

CHOICE ELEMENTS IN INTERTEMPORAL PLANNING*

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The utility of intertemporal or dynamic planning arises not only from its formulation of future goals but also from its specification of the means to achieve those goals. A plan for economic development is not just a set of targets. To be operational it must specify the measures necessary to achieve those targets.

An intertemporal plan is like a guide map. It shows the beginning and ending of the journey and the road to be travelled in order to make the trip. Just as incomplete maps would result in wasted effort, in the same way, short term or annual plans are, by themselves, inadequate planning tools. The increasing uncertainty of longer periods, the inevitable short run deviations from prescribed paths, the changes in technological possibilities, for example, all such influences justify annual and short term plans. But such plans will be most effective when placed in the context of a long term plan with its broader perspective and greater flexibility. Only long term plans moreover can adequately encompass projects with long technical gestation periods and other slowly working initiatives.

The same type of influences which justify short plans necessitate frequent re-planning on a long term basis. This means that long term planning as well as short term planning, is not a once-and-for-all operation. It must be a continuing process with modifications in the light of new knowledge, changing objectives and for elaboration to greater detail.

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All planning is a political as well as an economic process. Though the political constraints often remain implicit in an economic program, they constitute the boundaries within which the economist must work. The components of economic policy are often competing, however, both as regards means as well as choice of ends, and the difficulties in political decisions arise not so much in formulating the ideals of a good life as in making the inevitable choices among its components. The economist has, therefore, the responsibility of defining the economic content of the political constraints given to him and to demonstrate the implications of alternative policies for concrete economic magnitudes.

I. The Choice Elements in Intertemporal Planning

In plans as in life not every wish can be satisfied and not every element can be chosen independently. There are political constraints which we shall not attempt to explore in detail here and economic constraints which we shall illustrate. These constraints arise out of the economic structure and the interrelationships within it. In any planning model there must be a number of options which can be utilized to achieve a preferred economic situation. We refer to these options as choice elements in the planning problem. The precise nature of these choice elements and the manner in which they may be determined depends on the way the planning problem is posed and the type of planning model which is set up. In a planning model whose purpose is simply consistency, i.e., the determination of an intertemporal path of resource allocations and output levels which will lead from a given initial position to a specified terminal

stock, there are four such choice elements: (1) the initial level of consumption, (2) the planning horizon, (3) the growth of consumption during the plan period, (4) the terminal conditions. Not all of these can be chosen independently. Once three are stipulated, the feasibility and, in that case the magnitude of the fourth is also determined.¹ However, for planning models whose purpose is to determine the 'best' of all possible paths of development which connects two different positions in time, these choice elements will have to be reformulated. Since the concept of a 'best path' is itself a matter for discussion we shall take up this reformulation in Section III of this paper. In this section and the subsequent one we deal only with the first type, the consistency model.

1. Levels of Consumption and Saving at the Beginning of a Plan.

The point need not be elaborated that most of the resources required for growth in any country must be provided internally. Just as the productive resources currently available depend on past accumulation so also the endowment which the present leaves to the future depends on the manner in which current resources are allocated between consumption and investment.

The vicious circle of poverty and stagnation from which the less-developed countries are trying to escape sets limits on the proportion of output from currently available resources which can be diverted from consumption to building up productive resources for future use. The proportion can be changed, however, by individuals in some of the income brackets, at least, and by the State in

1. In the implementation of a plan there will be many more detailed choices to be made such as the relative emphasis to be given to import-saving or export-gaining industries and the choice of the technologies which will be used. These choices, however, while of great significance are derivative and constitute a choice of means rather than ends.

pursuance of the national goals. This proportion is one of the fundamental choice elements in planning.

Most important from the viewpoint of planning is that the State can affect the initial levels of consumption and saving by the various tax and control measures at its command. The economic analyses of alternative policies should not obscure the fact that the choice is essentially political. In some countries physical coercion has been used. Where such means are abhorrent, fiscal and other indirect devices are employed and the element of State coercion becomes less obvious. These indirect measures are each likely to have a limited scope where consumption is already low but they are not without effect.

To force down consumption by any means will be a difficult process. More often the practical issue is to what level it will be allowed to rise. The decisions have to be political but their consequences are profoundly economic. This also applies to the degree of inequality of consumption which is tolerated in the process of development. This inequality influences the level and pattern of consumption and may be as significant in the latter respect as in the former since the consumption of the upper income groups makes special demands on such particularly scarce resources as foreign exchange. Therefore, a redistribution of income, or of poverty, to put the point another way, may be required to create the initial conditions necessary to achieve the other economic goals which a nation sets for itself.

