

Allocation of Industries in Integration Schemes Among Less Developed Countries

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One of the most important problems to be resolved in integration schemes among LDCs is that of the distribution of the resulting benefits.¹ In these integration projects the participating countries are often more interested in the benefits resulting from import substituting industrialization on an area wide level than from the benefits resulting from trade creation as presented in the traditional customs union theory. In this instance the location of industries will not be left to the market because the relatively less developed countries fear that industry would choose to locate in the relatively more developed countries where there is already evidence of growth poles.² Acceptable distribution of benefits is a crucial element of the problem. Thus, the problem generally reduces to one of allocating industries among the participating countries. The very limited interest of the LDCs in the static gains from integration, analyzed by such writers as Jaber, Cooper and Massell, is explained by the limited pre-integration trade, the high transport costs between countries and the relatively low tariffs on primary commodities, which limit the benefits derived from trade creation as developed in the customs union theory by Viner.³

Since negotiated allocations are not necessarily optimal and *also difficult to achieve*,⁴ it is important that a methodology be

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1 Morawetz (1974), pp. 72-96 and pp. 111-119. Jaber (1971), pp 254-67.

2 Perroux (1970), pp. 93-103; and Garbacz (1971).

3 Viner (1950).

4 The difficulty in arriving at negotiated solutions is clearly evidenced by the experiences of the integration schemes that set out to assign industries. See Morawetz (1974), pp. 111-119.

developed to assist in the allocation of industries among participating countries. One approach to this problem, that taken by Schydrowsky, utilized a linear programming model designed to maximize the net benefits to the region subject to distributional constraints.⁵ The benefits to be maximized were defined as the difference between the net foreign exchange saved (i.e., gross foreign exchange saved less the value of the intermediate traded inputs) and the real foreign exchange value of the factors of production employed. The model, while attractive because it efficiently solves the industrial location problem, is difficult to implement in practice because of its tremendous data requirements.⁶ It did, however, lay some important groundwork.

The purpose of this paper is to develop a more operational model to assign industries to the participating countries in integration schemes among less developed countries (LDCs).⁷ It is designed on the basis of the domestic resource cost (DRC) investment criterion developed by Bruno and Krueger and is formulated to minimize the cost of supplying the area with the products of the industries to be assigned subject to certain specified distribution constraints. It is essentially equivalent to Schydrowsky's approach although the objective function is presented in terms of theoretically equivalent measures that can be more easily calculated. Furthermore, the model can be implemented in practice to yield approximate results to serve as the basis for further negotiations among the participating countries by the utilization of the effective rate of protection (ERP) which does not require the estimation of shadow prices for goods and factors.

The paper is organized in the following way. In the first section Schydrowsky's benefit criterion is formulated in terms of the DRC criterion. The second section is devoted to the formulation of two alternative objective functions that can be used to allocate industries depending on the availability of an estimate of the shadow exchange rate and on the restrictiveness of the constraints. Several possible distributional constraints are presented in the third sec-

5 Schydrowsky (1971), pp. 299-307.

6 Morawetz (1974), pp. 83-84.

7 The model is best suited for allocating industries in the Andean Common Market since it is the integration scheme which has most explicitly recognized the interest of the participation countries in the new opportunities for industrialization through its formulation of sectoral programs for industrial development. Nevertheless, it can also be applied to schemes with specific provisions for integration industries (Central American Common Market), complementation agreements (Latin American Free Trade Area), industrial coordination (Communaute Economique de l'Afrique de l'Ouest), or industrial location (East African Common Market).

tion, and in the final section several limitations of the model are briefly discussed.

I. The DRC Criterion and the ERP

Utilizing the benefit definition presented by Schydlosky, and assuming that the home inputs⁸ do not have imported components, the benefits to be derived from the production of one unit of output in industry *i* assigned to country *k* can be expressed as:

$$1. \quad B_i^k = P_i - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g - \left[\sum_{j=1}^J v_{ji} s_j + \sum_{g=1}^{G_i^k} a_{gi} P_g \right] \cdot \frac{1}{SER}$$

Where:

goods $g = 1 \dots G_i^k$ are home goods.

$g = G_i^k + 1 \dots H$ are tradable goods.

B_i^k = net benefit of project *i* in country *k*

P_i = shadow price of good *i*

P_g = shadow prices for good inputs

a_{gi} = physical input coefficients for goods

v_{ji} = physical input coefficients for factors

s_j = shadow prices for factors

SER = shadow exchange rate (units of domestic currency per dollar)

Equation 1 represents the Social Marginal Productivity criterion and requires that the net benefits be greater than zero for a project to be acceptable. If the shadow prices of the tradable goods are taken to be the international prices, following Little and Mirrlees,⁹ then the benefits are given by the difference between the international value added and the domestic value added evaluated at the shadow exchange rate. The measure of domestic value added, computed using shadow prices for goods and factors, comprises home goods. Thus, the net benefits of an industrial project at the margin can easily be computed providing that shadow prices derived from a full general equilibrium intertemporal optimizing model are given.

