

# Import Substitution: A Survey of Concepts, Measures and Models

by

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The purpose of this article is to survey briefly the current literature on development planning and import substitution in order to put in perspective the various contributions to the subject. Section I surveys some of the aggregative models on import substitution; Section II brings out the impact of recent discussions on import substitution on the process of development planning; Section III contrasts the various treatments of imports in inter-industry analysis; and Section IV surveys some of the development planning models with similar structure or motivation.

## I. CONCEPTS AND MEASURES

The relationship between economic growth and import substitution has been explored in a number of studies—both theoretical and empirical—in recent years. The most important and path-breaking of these is, of course, Chenery's analysis of the patterns of industrial growth based on inter-country cross-section analysis over a period of time[8]. The results of his study strongly suggest that the ratio of imports to domestic production in individual sectors and industries is systematically higher amongst countries with higher degree of industrialization.

The phenomenon studied by Chenery, however, was an 'historical' one. He attributed it to differences in comparative advantage in different countries. In keeping with the tenets of neoclassical trade theory, these were attributed to differences or changes in relative factor endowments and to changes in the pattern of demand brought about by increasing incomes and high Engel elasticities for industrial goods.

More recently, however, interest in import substitution has resulted from a desire to overcome the (real or alleged) uncertainties about, or the bleak prospects for, the expansion of exports of under-developed countries, which in a large measure have to pay for imports. The focus of such studies has been

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on import substitution as a strategy of economic development. These studies recognize the availability of foreign exchange to be a relevant, if not always a binding, constraint in the process of development. On an aggregative level, the role of these studies has been to stress that, in the face of less than perfect elasticity of exports at given prices, the trade deficit is not only a measure of the gap between needed investment and available domestic savings, but is also an indicator of the specificity of imports in the domestic production process. On a more disaggregated level, some of the studies in this category have tried to determine the pattern of domestic investment which would be compatible with the available resources of foreign exchange and domestic savings.

Another group of studies on import substitution is concerned with the evaluation or the effectiveness of "success" of the strategy in changing the pattern of comparative advantage in favour of commodities the country was previously importing[21]. The criteria used here are essentially price criteria. An import substitution policy is characterized as successful if the prices of domestically produced importables relative to their foreign prices are falling over time. It has been shown by Arrow that, in a linear production model, the choice of import substitution is independent of the relative prices of domestically produced and foreign importables[2]. Nevertheless, in view of the significant deviations in the real world from linearity and the other restrictive assumptions under which the Arrow demonstration is valid, the consideration of relative prices is not inappropriate.

The theoretical interest in import substitution has, however, not led to any uniform or accepted definition of the term. This is probably just as well since the motivations and purposes of different studies have not been alike. However, many studies fail to make explicit the underlying assumptions which determine the relationship between imports and domestic production and the extent of substitutability between them.

Import substitution can broadly be defined as an attempt by a country to improve its balance of payments by effecting changes in the import orientation of the domestic economy. The import orientation of the economy can, however, be measured in any of the following ways.

(a) *Aggregate*

- (1) Ratio of total (real) value of imports to the total (real) value of gross output in all sectors of the economy.
- (2) Ratio of total (real) value of imports to GNP.
- (3) Ratio of total (real) value of imports to total (real) exports.

(b) *Partial*

- (1) Ratio of imported raw materials to total intermediate inputs.
- (2) Ratio of imported investment goods to total fixed investment.
- (3) Ratio of imported consumption goods to total consumption.

(c) *Sectoral*

- (1) Ratio of imports to total supply in each sector.
- (2) Ratio of imported raw materials to total intermediate inputs in each sector.
- (3) Ratio of imported investment goods to total fixed investment by each type of capital good.
- (4) Ratio of imported consumption goods to total consumption expenditure by each type of consumption good.

The meaning of all these different ratios need not be elaborated here at any great length. No single measure can claim a conceptual superiority over any other. A few general observations may, however, be made to point up their differences and similarities. It is obvious that movements in all these different ratios are unlikely to be similar. The objectives of the economy are unlikely to be similar. They are usually set in terms of the aggregative measures, but the instruments or strategies used to achieve a given aggregative measure of import substitution are more meaningfully set in terms of the partial or sectoral measures.