2. Time Horizon of Planning.

The choice of a time horizon for planning is not just a question of whether there are technical-economic reasons for a five year plan or a ten or twenty year plan, though these are important. Some of the most important projects

require long periods to show their full benefits. In addition, the choice of a time horizon also influences the manner in which the sacrifices and benefits of economic growth should be distributed over time. The choice of a planning horizon of 50 years, for example, at the end of which relative austerity would be relaxed would be one aspect of a decision to deny the present generation any of the fruits of its own labor and sacrifice. A planning horizon of five years may imply the opposite.

There are technical-economic reasons for a long plan rather than a short plan in the opportunities the former provides for foresight and continuity of effort. These reasons are not finally decisive. For example, a policy of preparation for imminent doomsday would override such arguments and dictate short term planning in spite of its limitations.

The choice of the length of the planning horizon is more usually an implicit rather than an explicit decision in planning. Although this decision affects the path and content of economic growth in an essential, if intricate, way, the alternative choices are less fully debated than, say, questions related to current consumption and savings levels which may seem to be more tangible and pressing. The time horizon issues, however, have not been completely ignored. A common policy statement is that the present generation should participate in the benefits of the future economic growth for which it is making sacrifices. An explicit and open policy to the contrary has rarely if ever been enunciated in any country.

Yet the meaning of the policy of participation by the present generation in the returns for present sacrifices has to be spelled out. Today's patriarch cannot expect the same future benefits as the schoolboy. Still the impossibility

of promising fully equal participation does not prevent establishment of some standards of equity. One such standard would be that a representative member of the current population should have a better future. Another slightly different criterion would set this goal for an average person in the present labor force. For the application of such criteria the average length of life is important or, more precisely, the average life expectancy of the population or of members of the labor force. For the present population of India as a whole the average life expectancy is in the neighborhood of 32 years. It is substantially less for members of the current labor force. This suggests a limit to the postponement of the enjoyment of the fruits of development on the basis of either of the above standards of equity.

As the time horizon of planning is shifted further into the future, the main variables of an intertemporal planning model are significantly affected. Since results are so critically related to the choice of a single number which is bound to be somewhat arbitrary in character, economists have sometimes been tempted to set the planning horizon infinitely far off into the future. For certain types of analytical problems this particular choice of a boundary condition in time is useful. But, particularly in a consistency model, there would be something contradictory in postulating a set of finite terminal conditions to be reached only over an infinite period of time. This consideration is logically sufficient to rule infinity out of consideration. In choosing between finite horizons of varying lengths, the considerations outlined earlier, together with the inevitable cumulation of uncertainties of a receding future dictates the choice of a horizon which does not put off decisions for too long.

3. Rate of Growth of Consumption within the Planning Period.

The rate at which consumption is allowed to grow during the plan is another element in the decision as to how to spread the benefits of economic development over time. Moreover, it affects in a direct way the rate of growth of production and of capital accumulation for further growth. The more quickly consumption is allowed to grow, and the lower the rate of saving out of the increments of production, then the greater the current spread of the benefits of development. Development itself, however, depends on the plowback of increased output into investment. So a too large or premature diversion to production of consumption goods of the resources which become increasingly available as the result of development could stifle that development.

The decision as to what growth in consumption will be permitted is again a political one. Ordinarily, in free societies, it will be difficult to rule out at least some increase in consumption. As incomes rise and as unemployment, open and disguised, is reduced, there will be increasing demands for consumption goods.

Another major source of pressure will be the general upgrading of the working force which takes place as part of the process of development: increasing numbers of unskilled workers acquire skills; more persons move into foreman and supervisory status, become higher civil servants, managers, entrepreneurs and so on. As individuals participate in this process of upgrading their occupations they will also try to upgrade their consumption to the patterns of the new levels they are achieving. Thus the mere maintenance of the present relative supplies of consumption goods will mean growing scarcities of particular types as increasing numbers of persons bid for the apartments,

motor scooters, automobiles, etc. of the higher income levels. Denial of these amenities is in turn certain to become a pressing political issue.

The political and economic interconnections between the choice elements in long term planning are illustrated by the relations between the choice of initial consumption levels and of the rate of growth of consumption during the plan. Suppose the initial level of aggregate consumption from which planning starts could be diminished by reduction of the inequalities of consumption. Subsequent upgrading of consumption as occupational levels rise would then mean less overall pressure on consumption. On the other hand, the decision might be that current reduction of the inequalities of consumption is politically more difficult than delaying the upgrading process. Or there may be some planned use of both procedures.