⁸ Home goods are goods not usually traded because of their high transport costs.

⁹ Little and Mirrlees (1968).

The same ranking of projects is obtained if Equation 1 is written in terms of the DRC criterion, i.e., the ratio of the domestic value added to the international value added. This can be shown by setting B_i^k equal to zero and noting that the following expression derives:

$$2. \text{DRC}_i^k = \frac{\sum_{j=1}^J v_{ji} s_j + \sum_{g=1}^{G_i^k} a_{gi} P_g}{P_i - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g}$$

If the benefits, B_i^k , are zero, the DRC will be equal to the shadow exchange rate for country k . If the benefits are greater than zero, however, the DRC will be less than the shadow exchange rate and therefore it is immaterial whether a project is judged on the basis of B_i^k being greater than zero or DRC_i^k being smaller than the shadow exchange rate.

The second numerator term of equation 2 represents the indirect value added by the domestic factors vis-a-vis the utilization of home good inputs. Because the value of the home goods is equal to the sum of the costs of the inputs used in their production, the second numerator term can be expressed in terms of the input coefficients for home goods, and the shadow prices of the factors of coefficients for home goods, the factor inputs utilized in the production of home goods, and the shadow prices of the factors of production. Equation 2 can then be rewritten as:

$$3. \text{DRC}_i^k = \frac{\left(\sum_{j=1}^J v_{ji} s_j + \sum_{g=1}^{G_i^k} \sum_{j=1}^J a_{gi} v_{jg} s_j \right)}{P_i - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g}$$

The DRC criterion, which ranks projects according to the domestic resource cost of earning or saving a unit of foreign exchange, is employed to allocate industries in a multi-country situation for two reasons. First, "the DRC criterion is an explicit expres-

sion of the comparative cost principle in international trade".¹⁰ Thus, in allocating industries among countries on the basis of comparative advantage, the computations are not affected by the presence of distorted exchange rates.¹¹ Second, the DRC criterion corresponds to the Corden effective rate of protection measure (+1) which in practice permits the approximate estimation of DRCs on the basis of international prices and tariffs rather than shadow prices.¹² Since the DRCs can not be practically computed for a large number of industries because of the lack of adequate shadow prices for the factors of production in the various countries and the absence of detailed input-output data for the various industries producing domestic inputs, it is operationally necessary to resort to this alternative measure.

There has, however, been a considerable controversy on the equivalence of the two measures and the conditions for their identity. Krueger states that the DRC and ERP measures are identical only if the following conditions are met: "(1) all goods are traded (or tradable); (2) there are no transportation costs; (3) factors of production are perfectly mobile within the domestic economy but perfectly immobile internationally; and (4) all domestic markets are perfectly competitive".¹³ The first of Krueger's assumptions is redundant according to Balassa and Schydrowsky¹⁴ because in the absence of transportation costs all goods are tradable. More importantly, Balassa and Schydrowsky discuss the need to also assume that the country use an optimal set of tariffs and export taxes to equate the domestic product prices to marginal revenue from import substituting and exporting. Therefore, given Balassa and Schydrowsky's assumption and that Krueger's third and fourth assumptions hold, one issue is whether the DRC and ERP measures are equivalent if transportation costs are not zero and consequently there are nontraded goods.

Krueger stated that the DRC and ERP measures would be different if there were home goods. This would indeed be the case if the ERP were computed using the Balassa method. This ERP measure is given by the ratio of the difference between only the direct domestic and international values added to the direct inter-

10 Bruno (1972), p. 21.

11 An allocation based on comparative advantage does not necessarily minimize the cost of supplying the region with the products of the allocated industries unless all industries are of the same size. This topic will be examined in the next section.

12 The comparability of the DRC and the ERP has been discussed recently by Srinivasan and Bhagwati (1978), pp. 97-116.

13 Krueger (1972), p. 54.

14 Balassa and Schydrowsky (1972), p. 67.

national values added. With the Balassa method the domestic value added is given by the difference between the domestic price of output and the domestic value of all non-primary inputs, both tradable and home goods. The domestic value of the home goods is given by the sum of the domestic value of the tradable inputs that enter into the production of nontraded goods and the value of the pure home goods and of the primary factors that are utilized in the production of these goods. The international value added is obtained by subtracting the value of home goods, valued at international prices, from the difference between the international price of output and the value of the sum of tradable inputs valued at international prices.