## II. DEVELOPMENT PLANNING AND AGGREGATIVE GROWTH MODELS

The process of planned economic development in underdeveloped countries began only recently. It grew not from a doctrinaire desire for comprehensive planning in all spheres of the economy—though the inspiration of Soviet Planning experience is clearly discernible, at least, in the nomenclature of the plans and planning bodies—but from the practical problems faced by the new nationalist regimes in attempting to fulfil the rising expectations of the masses. The gap between the availability of resources and politically popular social and economic goals soon became obvious to them. The old administrative machinery inherited by these regimes proved inadequate to the tasks of economic development. However, a complete revamping of the administering machinery was feasible neither politically nor physically. The creation of a planning commission to coordinate development policies in different areas and to give an overall view was a far easier political measure to adopt. The mushrooming of planning commissions as a new status symbol was a testimony to the strength of the revolution of rising expectations, which was fast spreading all over the underdeveloped world.

The fact that the process of planning was accepted not as a matter of doctrine but expediency also tended to make it an ad hoc affair. Most plans became a collection of hastily worked out projects, giving scant attention to their economy-wide implications and the resource scarcities. Soon, however, the necessity for some kind of theoretical underpinning for a plan was forced on planners. This led to the building up of macroeconomic aggregates and national income accounts, where such were not already in existence, and along with them rudimentary application of the Harrod-Domar model.

The application of Harrod-Domar model had, at least, three major drawbacks from the point of view of national economic planning. Firstly, due to its aggregative nature it left unanswered the important question of

sectoral allocation and inter-sectoral consistency. Secondly, it provided no guidelines as to the appropriate choice of techniques in individual projects and the setting up of criteria for determining investment priorities. Thirdly, due to its inadequate treatment of the foreign sector, it gave domestic savings a disproportionate emphasis as a resource scarcity.

The first defect was remedied by the application of inter-industry analysis to the problems of development programming.<sup>1</sup> Interest in inter-industry analysis usually brings with it several statistical and analytical by-products. It places the national income accounts on a firmer statistical ground and by discovering various lacunae in the country's statistical system, points out the need for further statistical research. The estimation of inter-industry coefficients also makes possible the formulation and implementation of various programming models based on them. However, the treatment of imports in inter-industry models is by no means uniform. In Section III we discuss the different treatments in order to elaborate the nature of underlying assumptions about the relationship between imports and domestic production.

The question of choice of techniques, which occupied the attention of economists working on development problems a decade or more ago, gave rise to a voluminous and interesting, if inconclusive, literature on the subject [19; 15; 18]. It is not the purpose of this section to survey that literature. Our interest here is rather in a certain class of growth models which presume the choice of techniques on *a priori* grounds. One such model is the Mahalanobis model for India, which has claimed wide attention in development planning literature and has direct bearing on the problem of import substitution.[22].

The Mahalanobis model has evoked controversy due to its emphasis on "heavy industry". The model has four broad sectors with differing capital- and labour-output ratios. The model is designed to allocate given investment resources among the four sectors, so as to achieve a given rate of increase of national income and full employment of labour. However, in allocating the investment funds, the investment goods sector is given special priority over the other sectors, receiving one-third of total new investment [20].

The preference for heavy industry was defended by Mahalanobis for "reasons of long-run growth". In a subsequent article, Mahalanobis gives three explicit reasons for this preference[23]. The first is the presumption that investment in capital-intensive investment goods industries will, in the long-run, lead to a higher rate of growth of income (and employment). Secondly, "success in establishing basic industries would give the Government increasing control over the national economy". The third argument is that the establishment of basic industries would secure "economic independence". Once the heavy capital goods industries are established, the argument goes, "everything else can be gradually manufactured in India mostly out of domestic resources".

It is this last argument which is of interest to us since it provides a definite way to achieve import substitution in India. Mahalanobis exemplifies this by

<sup>1</sup> See [3] for a survey of the application of input-output analysis to development programming in a number of countries.

reference to the goal of self-sufficiency in food grains. Several alternative routes or all-or-nothing import choices to achieve this goal are pointed out. The first consists in importing foodgrains directly, the second in importing fertilizers, the third in importing fertilizer plants, the fourth in importing machinery for engineering works which would build such plants in India. Mahalanobis shows with some arithmetic examples that the last route results in the largest savings of foreign exchange [23, Pp. 83-7]. Raj and Sen try to drive the same point home by more elaborate methods of calculus[32].

