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COMPARATIVE ADVANTAGE AND DEVELOPMENT POLICY

By Hollis B. Chenery (*)

In the grat revival of interest in economic development that has marked the past decade, attention has centered on two main questions: first, what determines the over-all rate of economic advance?; second, what is the optimal allocation of given resources to promote growth?. Analysis of the growth rate has relied mainly on the Keynesian tools and has produced a multiplicity of aggregate growth models. The second question, however, reopens more ancient economic issues, and their analysis must start from the classical and neoclassical solutions. Only very recently have the two types of discussion tended to come together in the more comprenhensive framework of general equilibrium analysis.

In the field of resource allocation, controversy centers around the implications of the classical principle of comparative advantage, according to which growth is promoted by specialization. The defenders of this principle draw their inspiration from David Ricardo, J.S. Mill and Alfred Marshall, while the lines of attack stem from Friedrich List, J.A. Schumpeter, A.A. Young and J.H. Williams. The chief criticism is that comparative advantaje is essentially a static concept which ignores a variety of dynamic elements.

This issue is of great practical importance to the governments of underdeveloped countries, most of which take an active part in allocating investment funds and other scarce resources. The main purpose of the discussion has therefore been to discover workable principles for the formulation of development policy. The classical approach derives these principles from international trade theory, while its critics base their analysis on modern growth theory. Elements of a dynamic, general-equilibrium theory are needed to resolve the differences between the two approaches. The more general analysis is of very limited value, however, unless its empirical implications can be ascertained.

The present paper discusses the analysis of resource allocation in less developed economies from thee points of view. Section I tries to ascertain the extent to which the allocation principles derived from trade theory and from growth theory can be reconciled with each other without losing their operational significance. Section II compares various approaches to the measurement of optimal resource allocation in terms of their logical consistency and their applicability to different conditions. Section III examines some of the practical procedures followed in setting investment policy in underdeveloped countries in the light of the earlier discussion. Finally, some of the theoretical issues are re-examined to indicate their practical importance.

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1.- Conflicts Between Trade Theory and Growth Theory

The main contradictions between comparative advantage and other principles of resource allocation derive from their different orientation and assumptions. The classical analysis focuses on long-run tendencies and and equilibrium conditions, while modern theories of growth are concerned with the interaction among producing and consuming units in a dynamic system. Since both approaches are familiar, I shall only try to identify the differences in assumptions and emphasis that lead to different policy conclusions.

A. The implications of Comparative Advantage for Resource Allocation.

The modern version of the comparative cost doctrine -20- is essentially a simplified form of static general equilibrium theory.(1) The optimum pattern of production and trade for a country is determined from a comparison of the opportunity cost of producing a given commodity with the price at which the commodity can be imported or exported. In equilibrium, no commodity is produced which could be imported at lower cost, and exports are expanded until marginal revenue equals marginal cost. Under the assumptions of full employment and perfect competition, the opportunity cost of a commodity, which is the value of the factors used to produce it in their best alternative employment, is equal to its market value. Market prices of factors and commodities can therefore be used to determine comparative advantage under competitive conditions. Longterm changes are not ignored, but they are assumed to be reflected in current market prices.

The Heckscher-Ohlim version of the comparative cost doctrine has been widely recommended as a basis for development policy because it provides a measure of comparative advantage that does not depend on the existence of perfect competition and initial equilibrium. This version states that a country will benefit from thade by producing commodities that use more of its relatively abundant factors of production. It will export these commodities and i import commodities using more of its relatively scarce factors unless its pattern of domestic demand happens to be biased toward commodities using domestic factors. The critical assumptions in this analysis are that factors of production are comparable among countries and that production functions are the same. These assumptions are not required by classical trade theory.

The applicability of the comparative cost doctrine to present-day conditions in underdeveloped countries has been re-esamined by Viner and its validity has been reaffirmed with some modifications. Viner criticizes the Heckscher-Ohlin version because its assumption of comparable factors does not allow for observable differences in their quality -63, p. 16-. In his recent answer to critics of the comparative cost approach -64-, however, Viner admits the necessity of interpreting comparative advantage in a dynamic setting in which the efficiency of production may change over time, external economies may exist, and the market prices of commodities and factors may differs from their opportunity cost. As Nurkse points out -64,p.76-, these modifications rob the original doctrine of much of its practical value. It is now necessary to have an explicit analysis of the growth process itself before it is possible to determine, even theoretically, where comparative advantage lies; market prices and current opportunity costs are no longer sufficient.

B. Implications of Growth Theory for Resource Allocation.

Modern growth theory is concerned with the interactions over time among producers, consumers, and investors in interrelated sectors of the economy. In the writings of such economists as Rosenstein-Rodan -43-, Lewis -29- Nurkse -36-, Myrdal -34-, Rostow -44-, Dobb -12-, and Hirschmen -23-, there is much more emphasis on the sequence of expansion and factor use by sector than on the conditions of general equilibrium. Growth theory either ignores comparative advantage and the possibilities of trade completely, or it considers mainly the dynamic aspects, such as the stimulus that an increase in exports provides to the development of related sectors or the function of imports as a carrier of new products and advanced technology. With this different point of view, growth theorists often suggest investment criteria that are quite contradictory to those derived from considerations of comparative advantage.

The conflicts between these two approaches to resource allocation may be traced either to differences in assumptions or to the inclusion of factors in one theory that are omitted from the other. Growth theory contains at least four basic assumptions about underdeveloped economies that differ strongly from those underlying the comparative cost doctrine: 1° factor prices do not necessarily reflect opportunity costs with any accuracy; 2° the quantity and quality of factors of production may change substantially over time, in part as a result of the production process itself; 3° economies of scale relative to the size of existing markets are important in a number of sectors of production; 4° complementary among commodities is dominant in both producer and consumer demand.

Some of the implications of these factors are developed by Rosenstein-Rodan -43- and Nurkse -36- as arguments for "balanced growth", by which is meant simultaneous expansion of a number of sectors of production.(2) Assuming an elastic supply of either capital or labor, these authors show that investment will be more profitable in related sectors, because of horizontal and vertical interdependende, than in the same sectors considered separately. Market forces will not necessarily lead to optimal investment decisions because present prices do not reflect the cost and demand conditions that will exist in the future. This effect of investment in one sector on the profitability of investment in another sector, via increased demand or reduced costs, has been called by Scitovsky -47- a "dynamic external economy". The imputation of these economies to the originating sectors may seriously affect the estimate of comparative advantage.

If we assume fixed investment resources instead of an elastic supply, the same set of factors provide an argument for concentrated or unbalanced growth -48- -50-. In order to achieve economies of scale in one sector, it may be necessary to devote a large fraction of the available investment funds to that sector and to supply increased requirements in other sectors from imports (or to curtail them temporarily). The optimal pattern of investment will then be one which concentrates first on one sector and then on another, with balance being approached on ly in the long run. Streeten -53- has developed

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(2) The term "balanced growth" has been given a variety of meanings, but the idea of simultaneous expansion on several fronts is common to all of them.

futher dynamic arguments for unbalanced growth from the fact that technological progress may be more rapid if increases in production are concentrated in a few sectors, while Hirschman -23- argues for imbalance to economize on entrepreneurial ability.

The historical significance of the balanced growth argument has been examined by Gerschenkron -18-, Rostow -44-, and Ohlin -38-, in the context of nineteenth-century industrial development in Europe. They show that vertical interdependence has been important in stikulating the growth of related industrial sectors, although the nature and origin of these complexes differ from country to country. In one case they may be related to exports, in another to expansion for the domestic market. The importance of interdependence among producers emerges fairly clearly from these historical studies.