The Corden method differs from the Balassa method in that in the former the domestic value of the non-traded goods that enter as inputs to the production activity are included in the total domestic value added measure of the activity. That is, the Corden method uses a total rather than a direct measure of domestic value added. Similarly the measure of international value added includes the international value of the domestic resources employed in the production of the non-traded inputs. The ERP (+1) measure computed by using the Corden method will be equivalent to the DRC given that there are no foreign factors of production, that markets are in perfect competition and that tariffs and export taxes are optimal. Thus the domestic resource cost measure given by equation 3 can be written as:¹⁵

$$4. \text{DRC}_i^k = \frac{P_i(1+t_i^k) - \sum_{g=1}^{H_i} a_{gi} P_g (1+t_g^k) + \sum_{g=1}^{G_i^k} a_{gi} P_g (1+t_g^k)}{P_i - \sum_{g=1}^{H_i} a_{gi} P_g + \sum_{g=1}^{G_i^k} a_{gi} P_g}$$

$$= \text{ERP}_{\text{Corden}} + 1$$

¹⁵ The Balassa measure of ERP would be given as:

$$\text{ERP}_{\text{Balassa}} = \frac{P_i(1+t_i^k) - \sum_{g=1}^{H_i} a_{gi} P_g (1+t_g^k)}{P_i - \sum_{g=1}^{H_i} a_{gi} P_g}$$

where:

$g = 1, \dots, H_i$ - all inputs into i .

$g = 1, \dots, G_i^k$ - domestic inputs into i in country k .

DRC_i^k = domestic resource cost of a unit of foreign exchange earned in industry in country k .

P_i = international price of good i .

t_i^k = tariff on good i in country k .

a_{gi} = physical input coefficient.

The first two terms in the numerator of equation 4 represent the direct value added by the domestic factors of production and are equivalent to the first term of equation 3. The third term in equation 4 is the same as the second in equation 3 and represents the indirect value added by the domestic factors through the production of home inputs for industry i . The denominator in equation 4 represents the total value added by the domestic factors valued at international prices.

Further complications arise if import tariffs and exports taxes are allowed to be non-optimal. In the presence of intermediate inputs, the existence of tariffs, like transport costs, makes possible the domestic production of inputs that would otherwise be imported. Again there are differences between the Balassa and Corden methods of estimating the effective protective rate. As pointed out by Balassa and Schydrowsky if there were not transport costs and no non-optimal tariffs and taxes there would be no home goods and it would not matter whether the project was evaluated on the basis of processing costs in the last stage of fabrication or on the basis of combined costs at all stages.¹⁶ If the given conditions are not met, however, the direct and total measures of domestic resource cost will not be equal. This situation results from the fact that the market prices for goods and factors will no longer equal the shadow prices. Thus in the evaluation of projects, those with high priced inputs will be discriminated against if a total rather than a direct domestic resource cost measure is taken. Balassa argues that this measure of ERP, which measures only direct domestic resource cost at the last stage of fabrication, should be the appropriate project selection criterion because it does not penalize projects because of the high priced inputs that are possible because of transport costs and non-optimal tariffs. However, he notes that the total domestic resource cost measure, proposed by Bruno and Krueger and equivalent to Corden's ERP implicitly assumes: "(a) all existing industries will be maintained, (b) the expansion of the out-

16 Balassa and Schydrowsky (1972), pp. 65-69.

put of any one industry will bring forth increased output of all domestic industries providing direct and indirect inputs into it (i.e., the direct and indirect marginal input coefficients of domestic resources and of imports taken to equal the corresponding average coefficients), and (c) costs in input producing industries will continue at existing levels."¹⁷ Since it is feasible that changes in the domestic demands could well be satisfied by domestic firms in many LDC's, these restrictions do not appear formidable.¹⁸ Simply restricting production change to domestic industry is not, however, sufficient to guarantee that the total domestic resource concept is appropriate for the task at hand.

It is also important to note that if non-optimal tariffs and export taxes are applied, the market prices of the domestic factors of production will no longer equal their opportunity costs or shadow prices. Balassa and Schydrowsky point out that in a situation with non-optimal tariffs and taxes, "shadow prices will reflect neither the marginal social costs of inputs into the projects nor the marginal social utility of its output."¹⁹ Therefore, the DRC calculated from shadow prices for factors of production (equation 3) will no longer be equivalent to the DRC calculated using the prices of goods (equation 4). This is supported by Srinivasan and Bhagwati who have shown that in a simple trade model with primary factors producing traded goods, no intermediate goods, fixed international prices for the traded goods and a well behaved social utility function, distortions in the domestic price ratios resulting from tariff or trade subsidies produce an "inherently second best" problem.²⁰ In such an instance, correct ranking of projects utilizing the DRC measure occurs only if second best shadow prices of factors are used. Further, any measure such as the ERP or DRC which uses market prices of the goods will be inappropriate to the task. The DRC measure utilizing market prices is, however, shown to be equivalent to the ERP measure in the distorted case. Ideally, then, "in making decisions on projects one should therefore use second-best shadow prices reflecting marginal social costs and utilities under existing policies, with adjustment

¹⁷ Balassa (1974), p. 46.

¹⁸ Not only does there appear to be excess capacity in the industries or many LDC's, but there are instances where policy decisions would appear to encourage such behavior. For example, the countries of the Andean Common Market have retained the ability to protect local industries according to the Cartagena Agreement. With respect to excess capacity and the capacity to produce more with the given resources please see: Morgan (1975), p. 381, Leibenstein (1966), pp. 392-4 and Bruton (1967).

¹⁹ Balassa and Schydrowsky (1972), pp. 63-69.