However, the demonstration by Mahalanobis and by Raj and Sen neglects one aspect of the problem which vitiates their argument. They do not consider the indirect import costs of intermediate and capital goods which presumably increase as one progresses from the first route (import of foodgrains) to the last (import of machinery to make fertilizer plants). When these indirect costs are explicitly taken into account the case for import substitution in heavy industries is not so clear cut. Arndt tries to show this point by precisely the same arithmetic procedure as that of Mahalanobis but by bringing in these indirect costs[1]. Although he is unable to dispute the conclusions based on Mahalanobis' less realistic assumptions, he does succeed in showing that the foreign exchange savings are far less spectacular than those claimed by Mahalanobis. It seems, therefore, incorrect to presume that certain group of industries will save more foreign exchange than others without paying sufficient attention to the indirect costs mentioned above.

The third modification of the Harrod-Domar model for the purposes of development planning has been necessitated by the emergence of the so-called "two-gap" models[10]. The basic idea behind these models is quite simple and its relevance to countries with slow export growth and rigid import structure can hardly be doubted. If exports grow at a fixed rate and imports are a fixed proportion of income, it follows that income can grow no faster than the rate of growth of exports, if balance of payments equilibrium has to be maintained. The need for a balance of payments deficit arises in such a case, not in order to supplement inadequate domestic savings, but to finance the high import component of investment expenditures which domestic savings generate. The same conclusion emerges if we replace the assumption of a constant rate of growth of exports by the somewhat more realistic assumption that exports grow at the same rate as income and by postulating that the import-intensity of investment is higher than that of consumption. This, in essence, is the Mckinnon formulation of the problem[27]. Under these assumptions, it can also be seen that the need for foreign aid arises not to supplement domestic savings which may well be adequate but to sustain a higher growth rate which is inhibited by the lack of essential imports. An increase in the rate of savings, *cet. par.*, raises investment relative to consumption and raises the ratio of imports to income. With a given ratio of exports to income a trade deficit may result, even though domestic savings are being increased. In a Harrod-Domar model domestic savings are perfectly substitutable for balance of payments deficit, whereas in the two-gap models the former become redundant beyond a certain point.

Whether domestic savings or the foreign exchange availability is the crucial bottleneck of growth in a given country is a matter by no means easy of empirical verification. It will depend on a number of factors such as the pro-

spects for exports, the desired rate of growth of income or consumption and the substitutability between imported and domestically produced goods in different uses. Chenery and Strout[9] have tried to test the two-gap theory for a number of countries and, on the basis of their results for about 50 countries, they have developed a rather deterministic three-stage theory of growth in which a developing country always encounters the savings constraint at an earlier stage of growth than the foreign exchange constraint. Fei and Ranis[17] have pointed out the various theoretical and empirical pitfalls inherent in the Chenery-Strout[9] analysis. Their criticism of Chenery-Strout's neglect of the conditions of the supply of foreign aid and almost exclusive preoccupation with the demand for foreign aid is specially deserving of mention. However, their criticism does not preclude the possibility of developing a testable model of determining whether the real constraint faced by a country is that of the supply of foreign aid or that of domestic savings.

If it can be determined that the crucial bottleneck facing a country is that of foreign exchange and if exports are not perfectly elastic at a given price, the obvious strategy for such a country is to embark on the policy of import substitution or the domestic production of importables. However, as most developing countries have recently discovered, the policy of import substitution is by no means an unmixed blessing. Import substitution creates its own pressures on imports for a variety of reasons. For one thing, import substitution increases the requirements of intermediate and investment goods imports. For another, the additional incomes generated in the process of import-substituting industrialization are spent on importables (whether home-produced or imported) by the new entrepreneurs and workers.<sup>2</sup>

The pursuit of a policy of import substitution can also lead—and there is ample evidence of this in the contemporary experience of underdeveloped countries—to a flagrant disregard of the principles of comparative advantage and establishment of industries which can survive, even in the long run, under the umbrella of protective tariffs.<sup>3</sup> What is more, once such domestic distortions are created in the domestic production structure, they tend to perpetuate themselves through the vested interests created in the established industries. Preoccupation with aggregative policies of import substitution has very often resulted in scant regard being paid to the sectoral priorities which they imply.

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<sup>2</sup> This is also used as an argument in favour of establishing heavy industries and against consumer goods industries. Bettelheim [4] argues that investment in capital-intensive investment goods industries, while securing more rapid rate of growth in the long run, involves a slower rate of growth in the early years. It will thus give rise to smaller increase in demand for imported goods in the short run and put less strain on the balance of payments. Power [30] makes much the same argument in regard to Pakistan, though not very convincingly, that the establishment of consumer goods industries has led to a fall in domestic savings rates.

<sup>3</sup> An attempt to evaluate Pakistan's import substitution experience from this viewpoint has been made by Soligo and Stern [34].