The net effect of the discussion of cynamic interdependence and balanced vs. unbalanced growth is to destroy the presumption that perfect competition, even if it could be achieved, would lead to the optimum allocation of resources over time. Since the doctrine of comparative advantage in its conventional form is a corollary of general equilibrium theory, the theoretical qualifications that apply to the latter also apply to the former. If, them, the doctrine of comparative advantage is to be useful for development policy, the essential elements of the growth analysis must be combined with it.

C. Dynamic Modifications of Comparative Advantage.

Classical trade theory does not exclude changes in the supply of factors and other data over time, but it does insist that under perfect competition the effects of such changes will be reflected in the market mechanism. If, on the other hand, we take comparative advantage as a principle of planning rather than as a result of market forces, we can include any foreseeable exogenous changes in thechnology, tastes, or other data without going beyond the framework of comparative statics.

Some of the modifications suggested by growth theory are dynamic in a more essential way, in that a particular changedepends not only on the passage of time but on other variables in the system. For example, the rate of increase in the productivity of labor in an industry may depend on an increasing level of production in that industry. Some of these dynamic elements can also be analyzed by methods of comparative statics if our purpose is only to choose among alternative courses of action.

The four assumptions of growth theory discussed above (Section B) lead to the following requirements for the analytical framework to be used in determining comparative advantage in a growing economy:(3) 1° recognition of the possibility of structural disequilibrium in factor markets; 2° the inclu-

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(3) Some of these criticims of static analysis were made years ago by Williams -66-, and a number of the elements were, of course, recognized by the classical economists themselves. I am not concerned with explicit criticism of the classical analysis, but with the possibility of reconciling it with growth theory

sion of indirect (market and nonmarket) effects of expanding a given type of production; 3° simultaneous determination of levels of consumption, imports, and production in interrelated sectors over time when decreasing costs result from the expansion of output; and 4° allowance for variation in the demand for exports and other data over time.

These changes destroy the simplicity of the classical system, in which allocation decisions can be based on a partial analysis because adjustments in the rest of the economy are reflected in equilibrium market prices. In the dynamic analysis, it may not be possible to state that a country has a comparative advantage in producing steel without specifying also the levels of production of iron ore, coal and metalworking over time. In short, we are forced to compare alternative patterns of growth rather than separate sectors, and we cannot expect to find simple generalizations of the Heckscher-Ohlin type concerning the characteristics of individual lines of production.

Since there is no well-developed body of theory concerning the formal properties of the system just outlined, (4) I shall only try to indicate in a general way the modifications that some of these elements of growth theory will produce in the analysis of comparative advantage.

Factor Costs. It is generallly agreed that costs of labor and capital in underdeveloped countries do not reflect their opportunity costs with any accuracy because of market imperfections, but there is wide disagreement as to the extent of the typical discrepancies. Some types of labor may be overvalued while particular skills are undervalued. Factor costs may also change markedly over time as a result of economic development, so that an advantage based on cheap labor may prove quite limited in duration. As Lewis -29- and Hagen -21- show, the effects on comparative advantage of correcting for disequilibrium factor prices are often very substantial. (The effects of disequilibrium in factor markets are discussed further in Part II).

Export Markets. Two of the main arguments against the trade pattern produced by market forces concern 1° the fluctuating nature and 2° the low income and price elasticities of the demand for primary products. The existence of cyclical fluctuation is well established, but the income and price elasticities vary considerably among primary commodities. Their net effect on the terms of trade of primary producers over time is a matter of dispute -64-. These characteristics are often used as an argumento for reducing specialization in underdeveloped countries and for expanding industry for local consumption rather than expanding primary exports -41- -51-.

These factors can be admitted without seriously modifying the principle of comparative advantage. The market value of the stream of export earnings should be reduced to reflect the drawbacks to the economy resulting from its variable characteristics, and this social value should be used in comparing investment in primary exports to other alternatives. When export demand has a

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(4) In his survey of modern trade theory, Caves -7- shows that attempts to introduce dynamic elements have been concerned mainly with particular aspects and have led not to new principles, but rather to extensions of static results.

low elasticity, marginal revenue should be used in place of average revenue. Since it is quite likely that the market evaluation of the attractiveness of an investment in exports will differ from this social evaluation, some form of government intervention may be warranted. It is wrong, however, to conclude from this analysis that continued specialization in primary exports may not be the best policy, because even the corrected return on exports may be greater than that on alternative investments. The supply of foreing investment may also be greater for export production.

Productivity Change. The possibility of rising efficiency as labor and management acquire increasing experience in actual production has long been recognized -66- and forms the basis for the infant industry argument. This argument has been generalized to include the effects of increasing production in any industry on the supply of skilled labor and management available to other industries. Since manufacturing is thought to have more important training effects than primary production -33- -41-, the fact that improvements in factor supply are not reflected in the market mechanism may introduce a bias against manufacturing. The empirical basis for this argument has been questioned by several economists -46- -63-, who asset that there is often as much scope for technological improvement in agriculture as in industry. Without trying to settle the empirical question that has been raised, it may be concluded that productivity change is an important factor and therefore that comparative advantage should be measured over time. It cannot be said, however, that allowance for this factor will always favor manufacturing.

Dynamic External Economies. As indicated above, dynamic external economies are received by an industry from cost reductions or demand increases in other sectors. Cost reductions may result from economies of scale, productivity increases, or new technology. The customary analysis of comparative advantage on a sector-by-sector basis would require that the cost reduction from simultaneously developing interrelated sectors be allocated separately to each. However, if a group of investments will only be profitable when they are undertaken together, comparative advantage can only be determined for alternative combinations of investment. As shown in -11- not only do market prices fail to produce the best investment allocation in this situation, but any structure of equilibrium prices may also be an inadequate guide in the presence of economies of scale.

There is considerable evidence that external economies are more important in the industrial sectors than in primary production because of internal economies of scale, training effects, and high demand elasticities. Their omission from the market mechanism is therefore likely to bias resource allocation against manufacturing. The quantitative significance of this factor is very hard to determine, however, since it involves simultaneous changes in a number of sectors.

Uncertainty and Flexibility. The limited ability of policy-makers to foresee changes in demand and supply conditions puts a premium on flexibility in the choice of a development strategy. This factor not only argues against specialization in one or two export commodities but it also favors the development of a diversified economic structure which will enable the economy to shift to new types of exports or import substitutes when changing

trade conditions may require them. Kindleberger -26- sees this factor as the main explanation for his finding that the terms of trade have favored developed countries although they have not favored countries exporting manufactured goods in general (5). The argument is similar to that of Stigler -52- concerning the optimum choice of techniques in a manufacturing plant. The optimum design for a changing market is likely to differ from the optimum under static conditions because in the former case the proper criterion is lowest-cost production for varying operating levels and with changes in product desing. Similarly optimum development policy should result in a pattern of resource allocation that allows for unforeseen changes in supply and demand condition even at the cost of some loss of short-term efficiency.

II. The Measurement of Optimum Resource Allocation

The development of an adequate theory is only the first step in formulating economic policy. In order to reach practical conclusions, it is also necessary to specify the environment in which the policy-maker functions. Relevant aspects of a particular society include its general objectives, the policy instruments to be considered, and the information available. The theory must then be combined with these elements in such a way as to yield guides to action or "decision rules" for particular situations.

Although the growing science of operations research is concerned with the development of decision rules for business and military operations, less progress has been made in developing an operational approach to long-run economic policy. Tinbergen -55- and Frisch -15- have outlined a general framework formpolicy analysis, but it has had relatively little impact on the discussion of the development of under-developed countries. In this field the failure to specify adequately the decision-making environment and to distinguish between decision rules and corollaries of pure theory has led to great confusion.

