plan	Alternate Plan	Third Plan	Alternate Plan
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Agriculture and Plantation	5.3	—	8.4	—	10.7	—	4.4	—	6.9	—
2 Mining and Metals	—	12.5	3.0	10.3	—	2.5	19.0	—	—	—
3 Equipment Manufacturing	—	34.0	—	48.9	14.3	46.5	25.1	23.8	—	14.0
4 Chemicals	15.0	15.5	21.9	16.6	27.0	10.1	24.1	—	—	—
5 Cement, Glass and Wood Products	10.4	10.9	11.5	5.6	8.9	0.8	9.6	—	—	—
6 Food and Textiles	10.7	6.0	14.2	6.8	15.5	7.9	9.8	—	—	—
7 Electricity Generation and Transmission	11.6	13.6	18.6	14.1	24.8	8.5	14.1	—	—	—
8 Transportation	8.1	9.4	12.6	15.0	6.6	18.6	—	9.5	—	—
9 Construction	—	—	3.7	—	3.6	—	8.8	0.4	—	3.0
10 Housing	7.3	2.3	9.6	0.7	11.6	0.4	11.7	—	18.3	—
11 Services	19.5	16.6	22.6	15.7	25.6	9.5	20.3	—	14.9	—

Plan" ends up the idle capacity in "equipment manufacturing" and "construction". Beyond the plan there is full utilization of capacity by assumption for the "Alternate Plan" while this question does not arise for the "Third Plan". We must also answer one question that may arise in the minds of some readers of the original paper or these comments: why should there be excess capacity in "Third Plan" run if it was based on official targets for gross outputs. The answer is simple: even though the terminal capacities for the "Third Plan" were derived on the basis of official targets and intra-plan growth rates, the optimizing procedure devotes enough investment to create these capacities but will use the capacities thus created to the full only if it is 'optimal' i e, only if it can yield a larger discounted sum of consumption during the plan. Because of the inflexibility of commodity composition of consumption and/or of the ceilings on competitive imports, such full utilization becomes non-optimal and excess capacity in some consumption sectors becomes inevitable.

Table 7 gives the commodity composition of consumption and sectoral capital output ratios used in the model. These are self-explanatory.

Table 8: Shadow Price of Foreign Exchange

Year	Third Plan	Alternate Plan
1961-62	0.1941	0.0968
1962-63	0.1767	0.1273
1963-64	0.5179	0.1260
1964-65	0.3685	0.1859
1965-66	0.3128	0.6060

Table 8 gives the shadow price of foreign exchange for the two runs in each year of the plan. We note from this table that an extra rupee of foreign exchange available during 1961-62 could have increased the sum of discounted consumption by only 0.1941 for the "Third Plan" run. In general the scarcity value of foreign exchange implied by these values is rather low. Part of the explanation for this may again lie in the fixed commodity pattern of consumption and the sectoral ceilings on competitive imports. These prevent the conversion of an extra rupee of foreign exchange in any year to a minimum of an extra unit of consumption in that year. Another contributing factor may be the assumption of "fixed three year lag in investment and no postponement possible of investment once started".

Conclusion

A model is only a device to derive some of the logical implications of the assumptions underlying it. These assumptions by necessity, have to be abstractions of the complex world the model is supposed to describe. An economic model to be useful as a policy tool must not carry abstraction to the limit of loosing all essential elements of a problem. Before a model is used as a policy tool a number of runs indicating the sensitivity of its results to changes in its assumption or numerical values of its parameters must be made. Also, if one policy or strategy is to be compared with another on the basis of the model, the objectives of the economy and all constraints have to be similarly derived for the two runs with the two policies.

It must also be made clear that the use of large electronic computers makes it possible to experiment with models of complex structure. The value of such experiments in bringing out the implications of a large number of assumptions and relationships is clear. In fact, it is hard to think of any other approach that can comprehend and take into account such complexities. A model has an added advantage that the very formulation of it forces one to make explicit one's assumptions and objectives leaving little room from implicitly smuggling in one's prejudices under the cover of 'judgement' or 'experience'. One important lesson to be learnt from this exercise is that we must go ahead with more experiments with similar or better models introducing elements of reality wherever lacking.

Table 7: Consumption and Capital Coefficients

Sector	Contribution to a Unit of Consumption	Capital-Output Ratio
1 Agriculture and Plantation	0.4328	1.50
2 Mining and Metals	0.0005	2.15
3 Equipment Manufacturing	0.0147	0.84
4 Chemicals	0.0238	0.70
5 Cement, Glass and Wood Product	0.0000	0.77
6 Food and Textiles	0.1408	0.60
7 Electricity Generation and Transmission	0.0009	6.12
8 Transportation	0.0147	1.84
9 Construction	0.0000	0.14
10 Housing	0.0451	10.00
11 Services	0.3267	0.15

Notes

[1] R Frisch (1957) and Alan Manne (1960) had introduced a similar artifice in unpublished papers.

[2] The summary results reported in the Lefeber-Chakravarty paper use a minimum growth rate of 5 per cent per annum for consumption within the plan in constraint (e) discussed under assumptions of the model. We do not have the detailed results for the "Third Plan" run for this case. Instead, we have used the available detailed results of the "Third Plan" run with the minimal growth rate of consumption of 2.5 per cent per annum. This change does not affect the results of the 'Alternate Plan' where the minimal growth rate constraint of 5 per cent per annum is not binding. Hence a lowering of this rate to 2.5 per cent will not change the optimal plan. The results reported in Tables 2-5 (b) have been worked out by us on the basis of computer print-outs and very kindly made available by Professor Lefeber. Tables 1 and 6-8 are reproduced from the print-outs.

One of the peculiar aspects of the model is the concept of 'capacity' for services, It is hard to justify the notion that supply of 'services' is limited by 'capacity' in existence in this sector.

The data relating to initial capacity were implicitly derived by the authors by assuming full utilization of capacity in the year immediately preceding the plan and using that year's gross output together with capital output ratios given in Table 7 of this paper.