### III. INTER-INDUSTRY TREATMENT OF IMPORTS

For the purpose of analysing the relationship of imports to domestic production structure, the inter-industry framework is the most illuminating. It enables us to trace the repercussions of a given amount of import replacement achieved in one sector of domestic production and imports of all other sectors. The treatment of imports in the input-output model, however, can take different forms depending on the role imports are assumed to play in different sectors of the economy. The different treatments of imports in the input-output model are based on the assumptions made about the extent of substitutability between imports and domestic production of the same "commodity".

The original formulation of the Leontief model did not take explicit account of foreign trade. The interest in the input-output model as a national accounting tool has tended to treat imports at par with domestic production and, implicitly, to assume perfect substitutability between them. The more recent concern with development programming and the balance of payments problem of underdeveloped countries, however, has focussed attention on the role of imports as essential inputs in the domestic production process and also as a source of supplementing domestic savings effort.

One restrictive assumption implicit in all attempts to treat imports endogenously in the input-output model needs to be made explicit. As is well-known, all input-output tables are constructed on the assumption that the economy is in equilibrium and that relative prices are constant. Extended to the realm of international trade, this assumption further implies that the foreign exchange rate remains constant. The various import coefficients in the following can be assumed to be stable only insofar as the foreign exchange rate remains fixed. Since most underdeveloped countries have over-valued currencies the computed import coefficients, in general, are likely to be lower than those based on the equilibrium or true exchange rate.

#### **Non-Competitive Imports**

A primary distinction of imports in the input-output model is according to whether the imported commodity is also produced domestically or not. Non-competitive imports are those commodities which cannot be produced domestically due to lack of natural resources, skills or insufficiency of demand. Such imports are usually treated in the input-output analysis as a "primary" or "non-produced" factor of production such as labour or capital. In the input-output table they are usually shown as a single row—although, if sufficient commodity details were available, it would be more appropriate to have several rows. The assumption of fixed coefficients for non-competitive imports would then be a closer approximation to reality.

Even when competitive imports have been distinguished to a sufficient degree of disaggregation, there remains the serious problem of handling new imports, which may vitiate a study of import substitution over time. For, during the period under study there may arise new products which were not being imported (or even produced anywhere else in the world) and there may thus be no basis for estimating non-competitive import coefficients for such

products. One may thus come up against an apparently contradictory situation of a constant or even increasing ratio of total imports to GNP, along with a declining ratio of imports to domestic production in each sector.

### Competitive Imports

The element of choice between domestic production and imports is confined to the category of goods and services which can be domestically produced, but where the possibility of importation is not excluded. The treatment of competitive imports in the input-output model depends upon the technological assumption one makes about their relationship with domestic production activity. In what follows we classify the various treatments according to the assumption made about the relationship between domestic production and competitive imports.<sup>4</sup>

#### 1. The National Accounts Model:

In this model the competitive imports serve merely as an augmentation of domestic supply of corresponding goods and services. They are not "needed" in any essential way by the domestic production process. The picture of the economy that this model envisions is that of extreme flexibility in its productive structure and expenditure pattern. If the entire level of current imports has to be replaced all the economy needs to do is to produce an additional amount  $(I-A)^{-1}z$  in the different production sectors.<sup>5</sup> No additional imports (or "balance of payments effects") are generated by this import-substitution programme. Any given level of imports may be replaced in this model by domestic production without generating additional imports. Import replacement here is equivalent to an increment in domestic final demand and its impact on domestic output levels is determined in the same manner as that of changes in final demand. There is no complementarity between imports and domestic production in any sense.

#### 2. Fixed Share Model:

This model takes cognizance of the fact that a certain part of the requirements of a given commodity is always met by imports and the remainder by domestic production. The model postulates a fixed relationship between imports and domestic products and can be formulated in either of the two following ways:

- (a) Imports are a fixed proportion of domestic production in each sector,<sup>6</sup> i.e.,

$$Z_i = m_i X_i \quad i=1, 2, \dots, n$$

<sup>4</sup> A similar and computationally more detailed survey of alternative ways of treating competitive imports is given by Matuszewski, Pilts and Sawyer [26]. However, whereas Matuszewski, *et al* concentrate on the computational aspects of the problem, our concern here is on the underlying economic assumptions of the different models.

<sup>5</sup>  $(I-A)^{-1}$  is the Leontief inverse and  $Z$  a sector of competitive imports. For determining total output levels the Leontief inverse is applied to final demand *minus* total imports in each sector. This treatment was first suggested in [16.]