Since the information needed for over-all economic analysis is available to a very limited extent in underdeveloped countries, there has been a considerable effort to derive decision rules or "investment criteria" that can be based on partial analysis. I shall group the various suggestions into three categories: 1° factor-intensity criteria; 2° productivity creteria; 3° programming criteria based on accounting prices. Although these various approaches often lead to contradictory results, eahc has come merit as a form of decision rule if properly qualified. In general, the theoretically more valid formulations require more information and must be replaced by cruder approximations when adequate data are not available. Since a major part of the literature in the developement field has been devoted to the discussion of investment criteria, it is important ot identify the sources of conflict among them and to specify the circumstances under which each may be approximately correct.

In economic theory, capital and labor are assumed to be separately allocated in single units to different uses. In national planning, however, it is more convenient to consider the decision to install a given productive process or plant, representing the allocation of a group of inputs in specified quantities, as the basic choice. Investment criteria are customarily formulated for "projects" of this sort, since they form the basis for the decision of plan-

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(5) This argument is also discussed by Caves -7, pp. 264-66-

ning authorities. This procedure recognizes that very small productive units are uneconomical, and it permits a consideration of different scales of output. The choice of techniques can be considered as a choice among projects producing the same output from different input combinations. In this way the allocation procedure can be divided into two steps: the choice of the best technique for a given type of product, and the decision whether to produce the commodity at all. The principle of comparative advantage is more directly relevant to the second type of choice, but the two cannot be separated entirely.

A. Factor-Intensity Criteria.

The simplest approach to any allocation problem is to concentrate on the scarcest resource. Since this is often capital in underdeveloped countries, it seems reasonable to choose the technique that uses the least capital to produce a given output. The same logic is applied to the choice of sectors of production: an underdeveloped country is advised to produce and export commodities that use relatively less capital per unit of output and to import items requiring more capital. Statements of this type occur in many economic writings of the past fifteen years. Buchanan -5- was among the first to state this criterion for investment in underdeveloped countries and to base policy recommendations upon it.

The "minimum capital-output ratio" criterion is only valid under the following restrictive conditions: (6) 1° Either capital is the only scarce factor in the system, or other inputs are so abundant relative to capital that the latter is the dominant element in determining cost differences. 2° Either the same output is produced by each investment alternative, or the market v values used to compare the different products coincide with their social values. 3° Production takes place under constant costs.

The use of the capital-output ratio theoretically requires a measurement of the total capital used in producing a given commodity, including the capital used in producing all materials and services purchased. Alternatively, the indirect use of capital can be allowed for by deducting the cost of purchased inputs from the value of output and expressing the criterion as the ratio of capital to value added. This procedure requires the futher assumption that market prices correctly reflect the use of capital in the rest of the economy.

A closely related allocation criterion is the capital intensity; the ratio of capital to labor. This test is derived directly from the Heckscher-Ohlin version of the comparative cost doctrine. If the same production functions exist in all countries and if capital is scarce relative to labor in the underdeveloped countries, comparative advantage in the latter can be indentified by low capital-labor ratios. This approach does not assume that labor has zero opportunity cost, as does use of the capital-output ratio, but only that the ratio of labor cost to capital cost is lower than in the country's trading partners. To allow for differences in the quality of labor among countries, it is sometimes suggested that the assessment of relative labor cost should be made for labor units of equal efficiency- e.g., the labor required in each

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(6) A rogorous analysis of the validity of marginal and average factor-output ratios as indicators of optimum allocation in a two-factor system is given by Bator -4-

country to perform a given type of operation with the same capital goods and organisation.

A principal criticism of the use of both these ratios is that they ignore the existence of other factors of production, such as natural resources. If either labor or natural resources has a significant opportunity cost, the capital-output measure must be replaced by the more general marginal productivity of capital criterion, which is discussed in the next section.

To judge comparative advantage by the capital-labor ratio is to assume either that this ratio will be the same for the same industry in all countries, or that capital is equally substitutable for labor in producing all the commodities traded. Deviations from these assumptions, along with the omission of other inputs and variations in efficiency by sector, make the capital-labor criterion a very crude approximation indeed to a proper estimate of comparative advantage.

B. Marginal Productivity Criteria (7)

A more comprehensive allocation criterion is the social marginal product of a given unit of resources in a given use. Where the factor-intensity creteria are at best only correlated with the increase in national income produced by a project, the productivity test is in turn less general than the over-all programming approach, because it is based on a partial equilibrium analysis that is only valid for relatively small changes in the economic structure.

The several forms of marginal productivity criterion that have been proposed differ in the assumptions made about the social selfare function and in the extent to which allowance is made for the indirect effects of a given allocation. All versions are alike in assuming that the government controls, directly or indirectly, a certain fraction of the investible resources of the country and wishes to allocate them in such a way as to maximize future welfare.

Since the productivity criteria are usually applied to investment projects rather than to single units of capital, they are "marginal" only in the sense that a project normally constitutes a small graction of the total capital invested in a given year. For very large projects a breakdown into samller units would be more appropriate.

The Static SMP Criterion. As proposed by Kahn -25- the social marginal product (SMP) is a general equilibrium concept which is conventionally defined as the net contribution of a marginal unit (project) to the national product. (8) The ralated decision rule is to rank investment projects by their SMP and to go down the list until the funds to be allocated are exhausted. Alternatively, any project having an SMP above a given level can be approved.

Kahn uses the SMP criterion to show the fallacies in the factor-intensity measures that had been advocated by Buchnan -5-, Polak -40-, and

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(7) Surveys of these and other investment criteria are given by Castellino -6- Vaidyanathan -62-, and the United Nations -61-

(8) To be more accurate, cost and output streams should be discounted to the present, but I shall not be concerned with differences in the time pattern of output of different projects.

other writers. He points out that: "the existence of a particular natural resource, specialiced skills, particular climatic conditions or the importance of a particular product or service may make the SMP of capital higher in a line which is more capital intensive than in another which is less so" -25, p.40-. He also argues that even when there is substantial rural unemployment, a considerable amount of capital and other inputs are required to transport, train, and house the workers who are to be employed elsewhere. Kahn's arguments against the simple capital-intensity criteria appear to have been generally accepted, although he admits that a lower capital-output ratio may be a useful guide when other information in lacking.

Some modifications in the SMP criterion were suggested by the present author -8- to allow for articial elemsnts in the price system (tariffs, subsidies, etc.) and to provide for the evaluation of labor and foreing exchange at opportunity cost rather than at market value. Further allowances for the difference between market price and social value can be made by estimating the benefits to provided to other sectors in the form of external economies, and by including overhead costs in the estimate of the cost of labor. All of these elements are included in Eckstein's synthesis and extension of the productivity aproach-14-. (9)

The SMP criterion is entirely consistent with the general programming approach discussed below, which derives opportunity costs from an explicit analysis of total factor use. In the absence of such an overall analysis, the corrections suggested for the calculation of the productivity of investment are likely to be quite approximate. There is no logical conflict between the results of the SMP analysis and the dictates of comparative advantage because each is a corollary of a general equilibrium solution over a given time period.

The Marginal Reinvestment Criterion. A sharp criticism of the SMP criterion was made by Galenson and Leigenstein -17-, who challenge soms of its basic premises. They would substitute a different social welfare function in which the aim is to maximize per capita income at some time in the distant future rather than to maximize a discounted stream of income over time. They also assume severe restrictions on the policy instruments available to the government, and in particular deny its ability to affect the rate of saving vy fiscal measures. Under these assumptions, it is necessary to take account of the division of income resulting from a project between profits and wages, since savings from the former are higher.

