This collection of essays on comparative advantage in rice production is the final product of the Food Research Institute's project on the Political Economy of Rice in Asia. Other results of the project have been reported in earlier issues of this journal, and three issues have been devoted entirely to this project, Vol. XIII, No. 2 and Vol. XIV, Nos. 3 and 4. Countries included in this analysis are two major rice exporters, Thailand and the United States, and two importers nearing self-sufficiency, Philippines and Taiwan. The collaborators have measured comparative advantage in rice production, first, among regions, seasons, or techniques within single countries and, second, across several countries.

Both types of measurements of comparative advantage yield interesting policy results. One of the striking features of the rice economies in Asia and in the United States is the great variability among countries of government policies affecting the production and trade of rice. Accordingly, it is of considerable interest to know which regions within a single country and which countries have strong comparative advantages in rice production and how specific government policies have influenced the actual pattern of rice production and trade. A comparative study of the relative efficiency with which rice is produced in selected countries should be a significant aid to policy analysis.
Succeeding sections of this introductory essay contain a discussion of techniques for measuring comparative advantage, a list of assumptions underlying these techniques, and some brief concluding remarks. The four country studies follow in turn, and the set of essays is then concluded with a detailed comparative analysis.

**COMPARATIVE ADVANTAGE, NET SOCIAL PROFITABILITY, AND THE DOMESTIC RESOURCE COSTS OF FOREIGN EXCHANGE EARNED OR SAVED**

A country has a comparative advantage in rice production if the social opportunity costs of producing an incremental unit of rice are less than the border price of rice. This definition of comparative advantage is based on the concept of social opportunity costs and hence on the distinction between social and private profitability. An individual or firm generally makes its private investment decisions on the basis of past, present, and expected future market prices for its inputs and outputs. In contrast a national government acting in the interests of its populace would make its investment decisions on the basis of social prices of inputs and outputs. These social prices may differ from market prices, and consequently the net social profitability (NSP) of an activity may differ from its private profitability. The difference between social and private profitability can be positive, negative, or zero, depending on the balance of a variety of effects.

The kinds of effects that contribute to (or detract from) NSP can be indicated with a more precise definition of this concept. Net social profitability (NSP) can be defined as the net gain (or loss) associated with the \( f \) economic activity when all commodity outputs produced and material inputs and factors of production employed are evaluated at their social opportunity costs (through the use of shadow prices) and when all external effects on the domestic economy are given a social valuation and included directly in the measure:

\[
\text{NSP}_f = \sum_{i=1}^{n} a_{ij} p_i - \sum_{s=1}^{m} f_{sj} v_s + E_j
\]

where \( a_{ij} \) is the quantity of the \( i \)th commodity output produced by the \( f \)th activity (or the quantity of the \( i \)th material input used by the \( f \)th activity), in which case the term is negative), \( p_i \) is the shadow price of the \( i \)th commodity output (or of the \( i \)th material input) (in domestic currency), \( f_{sj} \) is the quantity of the \( j \)th factor of production used by the \( f \)th activity, \( v_s \) is the shadow price of the \( j \)th factor of production.

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2 This definition is developed by Chenery (10, pp. 19-25). The social opportunity costs of rice production are defined as the value of all factors of production used to produce rice in their best alternative employment plus the value of all tradable inputs defined in terms of their border prices, i.e., the c.i.f. prices of comparable imports. The border price of rice refers to the f.o.b. export price if the country is an exporter of rice or to the c.i.f. import price if the country is an importer of rice.

3 It is assumed throughout the discussion that streams of benefits and costs are discounted at an appropriate social discount rate to allow comparability at one point in time. For expositional convenience, time and the discount rate are not introduced explicitly into the analysis.
production (in domestic currency), and \( E_j \) is a measure of the net external benefits or costs imparted by the \( j^{th} \) activity to the rest of the domestic economy.\(^4\)

If (a) all production units are profit maximizers, (b) no factor or product market distortions exist, (c) no economic rents are generated, (d) government tax/expenditure policies do not distort relative prices, (e) income redistribution measures are continuously enacted (or are of no concern), and (f) externalities are zero (or fortuitously offsetting), market prices and shadow prices of inputs and outputs will be equal. In this hypothetical situation, social benefits of an economic activity would equal social costs of production, and hence the net social profitability of the activity would be zero.

Typically, few, if any, of the conditions listed above are satisfied in developing economies, including those in Asia. A long list of policies and institutional considerations, such as legislated minimum wage levels, maximum interest ceilings, and overvalued exchange rates, often introduce distortions resulting in a divergence between private market prices and social opportunity costs. As a result, considerable interest attaches to an examination of net social profitability of economic activities in developing countries, under existing and changed constellations of government policies. For each assumed set of government policies, there will be a corresponding set of shadow prices for inputs and outputs. Input coefficients for activities may also vary, although for analytical convenience these coefficients are usually assumed to remain unchanged.