<sup>6</sup> This is the assumption made in [11].

(b) Imports are a fixed proportion of total supply or availability, i.e.,

$$Z_i = m_i^* (X_i + Z_i) \quad i = 1, 2 \dots n$$

where  $Z_i$  and  $X_i$  are the levels of imports and of domestic production, respectively of the  $i$ -th commodity.

It is easily shown that both formulations are in effect the same if

$$m_i^* = \frac{m_i}{1 + m_i}$$

The coefficients  $m_i$  of  $m_i^*$  are market-share and not technological ones and can be defended on institutional rather than technical considerations.

It is possible to interpret  $\frac{1}{1 + m_i}$  or  $1 - m_i^*$  as the self-sufficiency coefficient for the  $i$ -th commodity, whose possible values could range from zero to one, according as  $m_i$  ranges from infinity to zero or  $m_i^*$  ranges from unity to zero. These coefficients are, however, a very inadequate guide to the overall import-intensity of each individual sector.

Cameron[6] has suggested a computational procedure which tries to take advantage of the above "double-celled" model when there is less than complete information regarding all the import coefficients. The procedure consists essentially in estimating a few of the more strategic behavioural relationships between imported and domestically produced flows of a sector, e.g., the proportion of total final demand for a commodity supplied by imports, the proportion of inter-industrial demands of a commodity supplied by imports and the proportion of inter-industrial demands of a commodity supplied by imports. Two structural equations for each sector—one showing the demand-supply balance for imported and domestically produced flows combined and the other for imports alone—complete the system which can then be solved to give the total import requirements for a given set of final demands.

#### IV. PROGRAMMING MODELS OF IMPORT SUBSTITUTION AND GROWTH

In this section we will attempt to review in some detail a selected number of empirical models of development planning which have close affinity to those of the present author [28; 29]. These are Sandee's pioneering work in this field on India [33], Manne's study on the key sectors of the Mexican economy [25] Weisskopf's thesis on import substitution in India [36], Tim's growth model for Pakistan [35], Chenery and MacEwan's article on the time pattern of aid to Pakistan [12] and the inter-temporal model on India [7] by Chakravarty, Eckaus and Lefebvre.<sup>7</sup> All of them were designed to aid in the process of development programming in a particular country. It will not be the aim of this section to critically evaluate each of these models separately, but to emphasize the difference in treatments of the major issues involved in the formulation of a development planning model. We shall discuss these models with reference to (a) optimising procedure (b) period of optimization (c) degree of aggregation (d) choice of techniques (e) treatment of imports (f) treatment of investment and terminal conditions (g) treatment of savings and foreign aid.

<sup>7</sup> Although the authorship of [7] is ascribed only to Chakravarty and Lefebvre, Eckaus has contributed significantly to the formulation of the various aspects. In the text the model is also referred to as the Eckaus-Lefebvre and C.E.L. model.

**(a) Optimising Procedure**

All the models, with the exception of Tim's, use some kind of optimising procedure. Tim's model, although a consistency model, is interesting not only because it provides the formal theoretical framework for Pakistan's official Third Five Year Plan, but also because of its special emphasis on import substitution. The distinction between an optimising and a consistency model should not, however, be overemphasized. The relevance of a given model to the existing situation it attempts to portray does not crucially depend upon whether an optimising procedure is used—although in most cases it would be preferable to do so. If a consistency model, correctly specifying the economic relationships, is implemented with enough variation in its targets and availability of the scarce resources, it can obviate the need for explicit optimization. Also some degree of optimization has, of necessity, to be done outside a model, and has to be subsumed in the relations and exogenous variables it uses. For instance, most models under consideration treat exports as exogenously given and use some relationship between income and savings—on the implicit assumption that the exogenously given target and the savings relation has resulted from some optimization already done outside the model.