To maximize the total output at some distant future time, Galenson and Leigenstein easily show that the most "productive" project is not necessarily the one which maximizes national income in the near future but the one which leads to the highest savings. Since it is assumed that neither voluntary saving nor taxes can be extracted from wages, the most productive project will be the one with the highest profit rate per unit of capital invested.(10). The

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(9) Eckstein points out that the assumption of capital rationing implies a social judgment as to both the amount of investment in the current period and the discount to be applied to future outputs, since the market rate of interest is rejected for both purposes.

(10) I omit the possibility of an effect on population growth, which leads Galenson and Leibenstein to state the criterion on a per capita basis.

assumption that profits are saved and reinvested leads to the "marginal reinvestment quotient" as a decision rule to be applied in place of the SMP.

Galenson and Leibenstein push their argument one step further and indentify the most profitable project as the one with the highest capital-labor ratio. This result leads them to the paradoxical conclusion that the most capital-intensive rather than the least capital-intensive techniques in order to promote savings and future growth. This conclusion involves an implicit assumption about the nature of production functions; that increasing the capital intensity will necessarily raise the average return to capital in each sector of production. This is obviously not true in general and is not necessarily true of existing productive techniques. The savings effect of a given project should therefore be measured directly and not assumed to vary in proportion to the capital-labor ratio.

Galenson and Leibenstein have been widely criticized for their extreme assumptions -4- -14- -24- 35-, in particular for the use of a social welfare function in which the starvation of half the population in the near future would appear to be a matter of indifference and for the assumption that limitations on fiscal policy make a lower income preferable to a much higher one if the former has a higher savings component. Their analysis has nevertheless been useful in emphasizing that other effects of an investment beside its immediate contribution to the national product should be included in the productivity criterion.(11)

The Marginal Growth Contribution. Eckstein -14- has successfully reconciled the conflict between the Kahn-Chenery SMP approach and the Galenson-Leibenstein reinvestment approach, and in so doing he has provided a considerable generalization of each. First, he assumes that the social objective is to maximize the present value fo the future consumption stream. With a zero discount rate, this objective approximates the long-term income objective of Galenson and Leibenstein, while with a high discount of future consumption it leads to the maximization of income in the short term. Second, Eckstein assumes that there is a different savings (reinvestment) coefficient associated with each project, but he allows for any savings rate out of wages and profits. From these assumptions , he derives a measure of the "marginal growth contribution" of a given project that consists of two parts:1° an efficiency term, consisting of the present value of the consumption stream; and 2° a growth term, consisting of the additional consumption to be achieved by reinvesting savings.

The relative importance of the two terms depends largely on the rate of discount that is applied to future consumption. Even with a low rate of discount, the significance of the second term depends on how much variation there is in the fraction of income saved among different projects. If the savings ratio is not related to the form of income generated, then, as Bator -4- shows, there is no conflict between maximizing income in the short run and in the longer run. Eckstein's formula provides for all possible intermediate *

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(11) In -28-, Leibenstein restates in more restrained form his arguments for including labor training, savings, population growth, and other indirect effects in a comprehensive productivity measure.

assumptions between the two extreme views of the determinants of savings.(12)

In principle, one might include other indirect dynamic effects, such as the value of the labor training provided, in the measurement of the total productivity of a given project. There is a danger of double counting if partial-equilibrium analysis is extended too far, however, and most indirect effects can be more readily evaluated in the more general programming framework considered below.

C. Programming Criteria and Accounting Prices

The allocation rules discussed up to now are based on the existing economic structure and are strictly applicable only for relatively small changes in it. Although it may in many instances be necessary to rely primarily on these marginal criteria for lack of data on the rest of the economy, it is important to have some way of testing larger changes and of evaluating the errors that are introduced by the marginal procedure. Furthermore, without a more comprehensive analysis it is impossible to reconcile fully the conflicting policy implications of comparative advantage and growth theory.

The difficulties of partial analysis increase with the number of modifications that have to be applied to market prices in order to arrive at social value. Both the factor-intensity ratios and the partial productivity measures assume that there is one principal restriction on the system, the scarcity of capital. They do not allow for the fact that in allocating capital according to any one of these rules some other restriction on the sustem, such as the supply of foreign exchange, of skilled labor, or of a particular commodity, may be exceeded.

The programming approach to resource allocation begins with the problem of balancing supply and demand for different commodities and factors of production. Until quite recently, practical programming methods have been more concerned with ensuring the consistency of a given allocation of resources with certain targets than with testing the efficiency with which resources are used. Historically speaking, the programming approach is thus the operational counterpart of the theory of balanced growth, from which much of its conceptual framework is derived.

One of the earliest attempts at formulating a comprenhensive development program for an underdeveloped area was Mandelbaum's illustrative model for Southeastern Europe, undertaken during the war -31-. He starts, as many subsequent programs have done, from an estimate of the increase in national income required to absorb a prospective increment in the labor force. The allocation of capital and labor is made initially from demand estimates and by analogy to the structure of more advanced countries. The principle of comparative advantage is only introduced intuitively in modifying the initial projection. The main test of resource allocation is the balance of demand and supply for each sector and factor of production.

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(12) Sen -49- independently formulated a more general investment criterion that is very similar to Eckstein's, in which the SMP and reinvestment criteria are shown to be limiting cases.

The development of mathematical programming methods makes it possible to carry out this type of analysis in a much more precise way. In several countries, consistent development programs have been formulated by using input-output analysis, as in the studies of the Economic Commission for Latin America 58- -59- -60-. It is only with the development of linear programming, however, that it is possible to reconcile the consistency criteria and the productivity criteria in a systematic way.

A link between the test of consistency (feasibility) in resource allocation and the test of productivity (efficiency) is provided by a consideration of the price implications of a given allocation. Assume that a set of production levels has been worked out so as to be consistent with the available supplies of labor, capital and natural resources, given the structure of consumer demand and the country's trading posibilities. These sector production and trade levels constitute a "feasible program". Any such program implies a unique set of commodity and factor prices if the economy is in equilibrium. If production activities are assumed to operate at constant costs, linear programming provides a method of calculating the "shadow prices" corresponding to the equilibrium conditions, in which the price of each commodity is equal to its cost of production.(13) Prices are determined by the solution to the following set of simultaneous equations, one for each production activity included in the program:

$$a_{1j}P_1 + a_{2j}P_2 + \cdots + a_{nj}P_n = 0 \qquad (j = 1, \ldots, n) \tag{1}$$

where a_{ij} is the input or output of commodity or factor i by activity j, and P_i is the shadow price of commodity or factor i. The input coefficients may be measured at existing prices or in other convenient units. In an open economy, activities of importing and exporting are also included in the system, and the price solution contains the equilibrium price of foreing exchange. An example of this calculation is given in Table 1, which will be explained shortly.

The use of shadow or "accounting" prices in evaluating investmet projects has been suggested by Tingergen -54- -56-, Frisch -15- -16-, and Chenery -9- -10-. Although Tinbergen does not use a linear programming framework, his accounting prices for factors have the same meaning as shadow prices: the opportunity cost implied by a given resource allocation.(14) He suggests computing the costs associated with a project by using acounting prices; any project that shows a positive net return over cost (including capital cost) should be approved. This test is equivalent to the SMO criterion, as shown below.