There is, from the standpoint of production possibilities, great flexibility in the rates of consumption growth at various phases of a plan over the planning horizon: fast at first, slow later, or vice versa or any other pattern. Each pattern of growth rates and each composition would have a different economic significance and each would pose a different political problem. High consumption growth rates in the early plan stages may be justified not only on humane grounds but on those of increasing human stamina or giving necessary encouragement for future sacrifices. On a political evaluation that it is more difficult to hold down consumption once it has begun to grow, just the reverse procedure might be dictated. The detail of alternative patterns of consumption growth must also be considered in order to have a full appreciation of their political as well as economic significance.

4. Terminal Conditions in Planning.

Stipulation of the terminal conditions of an intertemporal plan requires the choice of one or another set of national economic goals. These terminal conditions may have alternative characterizations. For example, it may be specified as a political decision that at the end of the planning horizon certain minimum consumption levels should be achieved and that some particular rate of growth should be maintainable thereafter. Or it may be stipulated that a particular level of employment should be a terminal condition or that independence from external assistance be established by the end of the plan.

Of course it may not be possible for the economy to achieve whatever set of targets is specified. Or it may be possible to achieve the targets only by means of sacrifices in the other choice elements. There will be interrelations also among the various components of the terminal conditions and possibilities of doing better in one sector by accepting a lower level of performance in another sector. There are detailed problems of economic analysis in determining the feasibility of the terminal conditions and their relations with each other as well as with other choice elements.

The particular year-by-year production targets of a plan are not terminal conditions in themselves. They are the implications of such conditions taken together with the values given to the other choices elements. The annual production levels emerge as the result of the total planning process.

The content of the terminal conditions is a political decision: the economic goals which it is the nation's objective to achieve by the end of the planning horizon. If the goals are specified in terms of consumption levels, then the

politics of consumption levels and distribution are involved in an obvious way. Statements of terminal conditions in terms of resources of productive capacity, i.e., in terms of steel capacity, or dams or power stations or machine tool production, have implications for consumption and saving as well and, therefore, are just as political. If the implications are hidden, the content of the political decisions may be obscure. It is possible that the statement of terminal conditions in terms of productive capacity raises fewer internal political issues just because the consumption, saving and tax implications are unspecified, though not by any means undetermined.

The choice of terminal conditions for a planning period does not mean there is a lack of concern for succeeding years. Rather it is a decision about the desired characteristics of a way station in economic growth. These characteristics may include rewards for previous effort and provide also for more future growth depending on political evaluations and satisfaction of economic feasibility requirements.

In the re-planning mentioned above the terminal conditions as well as the choice other/elements of the intertemporal plan may be modified in the light of new alternatives which become available or new exigencies which must be faced. If a plan is made with standards of equity in mind and if it is regarded as a national compact, the new set of choices should, to the maximum extent possible, provide for no worse standards of life for the population and exploit to the fullest any new opportunities which arise.

II. Substitution among Choice Elements

The economic and technical limitations on the choice elements have already been referred to as they are inescapable characteristics. For example, the

higher the value given to consumption in the initial conditions, the less the initial investment and the subsequent growth possibilities. The higher the intermediate rate of growth of consumption, all other things being equal, the less the achievement possible in the terminal conditions. The longer the planning horizon, the lower the initial investment necessary to reach any specified terminal conditions. The more ambitious the terminal conditions, the greater the need for stringency in consumption initially and/or through the planning period. These are straightforward qualitative conditions which arise out of the basic facts of limited resources and which do not require any specific planning framework for their revelation. In practical planning, of course, it is the exact quantitative nature of the limitations and substitution possibilities which are of great interest. To know these quantitative possibilities in detail requires a great deal of technical and economic information, the specification of a planning model and a lot of computation. The basic logic can be illustrated simply, however, with an aggregate model whose objective is the achievement of consistency among the choice elements.

Suppose we think in terms of the production of a generalized output which is divided between consumption and investment. We start with the amount of resources available at the beginning of the plan. This availability in this aggregative approach is represented by the stock of capital and the productivity coefficient. As the first decision about one of the choice elements we might stipulate the initial levels of consumption and, thus, also determine the initial use of the available resources in the production of consumption goods and in capital formation. However, we provisionally leave this element to be determined by decisions about the other three choice elements. The terminal

conditions will be translated into a specific level of capital stock to be reached at a particular time in the future. The choice of that time determines the planning horizon. Finally a decision must be made about the choice of the rate of growth of consumption which will be allowed during the plan period.