²⁰ Srinivasan and Bhagwati (1978).

made for prospective policy changes."²¹ These second-best shadow prices should be derived from a full general equilibrium system incorporating the present policies. The acquisition of such shadow prices is, however, very difficult, if not currently impossible.

Because of the difficulty in practice in finding appropriate shadow prices, Balassa and Schydlosky suggest that projects be ranked by direct DRC's evaluated at market prices.²² The total DRC can also be computed from market prices for the primary factors of production by using equation 3. However, this computation would be feasible for only a very limited number of projects in any country because of the difficulties of getting data (prices as well as production coefficients) for detailed activities where the primary factors could be subdivided and reclassified into any number of specialized subgroups. Therefore, in practice it appears preferable to calculate the DRC's using the approximate market prices for goods given by the international prices plus tariffs. That domestic prices do indeed reflect international prices plus tariffs is not only a firmly held principle in theory but is also suggested, at least for relatively basic homogeneous goods, by N. R. Norman's study of domestic price responses to changing tariffs in Britain.²³

It should be noted further that the Corden measure of effective protection and the resulting DRC can be altered so as to allow for the use of foreign capital and the international movement of factors. Assuming that no imported capital or foreign factors are used in the production of home goods, rewriting equation 3 as a benefit equation like 1, letting imported capital be the J th factor with a domestic price of K , and letting foreign factors be the first factor with a repatriated return of s_2^k , the following expression is obtained:

$$5. \text{DRC}_i^k = \frac{\sum_{j=2}^{J-1} v_{ji} s_j + \sum_{g=1}^{G_i^k} \sum_{j=1}^J a_{gi} v_{jg} s_j}{P_i - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g - v_{Ji} K r^k - v_{2i} s_2^k}$$

21 The comparability of the DRC and the ERP has been discussed extensively in the literature. See Balassa and Schydlosky (1972), pp. 63-69. Balassa and Schydlosky (1968), pp. 348-360. Bruno (1972), pp. 16-33. Findlay and Wellisz (1976), pp. 543-552.

22 This alternative is based on the assumption that nonoptimal measures of protection have not affected the relative prices of primary factors other than foreign exchange. However even though non-fulfillment of this assumption will introduce estimation errors, the choice of a project on such a basis may nonetheless, in certain cases, be a correct choice.

23 Norman (1975), pp. 426-439.

where

DRC_i^k = the domestic resource cost of a unit of foreign exchange saved or earned.

v_{ji} = the amount of factor j necessary for the production of one unit of good i in physical units.

s_j = the shadow price of factor j .

a_{gi} = the amount of input g necessary for the production of one unit of good i in physical units.

v_{jg} = the amount of factor j necessary for the production of input good g .

P_i = international price of good i .

P_g = international price of good g .

v_{ji} = amount of imported capital necessary for the production of one unit of i .

K = international price of capital.

r^k = rate of return to capital in country k .

v_{2i} = amount of factor 2, foreign factors, employed in the production of input good g .

s_2^k = repatriated return to foreign factors of production in country k .

$g = 1, \dots, G_i^k$ - domestic goods utilized in the production of good i in country k .

$g = G_i^k + 1, \dots, H$ - imported goods utilized in the production of good i in country k .

In order to allow for imported and foreign owned factors of production their contributions to value added were subtracted from both the numerator and denominator of the original expression for DRC. Upon making these corrections

$$6. DRC_i^k = \frac{P_i(1+t_i^k) - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g (1+t_g^k) - v_{ji} K r^k - v_{2i} s_2^k}{P_i - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g - v_{ji} K r^k - v_{2i} s_2^k}$$

Where:

t_i^k = tariff on good i in country k .

t_g^k = tariff on input good g in country k .

In order to simplify the derivation of equation 6 two assumptions were made. First, it was assumed that no tradable inputs were

used in the production of home good inputs. Second, it was assumed that imported capital and foreign factors of production were not utilized in the production of home goods utilized as inputs to the production of final good *i*. These two assumptions can be relaxed by allowing for the contributions to value added attributable to tradable inputs, imported capital and foreign factors of production. Thus, the sum of the contributions through the different stages of production of home goods are subtracted from the numerator and denominator of equation 6 to obtain.²⁴

$$7. DRC_i^k = \frac{P_i(1+t_i^k) - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g (1+t_g^k) - v_{ji} K r^k - v_{2i} s_2^k - Y_{in}^k - L_i^k - F_i^k}{P_i - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g - v_{ji} K r^k - v_{2i} s_2^k - Y_{id}^k - L_i^k - F_i^k}$$

Where:

DRC_i^k = the domestic resource cost of a unit of foreign exchange saved or earned.

v_{ji} = the amount of factor *j* necessary for the production of one unit of good *i* in physical units.

s_j = the amount of input *g* necessary for the production of one unit of good *i* in physical units.

v_{jg} = the amount of factor *j* necessary for the production of input good *g*.

P_i = international price of good *i*.

P_g = international price of good *g*.

v_{ji} = amount of imported capital necessary for the production of one unit of *i*.