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(13) The assumptions of linear programming and methods of finding solutions to programming models have been discussed in a number of recent publications, such as -13-

(14) Tinbergen -56, p.39- defines accounting prices as those "that would prevail if (i) the investment pattern under discussion were actually carried aout, and (ii) equilibrium existed on the markets just mentioned" (i.e., labor, capital, foreign exchange markets). The relation between acounting and shadow prices is discussed en Chenery -10- and Qayum -42-

The general linear programming problem is to maximize the value of a linear objective function subject to linear constraints. In development programs, the principal constraints are that the demands for commodities and factors should not exceed their supplies; the function to be maximized is usually taken as the national income. Alternatively, the objective may be the achievement of a given increase in output at minimum cost in intestment (including foreign investment). Other social objectives, sucha as a minimum employment level or a specified degree of regional balance, can be included as additional restrictions on the program. The instrument variables can also be constrained to fall within specified limits, as in the models of Frisch.(15)

To illustrate the meaning and use of shadow prices in evaluating investment projects, I shall take up a very simplified programming model that is worked out in more detail elsewhere -11-. The truncated system given in Table 1 covers only a small part of the economy, but it will serve to illustrate the way in which interdependence influences investment decision and the effect of having more than one scarce factor.

The model contains four production activities (X_1, X_2, X_3, X_4,) and three import activities (M_1, M_2, M_3,). Each activity is represented in Table 1 by a column of coefficients, a_{ij}, showing the amount of input (-) or output (+) of commodity i when the activity is operated at unit level. (These coefficients are the boldface figures in columns 1 to 7). The net output is taken as unity in all cases. The production activity X_1, for example, represents the production of one unit of metal products from .22 units of iron and steel, .20 units of "other inputs", .70 units of labor, and .70 units of capital. The import activity M_1 provides an alternative way of supplying a unit of metal products by an expenditure (input) of .85 units of foreign exchange. A similar choice is provided between X_2 and M_2 (iron and steel) and between X_3 and M_3 (iron ore). The fourth production activity shows the resources used in the marginal export sector to provide a unit of foreign exchange.

In a complete programming model, the amounts of all commodities required for final use at a given level of income would be entered as restrictions on the solution. Similarly, the amounts of available capital and labor of different types would be specified. In this limited illustration, the problem is to supply requirements of 1000 each for metal products and iron and steel at minimum cost. Iron ire and foreign exchange are therefore taken to be intermediate goods having no net outside demand. "Other inputs", labor and capital are supplied from outside the model at prices reflecting their opportunity costs in the rest of the economy. The main difference in principle bet-

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(15) Frisch is one of the strongest advocates of the use of linear programming for development planning, as indicated in the preface to a recent methodological study: "In the beginning of 1959, during my work as a United Nations expert in Cairo, I was confronted with the problem of working out a methodology for optimal investment programming in a rapidly expanding underdeveloped country. I have always believed - and my Cairo experiences have confirmed it- taht such a method must be formulated in terms which ultimately make the problem amenable to linear programming. Otherwise one is practically certain to taken by suprise afterwards in unexpected balance of payments difficulties and other troubles" -16, p. 1)

TABLE 1 "EVALUATION OF PRODUCTION AND IMPORT ACTIVITIES BY ACCOUNTING PRICES[a]

Commodities and factors	Production Activities				Import Activities			Accounting Prices				Restricciones
	X 1 (1)	X 2 (2)	X 3 (3)	X 4 (4)	M 1 (5)	M2 (6)	M3 (7)	Trial a (8)	Trial b (9)	Trial c (10)	Trial d (11)	(12)
1 Metal Products	1.00 (3.41)				1.00 (3.41)			2.55	3.42	3.41	2.26	1000
2 Iron and Steel	-.22 (-.89)	1.00 (4.03)				1.00 (4.03)		3.60	4.82	4.03	3.50	1000
3 Iron Ore		-.08 (-.25)	1.00 (3.12)				1.00 (3.12)	3.30	4.42	3.12	2.19	0
4 Foreign Exchange				1.00 (4.01)	-.85 (-3.41)	-1.20 (4.81)	1.10 (4.41)	3.00	4.02	4.01	2.92	0
5 Other Imputs	-.20 (-.62)	-.25 (-.78)	-.70 (2.17)	-.10 (-.31)				3.00	3.20	3.10	2.20	-
6 Labor	-.70 (1.05)	-.20 (-.30)	-.30 (-.45)	-1.00 (-1.50)				1.50	1.50	1.50	.50	
7 Capital	-.70 (-.70)	-2.70 (-2.70)	-.50 (-.50)	2.20 (-2.20)				1.00	1.00	1.00	1.00	
Social Profitability [b]												
Trial a	-.50	-.41	+.25	-1.00	0	0	0					
" b	-.03	+.37	+1.23	0	0	0	0					
" c	+.15	0	0	0	0	-.78	-1.29					
" d	0	-.03	0	0	-.22	0	-1.02					
Production and Import levels												
Trial a	0	0	0	2050	1000	1000	0					
" b	0	1000	80	850	1000	0	0					
" c	1000	1220	98	0	0	0	0					
" d	1000	0	0	1464	0	1220	0					

a) Based on chenery - II-, Table 1, Prices equation '1' except for P4 in trial 1. Figures in parenthesis are (aij Pi) for trial c

b) Calculated from equation '4'

ween this submodel and a complete programming system is that the prices of only the first four commodities are determined in the model in the present case, while in general all prices are so determined.

The four restrictions in the model consist of equations stating that the supply of each of the first four inputs must be equal to the specified demand:(16)

$$X_1 + M_1 = 1000$$

$$-.22X_1 + X_2 + M_2 = 1000$$

'2' $$-.08X_2 + X_3 + M_3 = 0$$

$$X_4 - .85M_1 - 1.20M_2 - 1.10M_3 = 0$$

The objective is to minimize the amount of capital required to suply the given final demands, with the use of labor and "other inputs" valued at their oppoftunity costs in terms of capital. This is the same as supplying each commodity at minimum unit cost, since the amount of each to be supplied is fixed.

A feasible solution to the model contains either a production or an import activity for each of the three commodities plus the export activity for foreign exchange. The corresponding activity levels can be determined from equations '2' and are shown at the bottom of Table 1. The amounts of the outside factors (F_i) - labor, capital, and "other inputs"- required by each solution can then be determined from the following equations:

Other inputs: $F_5 = .20X_1 + .25X_2 + .70X_3 + .10X_4$

'3' Labor: $F_6 = .70X_1 + .20X_2 + .30X_3 + 1.00X_4$

Capital: $F_7 = .70X_1 + 2.70X_2 + .50X_3 + 2.20X_4$

The programming model thus contains two types of equations: price equations of the type of '1', and equations for the supply and demand of commodities and outside factors, '2' and '3'. As outlined in -10-, the general procedure for solving a programming model of this type involves three steps: (a) finding a feasible program or set of activity levels that satisfies the supply-demand restrictions; (b) calculating the shadow prices associated with the given program; (c) using these prices to determine whether any improvement in the initial program is possible. This procedure is repeated as long as any further improvements can be made.

The programming criterion used to compare projects or activities is the social profitability of each as measured from the shadow prices. Any profitable activity should be included in the program. It is the recalculation of prices that distinguishes this procedure from the partial program-

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(16) I omit the possibility of overfulfilling demands, since there are no joint products in the present case.

ming approach suggested by Tinbergen. In either case, however, the test of social profitability of activity j can be expressed as:

'4' $$\Pi_j = \sum_i a_{ij} P_i$$

By definition, the activities that were used in determining the shadow prices will have a profitability of zero. The optimum solution is identified by the condition that all other activities have zero or negative profitability.

Some idea of the type of adjustment that results from moving from partial toward general equilibrium analysis may be given by determining solutions to the model in Table 1 under four different procedures: (a) the use of market prices; (b) correcting for the overvaluation of foreign exchange; (c) finding the optimum solution for the submodel alone; (d) finding the optimum solution for the submodel with changes in the opportunity costs of labor and other inputs determined from a general programming model. The accounting prices corresponding to each assumption are shown in columns 8 to 11 of Table 1. Calculation of social profitability of each activity, given the accounting prices, is illustrated in the table for trial c by given cost and revenue figures in parentheses in columns 1 to 7.