The Tim's model calculates the sectoral output, import and investment requirements for the terminal year of the plan, corresponding to different target rates of growth of national income. Manne minimizes the total import requirements of key sectors of the Mexican economy subject to the satisfaction of exogenously given final demands. Weisskopf's optimization procedure is essentially the same as Manne's, except that he brings into the minimand domestic (essentially labour) as well as foreign exchange costs and changes the minimand by assigning different "weights" to the ratio between domestic and foreign costs, ranging from zero ("infinite tariff") to one (imports being valued at the official exchange rate). Sandee's maximand is total consumption in the terminal year, while Lefeber and Eckaus maximize the discounted value of consumption during the period. The Chenery-MacEwan objective function seeks to maximise the sum of discounted consumption both during and posterior to the planning period and not of the disutility of foreign aid inflow during the period. In his two models for Pakistan [28; 29], the present author has minimised the sum of imports in the terminal period and the discounted sum of imports during the period.<sup>8</sup>

There are thus two general approaches to the optimization problem: either to minimize a cost function or to maximize a welfare function. Although formally the two problems must lead to identical result, it is not entirely a matter of indifference how a given problem should be formulated in practice. Minimizing a cost function yields resource requirements which can be compared with actual or estimated endowments to determine the feasibility of the projected targets. On the other hand, maximization of a welfare function subject to given resource endowments yields shadow prices of the resources which can be compared with other estimates of such prices and, if necessary, the resource constraints modified. Thus if one had good estimates about resource endowments the appropriate formulation is a welfare maximization problem,

<sup>8</sup> With exports given exogeneously, this amounts to the minimisation of foreign aid.

while if one has more confidence in the estimates of the targets to be achieved it is more appropriate to solve the cost minimization problem first. The formulation of the welfare maximization problem has an added snag in that the specification of the welfare function is never quite satisfactory. It is hard enough to determine the welfare function of an individual—to determine that for a community is almost impossible.<sup>9</sup>

Among the three maximizing criteria used, Sandee's is the simplest since it maximizes the undiscounted value of terminal year consumption. Lefeber and Eckaus who work with an inter-period, in contrast to Sandee's single-period model, instead maximize the sum of discounted consumption during the period. The maximization of total consumption, discounted or otherwise, creates a problem in an inter-sectoral balance in maximized total consumption.<sup>10</sup> Sandee's method to overcome this problem is to place upper and lower bounds on each commodity's consumption based on its Engel elasticity of demand. Lefeber and Eckaus resort to the conceptually less elegant, though computationally more efficient, method of constant proportions for each sector's consumption. Chenery and MacEwan's objective function maximizes the flow of discounted consumption during the plan period and the discounted value of consumption in the post-plan years arising from the terminal year's national income. The Chenery-MacEwan objective function "deducts" the cost of foreign aid from the utility derived from intra-plan consumption and terminal year income. We shall have occasion to comment on their treatment of foreign aid later.

Manne and Weisskopf both minimize a cost function subject to the various constraints. Manne's minimand consists of foreign exchange costs alone, while that of Weisskopf consists of both domestic and foreign exchange costs. By varying the relative weights assigned to domestic and foreign exchange costs, Weisskopf conducts a sensitivity analysis on his objective function and generates results which range between two polar extremes: (a) when the relative weight of domestic to foreign costs is zero, the import minimizing solution emerges which is identical to that produced by Manne's objective function and (b) when the relative weight between domestic and foreign costs is one. This polar case corresponds to zero tariff protection at the official exchange rate. Moving from (a) to (b) reduces the extent of import substitution and increases the reliance on external relative to internal resources. The domestic costs included in the objective function by Weisskopf are essentially labour costs—direct and indirect. The labour requirements are measured in terms of their total wage costs rather than the size of the working force.

<sup>9</sup> Any reasonable specification of a welfare function has to be nonlinear and this renders the linear programming framework inadequate. Perhaps due to the greater computational difficulties associated with solving nonlinear programming problems the three welfare-maximizing models discussed here avoid a nonlinear formulation.

<sup>10</sup> The treatment of sectoral consumption in other models may be mentioned here. Tim's [35] uses a linear consumption function relating total and sectoral consumption. Manne [25] and Weisskopf [36] use Engel elasticities to determine the sectoral distribution of total consumption. Chenery and MacEwan do not distinguish between consumption goods originating from their two highly aggregated sectors.

While we consider Weisskopf's use of parametric programming methods on the objective function ingenious and his desire to find other than the extreme import minimizing solution justifiable, we think that the minimization of labour costs in a labour-surplus country like India is somewhat misplaced. It is, of course, true that even the most labour-surplus economy can develop shortages of specific labour skills. But as Weisskopf acknowledges in arguing for using wage costs rather than the size of the working force, "...different categories of labour cannot be adequately distinguished and independently treated" [36, p. 75]. What Weisskopf does is to take into account not the shortages of specific skilled labour but of generalized labour shortage, which does not exist in a country like India.