K = international price of capital.

r^k = rate of return to capital in country *k*.

v_{2i} = amount of factor 2, foreign factors, employed in the production of input good *g*.

s_2^k = repatriated return to foreign factors of production in country *k*.

Y_{in}^k = value added contributed by the tradable inputs valued at domestic price utilized in the production of home goods in country *k*.

²⁴ In practice it may not be necessary to proceed backward very far along the production process of home goods since the sums of the contributions due to tradeable inputs, imported capital and foreign factors are subtracted from both numerator and denominator and will therefore generally tend to cancel.

Y_{id}^k = value added contributed by the inputs valued at international prices utilized in the production of home goods in country k.

L_i^k = value added contributed by imported capital through the production of home goods.

F_i^k = value added contributed by foreign factors of production through the production of home goods.

$g=1, \dots, G_i^k$ - domestic goods utilized in the production of good i in country k.

$g=G_i^k + 1, \dots, H_i$ - imported goods utilized in the production of good i in country k.

The last of Krueger's requirements for the equivalence of DRC an ERP + 1 was that perfect competition existed in both the factor and goods markets. The relaxation of this assumption allows the divergence between the shadow prices generated by a full general equilibrium system and the market prices. This provides a further reason to evaluate projects utilizing DRC's calculated from goods prices as ERP + 1 rather than directly from market prices for factors of production since the latter can not be traded and therefore their prices are likely to be more distorted.

Finally, in allocating industries among member countries in a free trade area it is necessary to consider transport costs between producing and consuming countries. The transportation costs incurred in shipping goods from one country to other countries per unit of foreign exchange saved or earned have to be added to the DRC of each member country for each industry. This is accomplished by adding the following expression to the DRC:

$$8. \quad c_j^k = \frac{(\sum_j \sum_k e^{kj} D_i^j) f}{P_i - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_i - (v_{Ji} + \sum_{g=1}^{G_i^k} a_{gi} v_{Jg}) Kr^k - (v_{2i} + \sum_{g=1}^{G_i^k} a_{g1} v_{2g}) s_2^k}$$

Where:

c_i^k = transportation cost per unit of foreign exchange saved or earned.

e_i^{kj} = cost of transportation of good i from country k to country j.

D_i^j = the amount of good i demanded by country j as a fraction of the total amount of good i demanded.
 f = reciprocal of economy wide shadow exchange rate.

A DRC measure has thus been derived which is of operational value to decisions regarding the allocation of industries between member countries within an economic union. The next section deals with the choice of the objective function adopted in the decision making process.

II. The Objective Function

The industries can be assigned to the countries in a manner that minimizes the costs of supplying the region with the products of the given industries or they can be assigned on the basis of comparative advantage. In either case, they are assigned with an integer program designed to minimize an objective function subject to distributional constraints. An integer program is used in order to assign whole industries to the various countries so that advantage may be taken of economies of scale.²⁵

In order to formulate an objective function to minimize the costs of supplying the region with the products of the assigned industries it is necessary to convert the DRCs by the shadow exchange rates. These standardized DRCs, denoted as x_i^k , are multiplied by the relative weights of the industries, given as the ratio of the international value added in the package of industries to be allocated. The total international value added in one industry is defined as the product of the international value added the production of one unit and the number of units required.²⁶ Thus, the objective function of an integer program designed to allocate industries sub-

25 In the formulation of the objective function it is implicitly assumed that economies of scale more than outweigh transport costs so that only one country can be the recipient of one industry. This assumption is necessary for two reasons. First, if the various countries were allowed to produce the same product it would be impossible to formulate non-exclusive constraints in order to satisfy the condition that one market be satisfied by only one source. That is, it would be impossible to eliminate the possibility that one country would produce for itself and at the same time import the same product. Second, even if the problem of mutually exclusive constraints could be solved by the judicious selection of constraints, the size of the integer program to be resolved would become unmanageable given the existing solution methods for integer programming problems.

26 Since the model allows for different amounts of international values added in the various industries in the various countries it may be necessary to compute the total international value added for the package of industries on the basis of the average of the international values added in the various countries for each industry.

ject to constraints is formulated as:

$$9. \text{ Minimize } \sum_k \sum_i x_i^k \frac{W_i}{W_T} Z_i^k$$

Where:

- x_i^k - stands for the domestic resource cost of producing one unit of good i in country k divided by the shadow exchange rate.
- W_i - total international value added in industry i .
- W_T - total international value added in all industries to be assigned.
- Z_i^k - dichotomous variable taking on the value of one or zero depending on whether industry i is assigned to country k or not.

The objection that may be raised against the utilization of the objective function presented above is that the assignment may be affected by the use of distorted shadow exchange rates. Although a valid criticism, it must be noted that any inaccuracies caused by the use of distorted exchange rates are attenuated by the fact that the objective function is restricted by distributional constraints. The more restrictive the constraints in terms of minimum assignments to the countries, the less the distortion.

The inaccuracies introduced by the use of a distorted shadow exchange rate can be avoided by allocating the industries on the basis of comparative advantage since on this basis it is not necessary to standardize the DRCs to the same units. Furthermore, an allocation on the basis of comparative advantage also obviates the problem of distortions caused by different levels of non-tariff protection in the various countries²⁷ since these non-tariff restrictions may be viewed as distortions of the shadow rate of foreign exchange.