Trial a. Assume that market prices are based on the cost of importing and are determined by setting profits on the import activities equal to zero, with a given foreign exchange cost of 3.00. The exchange rate is assumed to be overvalued, so that the price of foreign exchange is less than the cost of securing it through expanded exports. At these market prices, only activity X_3 (iron ore) is profitable, but there is no domestic demand for iron ore unless steel is also produced (the export price is lower than that of imports because of transport costs). The use of market prices therefore leads to imports of steel and metal products, since the opportunity cost of expanding exports is not taken into account. The corresponding activity levels are shown at the bottom of the table.

Trial b. Assume now that we correct for the existing structural disequilibrium by setting the price of foreign exchange equal to its opportunity cost of 4.02 as determined from the export activity X_4. Allowance is also made for a rise in the accounting price of "other inputs", some of which are imported. A new set of accounting prices for commodities 1-3 is determined from the cost of imports. Substituting these prices into equation '4' shows that X_2 and X_3 are both profitable ($\pi_2 = .37, \pi_3 = 1.23$). Investment should therefore take place in steel, iron ore, and exports on this test.

Trial c. To find the optimum solution to the submodel by linear programming, we can start from tial b and recalculate the shadow prices from the activities that are included: X_2 X_3 X_4 M_1. The four shadow prices P_1 to P_4 are determined by applying equation '1', taking the prices of the outside inputs (P_5, P_6, P_7,) as given. The elimination of excess profits from the prices of iron ore and steel lowers the cost of producing metal products, providing an example of pecuniary external economies. Instead of a loss, activity X_1 now shows a profit of .15 and should be substituted for the import activity M_1. With the original prices for labor and capital, the optimum solution to the

submodel is therefore to produce all three commodities and import nothing, since all import activities are unprofitable.

Trial d. If a similar analysis is carried out for the economy as a whole, it is likely that the initial estimate of the opportunity cost of labor (equal ot its market price) will be revised. Assumed that the shadow price of labor (equal to its marginal product in the rest of the economy) is only a third of its market price, or .5 units of capital. This lower labor cost will reduce the costs of production in different activities in proportion to their use of labor, Since exports are cheapened more than steel production by this calculation, it now becomes socially profitable to import steel and produce metal products. The optimality of this solution is shown by the prices in trial d, in which there is a loss of - .03 on X_j . The optimum quantity solution is shown at the bottom of the table. Valuing other inputs and labor at their accounting prices, it has a capital cost of 5760, compared to 8200, 7470 and 7290 in trials a, b, and c.

The programming approach of trials c and d adds two elements to the analysis of accounting prices. The first is the inclusion of repercussions on input prices from investment in supplying sectors. This is one of the main types of dynamic external economies which are omitted from partial analysis. It is much more significant when there are economies of scale. The second element is the revision of the initial estimate of the opportunity costs of labor, capital, and foreign exchange. This revision is determined by the relation between supply and demand for these factors and thus takes into account the requirements of feasibility. (17)

The profitability criterion (usually called the "simplex" criterion) that is used in linear programming is logically equivalent to the SMP test if the same prices are used in both. The two can be put in a comparable form as follows:

'4a' Social profit on activity j: $$\Pi_j = \sum_i a_{ij} P_i - k_j$$

'5' SMP of investment in activity j: $$(SMP)j = \frac{\sum_i a_{ij} P_i}{k_j} = \frac{\Pi_j}{k_j} + 1$$

where $- k_j$ is used for the capital input coefficient instead of a_{ij}. An activity having a positive social profit in equation ('4a') will have an SMP of greater than 1.0 in ('5'), and the same projects would be accepted by either test. If the prices used are not the equilibrium prices, however, the project ranking by the two formulae will not necessarily be the same.

Although the example given here contained only one technique of production for each commodity, linear programming methods readily encompass alternative techniques. In a trial application of linear programming to Indian planning, Sandee -45- includes three alternative ways of increasing agricultu-

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(17) An example in which these successive adjustments are calculated in detail is given in -10- . Frisch has outlined a computational procedure for handling large numbers of investment projects without going beyond the capacity of simple calculating equipment -16- .

ral output -increased use of fertilizer, irrigation, and extension services- which are substitutes over a limited range. The four alternative techniques for producing textiles cited by Galenson and Leibenstein -17- could also be more properly evaluated in a programming model in which the cost variation associated with their different requirement for materials, maintenance, and skilled labor could be included. However, it is only necessary to include alternative techniques in a programming model when the choice between them depends on the outcome of the solution. Probabley in most cases the range of shadow prices can be foreseen accurately enough to determine in advance which technique is more efficient for a given country. The initial asumption can always be verified after the analysis has been completed by using the resulting prices.

Linear programming can be extended to include many of the indirect effects of investment that are suggested by growth theory. The production of trained labor, the effect on savings or other indifect benefits can be considered as joint outputs whose value can be specified in the objective function. Similarly, indirect costs of production, such as the provision of housing to urban workers, can be included as additional inputs. The shadow prices computed from such an expanded system will therefore reflect nonmarket as well as market interdependence to the extent that it can be specified in quantitative form.

In formal tems, it is also quite easy to extend the programming model in time and to compute future prices for commodities and factors. The measurement of social profitability could then be made against a pattern of changing future prices. Given the degree of uncertainty attached to all future economic magnitudes, however, this is not likely to be a very useful procedure beyond the customary five-year planning period except in the most general terms. It would, however, be desirable to estimate the change in the equilibrium prices of foreign exchange and labor over a longer period of time, since these are the most important variables in choosing among investment projects.

D. Investment Criteria and Comparative Advantage.

The linear programming approach provides a convenient link to the principle of comparative advantage because the optimal pattern of trade is determined simultaneously with the optimum allocation of investment. The model is considerably more general than that of market equilibrium because it allows for different social objectives and takes account of costs and benefits other than those entering the market. The limitations to the programming model are of two sorts: the form of the restrictions that are specified, and the omission of relationships that cannot be expressed in quantitative form.

The introduction of inelastic deamand or increasing costs does not create any more theoretical difficulty in a programming model than in the corresponding general equilibrium system, although the computational aspects of such models have not been widely explored. The accounting prices perform the same function as guides to proper allocation, but the test of social profitability must be applied in marginal rather than average terms. In development programs, this modification is particularly important in the case of exports, where the price elasticity of demand is often rather low.(18). As Nurkse -37- points out, marginal comparative advantge for the underdeveloped countries may for this reason be quite different from that inferred from the average costs and prices

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(18) A programming model including this feature is given in Chenery -9-

of primary experts.

The existence of increasing returns creates the same problem for the programming model as it does for equilibrium theory. Marginal-cost pricing is not sufficient to determine whether an investment should be undertaken, and the total cost of alternative solutions must also be considered. Although practical methods of solving programming models containing decreasing costs are now being developed, they do not give allocation criteria that rely only on accounting prices. It is approximately correct to say that beyond a certain output level country A has a comparative advantage in the production of steel but the pricise determination of the break-even point depends on the level of output in other sectors also.(19)

The most serious theoretical qualification to the principle of comparative advantage comes from the type of nonquantitative interdependence among sectors that is assumed by Hirschmen -23-. If, as he supposes, one growth sequence is more effective than another because it economizes on decision-making ability or provides a greater incentive comparative advantage is implied. The empirical significance of these psychological and sociological factors remains to be established, but they lead to a conflict that cannot be resolved in economic terms.

When the practical limitations on information and analysis are recognized, the possibilities of conflict between comparative advantage and growth theory are greatly increased, and Wiles -65- suggests that marginal efficiency calculations may be less important. An aversion to risk-taking may be a valid reason for limiting the extent of specialization in the export of primary products beyond the amount that would be optimum in the light of more accurate information. An inability to measure the extent of economies of scale, labor training, and other sources of external economies also makes possible a continuing disagreement as to their magnitude.