Not every possible path and set of parameters are consistent, which reflects the constraints of the economic system, but we will consider only those which can be realized. The overall productivity of capital will be taken to be close to that implicit in the ^{Indian} Third Five Year Plan. We take, as well, the 1960-61 levels of consumption in India of roughly 14000 crores of rupees as the basis for comparison with the initial levels of consumption derived from the planning model.

The significance of alternative decisions on the choice elements in long term planning can now be illustrated by a set of numerical examples. The planning horizon is set at fifteen years. The terminal condition is at first set so that there is no growth in capital stock by the end of the planning period. Each row of Table I shows the necessary change in the initial consumption level as compared to that now prevailing as the result of a specification on the rate of growth of consumption allowed during the plan.² Thus, remembering that the rate of population growth in India is itself about 2 per cent, a small increase ^{immediately} in consumption would be permissible/if it were intended that per capita consumption were to remain constant over the next fifteen years and if there were to be no change in the stock of productive resources by the end of the period. If the rate of growth of consumption is set at 4 per cent during the plan period, and everything else remains the same, then, in order to give a 2 per cent increase in per capita consumption, current consumption levels must be cut by

2. These tables are based on a simple aggregative model which is outlined in a brief Appendix.

4.8 per cent. A 6 per cent rate of increase in consumption implies even greater current sacrifices.

Table I.

Rate of Growth of Consumption during Plan Period	Required Change in the Initial Level of Consumption
2%	+ 0.4%
4%	- 4.8%
6%	-10.0%

A more ambitious terminal goal has more austere implications. If the objective is to double the stock of capital goods by the end of the 15 year plan period, i.e., to achieve an annual average rate of growth in capital resources of slightly less than 5 per cent, we have the conditions of Table II. That table indicates that the terminal goal is achievable with no sacrifice in the current or future levels of per capita consumption. But, let the current level of consumption rise by ever so little, and that goal will not be achieved. If it rises by as much as 0.4 per cent, Table I says that the capital resources will just be maintained over the plan period. If per capita consumption is allowed to rise during the plan, then there must be greater immediate sacrifice if the terminal condition is to be achieved. There must be a sacrifice of 5 per cent in current consumption for a 4 per cent intermediate rate of growth of consumption and an immediate sacrifice of 10 per cent for a 6 per cent rate of growth in consumption over the plan period.

Table II.

Required Change in the Initial Level of Consumption	Rate of Growth of Consumption during the Plan Period
2%	0.0%
4%	- 5.0%
6%	-10.2%

These examples are not intended to be descriptive, though they are approximative with respect to the Indian economy. They are illustrative of the significance of alternative intertemporal planning decisions. They clearly demonstrate that what is done right now does make a great deal of difference for the future. Having a long term plan, for example, does not encourage complacency or procrastination. Rather its purpose is to indicate what must be done immediately. In the present circumstances, it suggests the need for great stringency in containing the pressures for raising consumption levels if the national goals are to be reached. This in turn implies the need for reviewing policies designed to restrict consumption at the upper income levels in order to share the burdens of sacrifice equitably.

Changing the decision about the planning horizon is not in itself so important in determining the current and future levels of consumption permissible as is shown in Table III for a planning horizon of twenty years. Of course, this does not imply that the choice of a planning horizon may not be important on political and equity grounds as discussed above.

Table III.

Rate of Growth of Consumption during the Plan Period	Required Change in the Initial Level of Consumption	
	If Capital Stock Is Not to Grow	If Capital Stock Is to Double over the Plan Period
2%	+ 0.3%	+ 0.2%
4%	- 5.0%	- 5.0%
6%	- 10.3%	- 10.3%

III. Optimizing Planning Models

The description of choice elements in intertemporal planning, as well as of the rates at which they can be substituted, has so far been based on a consistency planning model. This type of planning framework has as its major objective the maintenance of intertemporal and intersectoral consistency as the plan moves from its beginning to its end over the planning period, satisfying specified intermediate requirements. The choice element concept changes in the context of an optimizing model, however. To broaden the discussion it will be useful to turn briefly to such models whose goal is the immediate deduction of the best plan of development. It will be most convenient for the purposes of illustration to continue to deal with economic aggregates.