In order to assign the industries on the basis of comparative advantage it is necessary to minimize the product of the DRC for the various industries across the various countries. Thus, the objective function of the integer program is written as:²⁸

²⁷ It is assumed that the levels of non-tariff protection are equal across all goods in any one country.

²⁸ The minimum product criterion is turned into a minimum sum problem by the use of logarithms. See Jones (1961), pp. 161-175.

$$10. \text{ Minimize } \sum_k \sum_i Z_i^k \ln \text{DRC}_i^k$$

Where:

DRC_i^k - stands for the domestic resource cost of industry i in country k .

Z_i^k - dichotomous variable.

The assignment with respect to comparative advantage does not necessarily minimize the cost of supplying the area with the products of the package of industries to be allocated. This results because the DRCs are not weighted by the relative values added in the various industries.

In allocating the industries of a particular program a choice must therefore be made between a model with a cost minimizing objective function and a model that assigns industries on the basis of comparative advantage. This choice is complicated by the fact that an assignment on the basis of production efficiency does not necessarily represent an assignment that minimizes the cost of supplying the area with the program's products. The guidelines for selecting the appropriate program are presented in Table I.

Table I
SELECTION OF THE ALLOCATION PROGRAM

Exchange Rate	Industry Sizes	Program
Accurate	Unequal	Cost Minimization
Distorted	Equal	Comparative advantage
Accurate	Equal	Either of the two with identical results.
Distorted	Unequal	Neither of the two. (negotiated solution except if export oriented in which case the comparative advantage program should be used).

The choice of program, for a given size industry and a given accuracy of the exchange rate, remains unchanged in Table I if it is envisioned that the countries expect to export to third countries

rather than just meet regional demands except in the fourth case. In the fourth case, given a distorted exchange rate and industries of unequal size, the comparative advantage program should be used if it can be assumed that the objective of the countries is to export to third countries after the regional demands are met. If the objective is just to satisfy the domestic market, neither of the two programs is appropriate in the fourth case and the best that can be suggested is a negotiated solution between the assignments made by the two programs.

III. The Distributional Constraints

The participating countries of a free trade area in which sectoral programs of industrial development are implemented may have divergent views with respect to the benefits to be derived from these programs. Thus, it could be conceived that the various countries could view their benefits as consisting of industrialization, increases in income, increases in investment, improvements in the balance of payments, technological advancement or the generation of employment. Furthermore it is also possible to envision any number of distributional constraints since there are no guidelines for the adoption of a "generalized" constraint which would lead to the optimal distribution of benefits. The only generally accepted position on the problem of benefit distribution is the normative stipulation that the poorer members should receive somewhat more than their proportional share of benefits. Given this "base" position, several distributional constraints are now developed that would appear acceptable to all members.

The simplest allocation of industries in a free trade area would be achieved by assigning to each country an equal number of industries. This would probably be a very acceptable distribution if all countries had equal populations and equal incomes and all industries were equally important. If however, population sizes and incomes are not equal for all countries, then the poorer countries with lower than average per capita incomes would prefer an allocation scheme based on population while the richer countries with greater than average per capita incomes would favor a scheme based on country incomes. Therefore, without introducing normative distributional weights, the upper and lower bounds of acceptable distributions for the richer and poorer countries can be formulated. Given the aforementioned normative stipulation, the lower bound for the poorer countries would be a repartition accor-

ding to the countries' incomes. This lower bound imposed by the poorer countries is also the upper bound for the richer ones. Thus, the most the rich countries could expect would be a system of distribution that determined the numbers of industries to be assigned to the countries on the basis of the countries' incomes. The likely bound on number of industries assigned acceptable to the richer countries (hence the upper bound for the poorer ones) would be given by an allocation proportionate to population. Thus, if the poorer countries are $m = 1, \dots, K^*$ and the richer are $m = K^* + 1, \dots, K$ then the two constraints on the numbers of industries allocated to the countries can be written as:

a) lower bound for countries with smaller than average incomes per capita

$$11. \sum_i Z_i^k \geq \frac{Y^k}{Y^M} \sum_k \sum_i Z_i^k$$

for all $m = 1, \dots, K^*$

b) lower bound for countries with larger than average incomes per capita

$$12. \sum_i Z_i^k \geq \frac{\text{pop } k}{\text{pop } M} \sum_k \sum_i Z_i^k$$

for all countries $m = K^* + 1, \dots, K$

Z_i^k = dichotomous variable taking on the value of one or zero depending on whether industry i is assigned to country k or not.

Y^k = income of country k .

Y^M = income of the free trade area.

pop k = population of country k .

pop M = population of the free trade area.