III. Comparative Advantage and Balance in Development Programs.

The inconsistent procedures that governments employ in formulating development policies are probably the most important source of conflict between the dictates of comparative advantage and of growth theory. Official pronouncements on development policy usually allege that both types of criteria have been (or should be) utilized in drawing up the program that is put forward, but the procedure followed in reconciling conflicts between the two is rarely made explicits. Since the analytical basis of most development programs is quite limited, it is important to look into the procedure that is actually used in order to discover sources of bias.

Development programs must simultaneously confront two sets of problems. In the short run, progress is hampered by structural disequilibrium in factor markets and in the demand and supply of particular commodities. This disequilibrium is reflected in the balance-of-payments difficulties that beset most low-income countries as they try to accelerate the process of development In the longer run, the choice among sectors becomes increasingly important because the pattern of growth in eahc period will depend on the choices made

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(19) The nature of sulutions to this type of problem is considered in -11-, from which the data in Table 1 were taken. In this situation of decreasing average cost, the programming model may provide a greater improvement over the solution using partial criteria.

previously. Development progfams that are influenced mainly by the existing structural disequilibrium therefore tend to stress the need for greater balance between domestic demand and supply, while those that take a longer view tend to pay more attention to comparative advantage.

Although the procedures actually followed cannot be ascertained with any accuracy by an ourside oberver, these two aspects can be indentified from characteristic elements in the analysis. The balanced growth approach is generally associated with target-setting in key sectors, stress on the avoidance of bottlenecks, and attempts to equate the supply and demand of labor, capital, and the more important commodities. The extreme cases of this type of procedure are found in the communist countries. Less extreme examples, in which some attention is paid to comparative advantage, are the procedures of the Indian Planning Commission and the U.N. Economic Commission for Latin America.

Characteristic elements of the comparative advantage approach are attempts to measure the relative efficiency of different types of production, the weighing of balance-of-payments improvements against other benefits to the economy (by means of accounting prices or otherwise), and usually a greater emphasis on partial analysis than on over-all projections. Examples that will be cited are Puerto Rico, the Phillippines, and Israel.

A. Procedures Emphasizing Domestic Balance.

The planning procedures developed in the USSR and applied with some modification in other communist countries represent in extreme form the use of balance as a criterion for resource allocation and the virtually complete omission of any test of comparative advantage. As revealed in recent studies by Montias -32- and Balassa -1-, the main tool of Soviet-type planning is a very detailed system of material balances specified in quantitative terms. Policy objectives are translated into production targets in which pricrity is given to heavy industry and other sectors that are expected to contribute to further growth ("leading links"). Prices are used mainly as rationing devices and have no necessary connection with production costs. The cumbersome calculations involved in arriving at balance of supply and demand for a large number of commodities limit the alternatives that can be tried out, so the main effort is to find a feasible program -32-.-

The question of comparative advantage scarcely arises in the USSR because of its size and diversified resources, although similar problems arise in connection with the choice of production techniques. When the Soviet planning system was transplanted to the satellite countries, however, it ran into difficulties because of its inability to determine the advantages to be secured from trade. According to Balassa -1, p. 264-, the idea of comparative advantage did not exist in Hungarian development policy (at least until very recently) although trade has a high ratio to GNP. Exports are determined by import "needs", and the institutional structure is such as to encourage exporters to meet targets for exports without regard to production costs. Since prices do not reflect resource use, it is impossible to determine where comparative advantage lies and to what extent the trade pattern deviates from the optimum.

Despite their violation of most short-term welfare consideration, the success of Soviet planning methods in producing a rapid rise in the ratio-

nal product makes them attractive to many underdeveloped countries. In India, for example, Mahalanobis' "plan-frame" for the second five-year plan -30- draws heavily on Soviet methodology. He starts from the assumption that the rate of investment is determined by the level of domestic production of capital goods: "As the capacity to manufacture both heavy and light machinery and other capital goods increases, the capacity to invest (by using home-produced capital goods) would also increase steadily, and India would become more and more independent of the import fo foreign machinery and capital goods" -30, p. 18-. His analysis implies that export possibilities are so limited that they can be ignored, so that the composition of demand is limited by the composition of domestic output. In order to raise the level of investment, Mahalanobis concludes that investment in industries producing capital goods should be increased from less than 10 per cent to 30-35 per cent of total investment in the second five-year plan.

As Komiya -27- has shown, Mahalanobis' approach to development ignores price and demand considerations completely. The targests for the four sectors in his model appear to be based mainly on the goal of creating heavy industry, which is assumend to be the key to future growth. Criteria of efficiency and comparative advantage are entirely omitted from his analysis.

Although there are traces of the Mahalanobis approach in the second and third five-year plans formulated by the Indian Planning Comission, the final results are much less extreme. One basic problem is that exports are expected to rise only half as fast as national income between the first and third plan periods, while demand for the goods initially imported tends to rise much more rapidly. The inelastic demand for traditional Indian exports means that a considerable proportion of investment must be devoted to commodities that are presently imported. Within this category, the principles of comparative advantage should apply. In actuality, the emphasis has shifted somewhat from heavy industry in the second plan to agriculture in the third. In the latter document -19-, increasing self-sufficiency in basic industrial commodities -steel, petroleum, machinery, etc.- is listed as a high priority objective, but so is the maximum development of agriculture. Whether the resulting targets are consistent with comparative advantage is not considered in the published analysis.(20)

The balance-of-payments difficulties of many Latin America countries have also been a major factor in chaping the programming procedure developed by the Economic Commission for Latin America -57-. This approach has been applied in considerable detail in studies of Colombia -58-, Argentina -59- and Peru -60-. One basic conclusion of these studies is that the growth of exports will be much slower than the growth of demand for goods that are currently imported. Investment therefore has to be heavily oriented toward import substitution, and the equality of supply and demand must be tested on a commodity basis to avoid balance-of-payments difficulties. In the three cases men-

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(20) On the basis of a simplified linear-programming model, Sandee -45, p.25- finds that "up to 1970 more effective ways to employ capital for development exist than highly capital intensive steel-making", suggewting that an analysis of comparative advantage would indicate more reliance on imports. The nonmarket benefits of production are omitted from his analysis, however.

tioned, this balancing process is carried out by means of an input-output analysis in which imported goods are distinguished from domestic products in each category.

In principle, comparative advantage can be used in the ECLA procedure as a basis for the choice of import substitutes, but this has apparently been done only to a limited degree. Since the main emphasis is on balance, there is a danger that the initial assumptions as to levels of exports will not be re-examined after the extent of import substitution required by a given program has been determined. The result may be considerably lower productivity of investment in import substitutes than in exports if the two are not systematically compared. The drawbacks to this procedure are more serious in small countries like Colombia and Peru than in a large country like India, in which imports supply a smaller fraction of the total demand for commodities.

B. Procedures Emphasizing Comparative Advantage.

Among countries having development programs, procedures that stress comparative advantage are less common than those emphasizing balance. Practically all policy statements list among their priority criteria factors presumably leading to comparative advantage, but there is little evidence as to how they are applied in drawing up programs.