Two broad types of optimization models can be distinguished: (1) optimization models defined with respect to a terminal state and (2) models in which the optimization procedure attempts to single out the best among all alternative paths. In the first type of model the objective is to find a plan which leads to the highest possible value of a function made up of the economic magnitudes which describe the terminal conditions. Examples of this are models which maximize terminal consumption or the utility of terminal consumption or some mix of terminal consumption and investment. These belong to what have become known as "turnpike" type models. Compared to this the second type of optimization model takes into account the entire path leading from a specified initial position to a specified terminal position. Among the class of feasible paths it picks the one which is the best in terms of a stated preference function. These may be called Ramsay-type models after their original analyst.

In a turnpike type optimization model the choice elements are the length of the planning horizon, the initial level of consumption and the exact nature

of the preference function involving the terminal variables. The intermediate rate of growth of consumption cannot be chosen also but must be deduced or there would be no scope left for the optimizing procedure. In a Ramsay type planning model the choice elements are more intricate than in any of the alternative models discussed so far. As in the consistency model the planning horizon and terminal objectives are specified. The initial and intermediate levels of consumption emerge as part of the solution of the model. The other choice elements are in the definition of the preference function which must evaluate the utility of one entire consumption path against that of another. Composing a preference function with meaningful choice elements for this type of model is a difficult task.

IV. Intertemporal, Multi-Sector Planning

The basic components of intertemporal planning have been illustrated in terms of aggregate planning models. The next step is to elaborate these approaches in order to operate in the many-sector detail which constitutes the practical context of development programs.

Expanding the scope of planning to many sectors also requires more detailed specification of each of the various choice elements. The initial conditions must now be described in terms of each of the items which make up the consumers budget. The choice of a rate of growth of consumption now involves decisions about the different growth rates permitted for each one of these items at various stages over the plan period. The terminal conditions must also be specified in detail. Instead of stipulating only one level of aggregate consumption and aggregate investment in the terminal period, each of the consumption,

investment and other final output items must be indicated for that period. Only the planning horizon can continue to be given as a single number.

Detailed information is also required about the structural relations between the various sectors both with respect to their current requirements and their requirements for capital expansion. Interindustry or input-output information is an essential ingredient.

A multi-sector, intertemporal planning model can be envisaged which is essentially an extension to many sectors of the simple, aggregate consistency model already described. The result of the planning process would be the determination, period-by-period, of production levels or targets which are consistent with the decisions made about the choice elements.

The possibility of re-planning would always be kept open. In fact, the approach is envisaged as a continuing process which permits adjustments to take into account the actual levels of achievement year by year and changes in structural relations.

This type of planning procedure does what an intertemporal plan should do and tells what must be done now in order to achieve distant goals. The approach illustrated here is not one of general optimization, however, and would not attempt the ambitious task of finding the best of all possible paths of development. It would be desirable to explore the implications of alternative paths and in that way provide a basis for discrimination among them. Analyses of this type could also lead to the eventual use of optimization models to investigate the substitution possibilities among terminal conditions, for example, and, in this way, fuller exploration of the potentialities of economic development.

By no means all of the problems of intertemporal planning can be handled in any planning model. Much data collection and statistical estimation must be done outside it and fed into it. Results of the planning process must be interpreted and disaggregated. Fiscal and monetary issues have to be handled separately. Yet an intertemporal planning procedure provides the focus necessary to make all these separate activities coherent.

APPENDIX.

The simple, aggregative model underlying the numerical examples is familiar to economists. The following variables and parameters are used:

- $Y(t)$ -- National income or output in period t
- $C(t)$ -- total consumption in period t is $\bar{C} e^{rt}$ where \bar{C} is the initial level of consumption and r the rate of growth of consumption chosen for the inter-plan period
- $K(t)$ -- the capital stock existing in period t
- $I(t)$ -- investment, or the change in capital stock, in period t , or $K'(t)$
- b -- the output-capital ratio, or $Y(t)/K(t)$, which is set at 1/2.5 or 0.4
- T -- the planning period.

The initial level of capital stock $K(0)$ is set at 37000 crores of rupees. Then, substituting into the basic national income equation,

$$Y(t) = C(t) + I(t)$$

$$\text{We get } bK(t) = \bar{C} e^{rt} + K'(t)$$

This is a simple differential equation which is the basis of the numerical examples.

Since this is a first order equation, it determines a one-parameter family of solutions. However, since \bar{C} is an unknown of this problem, our solution is really a member of a two-parameter family of solutions. Specification of initial and terminal capital stocks enables us to determine a specific solution in this class.

The qualitative results are independent of the value of parameters chosen.