The number of industries assigned a country represents only a very rough index of the benefits gained from a particular distribution. More realistically the member countries would probably be more interested in the increases in incomes to be expected from the industries received. These gains in incomes can be proportional to the gains in value added due to the establishment of the integration industries and therefore it is sufficient to set guidelines for the distribution of these values added. As in the case of the number of

industries constraints, only upper and lower distributional bounds can be formulated. The lower bound acceptable to the relatively richer countries would be given by an assignment of gains in incomes proportional to populations. The lower bound acceptable to the relatively poorer countries would be set by an allocation according to income. These constraints would be expressed as:

a) lower bound for countries with smaller than average incomes per capita

$$13. \sum_i [P_i (1 + t_i^k) - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g (1 + t_g^k) - (v_{Ji} + \sum_{g=1}^{G_i^k} a_{gi} v_{Jg}) Kr^k - (v_{2i} + \sum_{g=1}^{G_i^k} a_{gi} v_{2g}) s_2^k] Z_i^k D_i \geq$$

$$\frac{Y^k}{Y^M} \cdot \sum_k \sum_i [P_i (1 + t_i^k) - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g (1 + t_g^k) - (v_{Ji} + \sum_{g=1}^{G_i^k} a_{gi} v_{Jg}) Kr^k - (v_{2i} + \sum_{g=1}^{G_i^k} a_{gi} v_{2g}) s_2^k] Z_i^k D_i$$

for all $m = 1, \dots, K$

b) lower bound for countries with larger than average incomes per capita

$$14. \sum_i [P_i (1 + t_i^k) - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g (1 + t_g^k) - (v_{Ji} + \sum_{g=1}^{G_i^k} a_{gi} v_{Jg}) Kr^k - (v_{2i} + \sum_{g=1}^{G_i^k} a_{gi} v_{2g}) s_2^k] Z_i^k D_i \geq$$

$$\frac{\text{pop } k}{\text{pop } M} \sum_k \sum_i [P_i (1 + t_i^k) - \sum_{g=G_i^k+1}^{H_i} a_{gi} P_g (1 + t_g^k) - (v_{Ji} + \sum_{g=1}^{G_i^k} a_{gi} v_{Jg}) Kr^k - (v_{2i} + \sum_{g=1}^{G_i^k} a_{gi} v_{2g}) s_2^k] Z_i^k D_i$$

$$(v_{ji} + \sum_{g=1}^{G_i^k} a_{gi} v_{Jg}) Kr^k - (v_{2i} + \sum_{g=1}^{G_i^k} a_{gi} v_{2g}) s_2] Z_i^k D_i$$

for all countries $m = K' + 1, \dots, K$

P_i = international price of good i .

t_i^k = tariff on good i in country k .

a_{gi} = amount of input g necessary for the production of one unit of good i in physical units.

P_g = international price of input good g .

t_g^k = tariff on input good g in country k .

v_{ji} = amount of imported capital necessary for the production of input good g .

v_{Jg} = amount of imported capital necessary for the production of input good g .

K = international price of capital.

r^k = rate of return to capital.

v_{2i} = amount of factor 2, foreign factors, employed in the production of one unit of good i .

v_{2g} = the amount of foreign factors necessary for the production of input good g .

s_2^k = repatriated returns to foreign factors of production.

Z_i^k = dichotomous variable assuming the value of one when the industry i is assigned to country k and zero otherwise.

D_i = total free trade area demand for product i .

Y^k = income of country k .

Y^M = income of the free trade area.

pop k = population of country k .

pop M = population of the free trade area.

$g = 1, \dots, G_i^k$ - domestic goods utilized in the production of good i in country k .

$g = G_i^k + 1, \dots, H_i$ - imported goods utilized in the production of good i in country k .

With respect to investment the member countries might have either of two objectives in mind: The distribution of total (direct and indirect) investment caused by the integration industries or the distribution of the direct investment in the integration industries. The distribution of the total investment would lead to a constraint similar to the value added distribution constraint if the capital output ratios are similar in the various countries. The other objective

of distributing the direct investment is probably more important to the member countries and will constitute an additional constraint. However, as in the case of the value added constraint, only upper and lower bounds are formulated.

a) Lower bound for the countries with relatively low incomes per capita.

$$15. \sum_i I_i Z_i^k \geq \frac{Y^k}{Y^M} \sum_m \sum_i I_i Z_i^k$$

for countries $m = 1, \dots, K^*$.

b) lower bound for the countries with relatively high incomes per capita.

$$16. \sum_i I_i Z_i^k \geq \frac{\text{pop } k}{\text{pop } M} \sum_m \sum_i I_i Z_i^k$$

for countries $m = K^* + 1, \dots, K$.

I_i = investment necessary to produce good i for the free trade area.

Z_i^k = dichotomous variable.

Y^k = income of country k .

Y^M = income of the free trade area.

pop k = population of country k .

pop M = population of the free trade area.

Another important benefit from integration is the relaxation of the pressure on the balance of payments of the area due to import substitution. Here, the question of whether import substitution does actually ease the pressure on the balance of payments is not considered. It is simply assumed that it does. The foreign exchange saved through import substitution can be divided in many ways. However, it seems plausible that no one country would wish to lose foreign exchange to any of the other countries and therefore another distributional criterion could be sales equalization: The sales of any one country to the area are equal to the country's purchases from the area.