### (b) Period of Optimization

All the models, except those of Lefebvre and Chenery and MacEwan and Naseem are single period models.<sup>11</sup> Sandee's model takes its starting point in year 1965-66, the first year of the India's Third Five Year Plan, and is concerned with the consistency of the plan in its last year (1969-70). Manne and Weisskopf have ten-year planning horizons and are concerned with the minimization of their cost function in the terminal year. Lefebvre's and Chenery and MacEwan's models are concerned with the maximization of an objective function consisting of yearly, rather than terminal year flows, and subject to constraints for each year. The single-period optimization procedure is, of course, analytically far inferior to year-by-year optimization because in such a procedure the arbitrariness of finite horizon models is carried one stage further. It is bad enough to set an arbitrary date beyond which one stops worrying about the state of economy; it is much worse to be concerned only with a particular terminal date and forget about what goes on within that period. For not only the terminal period solution may not be optimal for each of the periods intervening between the initial and terminal period, it may not even be consistent. The justification for single period optimization procedure is, of course, in terms of the relatively much smaller computational burden involved than in a full-scale inter-period model. At present, inter-period models can be computed only at considerable sacrifice of either sectoral details or limitation of the planning horizon. Thus, the Chenery-MacEwan model has only two sectors with a planning horizon of 25 years, whereas the Lefebvre model, although it has all sectors, is limited only to a 5-year planning horizon.

### (c) Degree of Aggregation

A linear production model can be considered an approximation to a more realistic nonlinear model if the number of sectors distinguished by it is sufficiently large. For practical policy purposes also a development planning model has more usefulness if it can be formulated in terms of a level of disaggregation at which selection of individual projects is made. However, the degree of aggregation adopted by any model is also related to the available data and the purposes of the model. Manne's model for Mexico and Weisskopf's for India use about 140 sectors each. Manne's model covers only the "key" sectors—mainly large industrial and mining project—whereas Weisskopf's model, although

<sup>11</sup> Bruno [5] also uses an inter-period model.

it is economy-wide, treats some of the sectors' demands for intermediate and investment goods exogenously. The Sandee model has 12 sectors, the C.E.L. model has eleven, the Tims study has seven, while the Chenery-MacEwan model distinguishes only between "regular production" and "production for trade improvement". The first two use aggregated input-output tables, whereas the last neglects inter-industry relationships altogether. In his single-period model, [29] the present author has 12 sectors, while in the inter-period model, [28] he has only 4 sectors.

#### (d) Choice of Techniques

An interesting aspect of the linear programming formulation of economy-wide production models is that they provide a choice between different techniques of producing the same commodity. Except for Chenery and MacEwan's model, which is highly aggregative, and Tims model, which does not use any optimising procedure, all the other models can be given an activity analysis interpretation. The C.E.L. model, however, provides only one technique for production of each commodity and the proportion of imports to total supply of each commodity is fixed. Manne's model provides not only for the choice of importing or producing a commodity at home, but also gives a choice among different domestic production activities for the same commodity. Sandee and Weisskopf both provide for the choice between importing and domestic production, but they do not allow for alternate domestic production activities. Sandee allows a set of net export variables to move between negative minima (import limits) and positive maxima (export limits) for each sector.

For the study of the import substitution problem it is more important to allow for choice between importing and domestic production than among alternative domestic production activities. However, there is an inherent difficulty in allowing for such a choice in linear models. The difficulty stems from the all-or-nothing character of solutions of such models. In the real world, gradual rather than precipitous changes in the import-domestic production mix of a particular sector occur. Again, if the degree of disaggregation is high then all-or-nothing solutions are not so implausible, but such solutions for highly conglomerate sectors do not make economic sense. One way to avoid this difficulty is to formulate a model in terms of changes from the initial period, rather than in terms of the absolute values of the variables, the assumption being that the supply of factors at the initial level of productive capacity is inelastic and must be utilized and the freedom to choose between imports and domestic production exists only at the margin. This is, in fact, what Manne and Weisskopf offer in their models. Sandee gets around this problem by placing upper and lower bounds on the extent of imports and or levels of domestic production in different sectors.

#### (e) Treatment of Exports

As we have remarked earlier the treatment of exports in most linear models is asymmetric to that of imports in that whereas the latter are determined endogenously in the model, the former are, of necessity, taken as exogenously given. This asymmetry arises from the nature of external demand for a country's exports. The endogenous treatment of imports implicitly assumes that

the supply of imports of a particular category is perfectly elastic at a given price. This assumption is valid for most sectors since the import demand by a given country for a particular commodity is only a small part of its total world supply. However, one cannot make a comparable assumption about the world demand for exports of an underdeveloped country. The endogenous treatment of exports in a linear model may thus result in too high levels of exports which cannot be absorbed in the world market. The only satisfactory attempt to treat exports endogenously in a programming model was attempted by Chenery and Kretschmer [13] who used a nonlinear export demand function. But apart from the computational difficulties of a nonlinear formulation, such an attempt also involves a considerable effort at the statistical estimation of reliable supply and demand functions of each individual commodity—which by itself is capable of becoming a full-fledged research project.