The development procedures of the government of Puerto Rico come as close to being a pure application of comparative advantage as Soviet procedures are of principles of balanced growth. Unlike many lowincome countries, Puerto Rico has an elastic demand for its exports to the U.S. market and can attract U.S. capital for profitable investments. The government's policy has been to give tax remission for ten years and to provide overhead facilities, labor training, and other inducements to industries that will benefit the island's economy. In deciding which industries to promote, the Economic Development Authority has studied the long-term comparative advantage of a large number of alternative projects, since comparative advantage will lead to both satisfactory profits and maximum income. Low-cost labor (even with allowance for differences in productivity) has been the main element in comparative advantage, since most industrial materials must be imported. Allowance is also made for external economies in industries that will supply inputs to other sectors. (21)

Under this policy, the growth of per capita income has been as rapid (nearly 5 per cent annually) and the development of industry as marked (from 19 per cent to 25 per cent of GNP) over the years 1948-1958 as in any country following a deliberate policy of balanced growth. The planning procedure depends very largely on the particular relation of Puerto Rico to the United States and its small size. These factors make it unnecessary to worry about the elasticity of demand for exports or the dangers of dependence on foreign sources for essential imports, which so preoccupy the Indian and Latin American planners. With reliable export and import markets, domestic balance is not a problem.

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(21) The Puerto Rican experience is discussed by Baer -2-; the evaluation procedures are described in mimeographed reports of the Economic Development Authority.

Since the assumption of the classical model are not approached so closely in most underdeveloped countries as in Puerto Rico, the calculation of comparative advantage usually departs farther from the market evaluation. In a more typical case the Philippine National Economic Council has outlined a procedure for applying the SMP formula under Philippine conditions -39-. This analysis starts from the market evaluation of the profitability of an investment and adds corrections for the project's effect on the balance of payments, its use of domestic materials, and its use of domestic labor, each with a suitable weight. This procedure may be justified by comparison to the linear programming criterion of social profit. In principle the proper correction to private profit is obtained by giving each a value equal to the difference between its shadow price and its market price.(22). In the Philippines, this would mean a bonus for labor and a penalty for foreign exchange use (or a bonus for foreign exchange saving). Higgins -22-,pp.654-62- shows that the weights assigned in the Philippines tend to exaggerate these effects. The use of the same weight for all domestic materials may lead to serious error, since not all are overvalued by market prices.

The government of Israel has developed one of the most systematic procedures for measuring comparative advantage as a basis for allocating investment funds and foreign exchange. In effect, the Ministry of Finance evaluates projects on the basis of accounting prices for foreign exchange and capital, taking into account the indirect use of foreign exchange in sectors supplying inputs such as power or industrial materials. The calculation is summed up as the cost in domestic resources of a dollar earned or saved, and it is applied equally to exports and to import substitutes. The calculation of domestic value added is also made by exporters as a basis for export subsidies -3,p.23-. In allocating the government's development budget, priority is given to projects whose domestic cost of earning or saving foreign exchange is less than the current estimate of its accounting price. This procedure can also be rationalized by means of the linear programming criterion of investment with acounting prices for foreign exchange and labor, as in the SMP formula, the cost per unit of foreign exchange acquired is computed using an accounting price for capital . When the same shadow prices are used, all three measures give the same result.

Although it is dangerous to generalize from the limited evidence on development policies that is available, there appears to be some relation between the type of procedure adopted and the characteristics of the economy in a number of the cases examined. Small countries are forced to pay more attention to comparative advantage because they cannot hope to produce the

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(22) The social profit, Π_j , may be expressed as:

'4b' $$\Pi_j = \bar{\Pi}_j + \sum a_{ij} \Delta P_i$$

where $\bar{\Pi}_j$ is private profit per unit of output calculated at market prices and ΔP_i is the difference between the market price and shadow price of commodity i. The elements ΔP_i may be regarded as weights attached to each input or output coefficient.

whole range of manufactures and primary products, while large countries may be tempted to follow more autarchic policies.(23) The importance given to balanced growth also depends to a large extent on the country's recent experience with its export markets and the state of its foreign exchange reserves and borrowing capacity. Puerto Rico and Israel can both count on substantial capital inflows which make it unnecessary for them to approach balanced trade in the near future, while India has much less leeway.

IV. Conclusions

This paper has considered development policy from the standpoint of economic theory, as a problem in operations research, and as it is actually carried on by governments. Much of the confusion in the field stems from a failure to distinguish these different levels of analysis. Theorists are prone to suggest decision rules that omit some of the relevant institutional limits, while economists who have been working in particular areas often arrive at conclusions that do not fit other cases. As in other fields of economics, most of the disagreement can be traced to implicit differences in assumptions.

There are a number of contradictions between the implications of trade theory and growth theory. To make the two theories consistent, it is necessary to discard the assumption of equilibrium in factor markets, to allow for changes in the quantity and quality of factors of production over time, and to take account of internal and external economies of scale. Although under these assumption market forces do not necessarily lead to efficient resource allocation, a pattern of production and trade can be determined that maximizes income over time. The commodities to be produced and traded cannot be determined by a simple ranking procedure along the lines of classical comparative advantage because of the interdependence among sectors. At best, it may be possible to say, for example, that a country has a comparative advantage in steel production for a specified set of production levels in supplying and using sectors. In advanced countries, this qualification may be unimportant, but in the less developed ones it is crucial in a number of industries.

Much of the attack on the use of comparative advantage is based on its omission of various nonmarket elements. It is assumed that the inclusion of the latter favors the development of industry, and special benefits are often attributed to capital goods and heavy industry. The intangible benefits stemming from trade in the form of new products, improved technology, and technical assistance tend to be overlooked in this discussion. Although I support the critics who wish to include more of growth theory in determining the desirability of specialization, I doubt that this extension will favor balanced growth to the extent that they suppose.

The other main theoretical attack on comparative advantage is aimed at its supposed support for continued specialization in primary exports. Granting the low elasticity of demand for many primary products, it is wrong to conclude that comparative advantage is thereby superseded by principles of balanced growth. The increasing shortage of foreign exchange makes it even more

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(23) Japan is one exception to this generalization, partly due to its dependence on imported raw materials.

important to economize on its use and to seek efficient ways for increasing its supply. The comparison of domestic to foreign sources of supply that is implied by comparative advantage is no less relevant to this situation than to the case in which investment is more evenly divided between exports and import substitutes.

The aspects of growth theory which do not seem to be reconcilable with the notion of comparative advantage are the sociological and political effects of choosing one production pattern instead of another. While the concept of opportunity cost can be extended to include a number of nonmarket phenomena, such as labor training and overhead facilities, it can hardly be stretched to cover differences in fertility rates or political attitudes. So far as I can see, in the present state of knowledge of social phenomena, considerations such as these may be used to modify the results of economic analysis but can not be directly incorporated into it.

At the level of operations research, the search for simple decision rules for investment in low-income countries seems to have been useful mainly in exposing the fallacies in some of the common rules of thumb. One can specify conditions under which ratios such as the capital intensity or the effect on the balance of payments would be a valid indicator of the desirability of an investment, but the apparent gain in simplicity is offset by the danger of applying the test in inappropriate circumstances. A more fruitful approach to partial equilibrium analisis is provided by the use of resources. This method allows simultaneously for several overvalued or undervalued inputs, and it cam include whatever elelemts of general equilibrium analysis are available.

Since market forces cannot be relid on to balance supply and demand un conditions of initial disequilibrium and accelerated growth, a principal concern of development policy is to ensure the consistency of production levels with commodity demands and factor supplies. The technique of linear progfamming is designed to combine the test of consistency with the test of the social profitability of a given resource use. Although it cannot be applied very extensively in underdeveloped countries as yet, the programming methodology serves as a guide to improved practical measures.

To most economists, a survey of the procedures actually followed in designing development policy would probalby suggest that balance is overemphasized and by an aversion to risk that is greater than seems warranted to the outside observer. Better understanting of the working of the underdeveloped economies and better information for planning is needed to redress the balance and enable countries to secure the potential gains from trade without conflict with measures for domestic development.

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