The sales equalization constraint may also be defended on the basis that the purchases of member countries' products at higher than world prices, because of protective tariffs, involve real sub-

sidies to the selling countries. In an integration scheme where the economies are of different sizes and incomes it would be expected that there would be a net transfer of resources from the smaller and/or poorer countries to the larger and/or richer countries if trade flows are not equated. Further, this criterion would not necessarily be incompatible with different rates of trade expansion inasmuch as participating countries need not limit their expansion to the rate of the small countries but may trade among each other. Further, this criterion can be imposed in practice since it is easily measurable. This constraint may be expressed as:

$$17. \quad \sum_{j \neq k} \sum_i D_i^j Z_i^k - \sum_{j \neq k} \sum_i D_i^k Z_i^j = |E|$$

for all countries k .

D_i^j = demand for product i by country j .

Z_i^k = dichotomous variable.

E = constant reflecting an allowable margin of error.

In spite of the advantages of the trade equalization it is possible to suggest a superior criterion, subsidy equalization, which directly rather than indirectly imposes limits on the net transfer of resources from one country to another in the form of subsidies. This criterion would equate the country's subsidization of the area with the area's subsidization of the country. The advantages of this are that it prevents the smaller countries from subsidizing the larger ones and it provides an incentive to become a low cost producer. This criterion is superior to the sales equalization constraint if the free trade area does not adopt a uniform common external tariff. It can be formulated as:

$$18. \quad \sum_{j \neq k} \sum_i u_i^k D_i^j Z_i^k - \sum_{j \neq k} \sum_i u_i^j D_i^k Z_i^j = |F|$$

where

$$u_i^k = \frac{P_i^k - P_i^w}{P_i^w}$$

P_i^k = price of good i in country k .

P_i^w = world price of good i .

D_i^j = demand for product i by country j .

Z_i^k = dichotomous variable.

F = constant reflecting an allowable margin of error.

A technological distribution constraint also seems necessary since countries generally prefer not to lag behind or be dependent on another for any type of technology. Further, the member countries may believe that should the market break up, it would be easier to transform the industry within the sector to produce the other products of the sector than it would be to transform the industries of a sector to produce the goods of other sectors. Therefore, it may be appropriate to assign each country at least one industry in each sector even though this may impair the efficiency of the extended market considerably. Dividing the industries of a sector into q subsectors such that $i^* = 1, \dots, q$ the technology distribution constraint can be formulated as:

$$19. \sum_{i \in i^*} Z_i^k \geq 0$$

for all k and for all subsectors $i^* = 1, \dots, q$.

A "generation of employment" constraint will not be formulated. Although the formulation of this constraint would not be difficult, in those cases where the industries allocated differed in the amounts and types of employment offered the implementation of the constraint might prove impractical. In other instances where the industries allocated have similar manpower needs, the amounts of employment generated would be proportional to either the total values added or to the direct investments in the integration industries. In such cases an employment generation constraint would be redundant.

IV. Concluding Remarks

This paper has concerned itself with the development of operational models which could be employed to generate useful information with respect to the assigning of industries among country members in a free trade area. A benefit criterion was suggested incorporating the use of an extended DRC measure. Two alternative objective functions were then analyzed and alternative distribution constraints presented. It is felt that the practical operational aspects of this approach make it a potentially useful tool for ex-

aming and proposing specific industry assignments within an economic integration scheme.²⁹ Nonetheless, the models developed herein can only provide indications as to how to allocate integration industries and the results should not be taken as definitive. Rather, corrections should be made for a number of elements not considered in either of the models and for possible biases introduced by the method employed to determine the comparative costs. For example, the industry assignments proposed by either of the models should be modified for dynamic considerations. The models are static and do not incorporate any dynamic changes brought about by the suggested allocations. This criticism is not, however, particular to these models since dynamic considerations are difficult to incorporate in any but the most general models for a free trade area.

More important criticisms of the models are that they do not allow for the allocation of one industry to more than one country and that they do not incorporate intra-regional trade in inputs. These restrictions do require that the results be modified to reflect these limitations by redefining industries and introducing additional constraints in the case of allocations of one industry to more than one country and by adjusting the DRCs for intra-regional trade in inputs.

Finally, attention must be given to the relationship between domestic and international prices. In this exercise industries are allocated on the basis of comparative costs as determined from a comparison of DRCs for the various industries in the various countries. These DRCs are calculated utilizing domestic goods prices assumed to be equal to international prices plus tariffs. Theory indicates that domestic market prices should be equal to the international prices plus tariffs and the empirical work by Norman³⁰ suggests that this is indeed the case at least for homogeneous goods. However, if domestic prices are not equal to international prices plus tariffs corrections should be made if the divergence between the two sets is not similar for all goods in all countries.

29 A successful attempt has, in fact, been made to apply the model to analyze and evaluate the chemical industry assignments within the Andean pact countries. See Wengel (Forthcoming).

30 Norman (1975), pp. 426-439.

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