#### (f) **The Investment Assumption**

In all finite time horizon models of economic planning—comparative static or dynamic—the problem of “edge effects”, i.e., the state of the economy at the end of the planning period is universal. One must postulate what the model leaves for “posterity”. One extreme assumption could be that the model leaves no capital stock at the end of the planning period. This would imply that posterity has to start from scratch and build its capital stock all over again. The other extreme assumption one could postulate is that the economy maximises the capital stock at the end of the planning period. This would imply a paternalistic approach towards posterity in which the present generation does the best it can to provide the future with its capital stock. However, it is difficult to know what the collective preference of the present would be towards the future generation. This inevitably introduces an element of arbitrariness in regard to the terminal conditions.<sup>12</sup> In the following, we shall examine the treatment of the different models in this regard.

Several alternative ways of handling this problem are suggested by the models under review. Chenery and Tims work under the assumption of balanced growth in the post-plan period—the rate of growth being determined by the marginal savings rate and the marginal capital-output ratio (as, in the long-run, these are the values to which the average ratios would approach). The C.E.L. model has tried two different approaches to the terminal stock problem. In one, terminal year stock requirements are imposed exogenously on the basis of independently determined targets. In the other, terminal year levels of investment are expressed as a function of the endogenously determined terminal year levels of consumption, imports and exports so as to provide for continuous post-terminal growth in these variables at a given rate.

Weisskopf borrows his investment assumption directly from Manne. The assumptions of Manne and Sandee are similar in spirit, though quite different in their detailed specification. Both Sandee and Manne relate investment

<sup>12</sup> The problem is by no means unique to single-period models. In an inter-temporal model, investment in pre-terminal year can be related by the familiar acceleration principle to change in productive capacity which it must bring about in the following year. In the terminal year, however, there is no built-in rationale for investment even in an inter-period model.

demand in the terminal year of the model with the change in the capital stock between the initial and the terminal year. Both result in a stock-flow conversion factor which is capable of being given the interpretation of the rate of return on capital. Whereas Sandee's assumption about the change in capital is that each kind of capital stock grows linearly through time, i.e., by a fixed percentage rate. It seems to us that the Manne assumption is more realistic of the two. The assumption of a quadratic time path for investment implicit in the Sandee approach leads to falling investment-output ratios which is inconsistent with actual experience of developing economies.

### **(g) Treatment of Savings and Foreign Aid**

The aggregative implications of the inter-sectoral models are obviously of great interest to the economist and the planner in order to provide the guidelines for public policy affecting these aggregates. However, it is not enough merely to study the aggregates that result from the endogenously determined import and domestic production structure but also to see the interaction of different aggregative resource scarcities on the endogenous solution. Aggregate resource scarcities, like savings and foreign aid, are in the nature of supply constraints and should be introduced in the programming models as such. Unfortunately, however, almost none of the models considered here treats these scarcities in such a manner. Instead, it is implicitly assumed that the resource requirements generated by the solution of the model will be forthcoming—and the necessary public policies carried out by domestic and foreign governments. However, it seems to us more realistic to introduce in advance, either on the basis of historical record or realistic estimates about future projections, the limits on the availability of such resources. This is done explicitly in the present author's inter-period model [28].

The models constructed by Chenery and MacEwan and by Manne do attempt to take into account the supply constraints on domestic savings. Chenery and MacEwan postulate the savings constraints in terms of the achievable marginal savings rates, whereas Manne postulates the savings scarcity in terms of average savings rate. Manne's constraint is merely to test the hypothesis whether domestic savings become redundant at specified average savings rates. He does not constrain his solution to ensure a given maximum savings rate.

Chenery and MacEwan alone pay explicit attention to the requirements of foreign aid generated by the model. However, their constraints are set in terms of the receiving country's demand for foreign aid, rather than in terms of the donor countries' supply behaviour. A related criticism of the Chenery-MacEwan approach is that the limit on foreign aid results from a "psychic disutility" of aid and not from any genuine scarcity from the supply side [31].

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