The relationship between NSP and comparative advantage is straightforward: a country (or region) has a comparative advantage in producing a commodity if the net social profitability of the activity is positive. Two adjustments to (1) and some algebraic manipulation will permit a demonstration of this result. First, all outputs are assumed to be tradable—either exports that earn foreign exchange, or import substitutes that save foreign exchange. Second, all input costs are divided into costs of tradable inputs and costs of primary domestic factors.

While the notation used below is similar to that applied by Bruno (7, pp. 18-22), this approach differs significantly. Bruno treats all locally produced inputs as nontradable, thereby defining them with respect to actual government policy. In the approach used here, the social opportunity cost of all inputs, like primary domestic factors, are estimated with reference to optimal government policy. Consequently, a locally produced input is classified as (a) tradable if it is fully traded, i.e., if the country also imports some of the good, or (b) nontradable if it is nonfully traded, i.e., if the country does not import any of the good.\(^5\)

Inputs classified as nontradable are then decomposed into tradable components and primary domestic factors by moving backward through the input-output chain.

With these two modifications, a second definition of NSP, equivalent to the first when all outputs are tradable is:

\[
\text{NSP}_j = (\alpha_j - \bar{m}_j - r_j) \nu_1 - \sum_{i=2}^{m} \bar{f}_{ij} \nu_s + E_j
\]

\(^4\) For a discussion of external effects, see Pearson (20, especially pp. 45-50).

\(^5\) See Joshi (13) for a discussion of the concepts of fully and nonfully traded inputs.
where \( u_j \) is the total value at world prices (in foreign currency) of the output of the \( j^{th} \) activity; \( m_j \) is the total (direct plus indirect) value (in foreign currency) of tradable materials used by the \( j^{th} \) activity; \( r_j \) is the total (direct plus indirect) value (in foreign currency) of repatriated earnings of foreign-owned factors of production employed by the \( j^{th} \) industry (including repatriated portions of the direct foreign factor costs, \( f_j v_j \), and of the indirect foreign factor costs); \( v_j \) is the shadow price of foreign exchange, expressed as a ratio of local currency to foreign currency; and \( \tilde{f}_s j \) is the total (direct plus indirect) quantity of the \( s^{th} \) primary domestic factor employed by the \( j^{th} \) industry.

As stated above, comparative advantage is implied if the social opportunity cost of producing additional amounts of a commodity is less than its border price. This definition of comparative advantage can be stated in terms of total, rather than per unit, costs and revenues to accord with the definitions of variables in (2):

\[
\text{comparative advantage } \leq \left( \sum_{s=2}^{m} \tilde{f}_s j v_s - E_j \right) v_j \leq u_j v_j \quad (3)
\]

A country has a comparative advantage in producing a commodity if total social costs of an incremental project—including direct and indirect tradable costs \( (m_j + r_j) v_j \) and direct and indirect costs of primary domestic factors \( \sum_{s=2}^{m} f_s j v_s \) less net external benefits \( E_j \)—are less than total social returns \( u_j v_j \). By rearranging the terms of (3), the relationship between a positive NSP and the existence of comparative advantage is established:

\[
\text{comparative advantage } \leq \left( u_j - m_j - r_j \right) v_j - \sum_{s=2}^{m} f_s j v_s + E_j > 0 \quad , \quad (4)
\]

\[
\text{or NSP } > 0 .
\]

Under some circumstances, it is convenient to employ an alternative technique in order to measure net social profitability and thus to indicate the existence or lack of comparative advantage. In evaluating activities in developing countries, an appropriate measure of the social value of foreign exchange is often a critical variable. But the shadow price of foreign exchange may be the most difficult of all to estimate. In that event, it is useful to formulate a ratio from the definition of NSP which excludes the shadow price of foreign exchange and is therefore free of errors introduced by using an improper estimate of this parameter.

The ratio obtained by setting NSP in (2) to zero and solving for \( v_j \) (the shadow price of foreign exchange) has been termed the domestic resource costs of foreign exchange earned or saved (DRC). With respect to the \( j^{th} \) activity, DRC\(_j\) is a measure of the social opportunity cost (in terms of the domestic factors of production employed directly and indirectly by the \( j^{th} \) activity) of earning a net marginal unit of foreign exchange:

\[
\text{DRC}_j = \frac{\sum_{s=2}^{m} \tilde{f}_s j v_s - E_j}{u_j - m_j - r_j} = \frac{\text{DC}_j}{\text{NVA}_j} \quad (5)
\]

6 This relationship was noted by Chenery (10, p. 45) and later demonstrated by Bruno (9, p. 106; 7, p. 20).
where $DC_j$ is the opportunity cost of domestic resources employed by the $j^{th}$ activity (in domestic currency), and $NV_{Aj}$ is net foreign exchange earned or saved (in foreign currency), or equivalently, value added at world prices. Again, while the algebraic definition of the DRC measure presented here is virtually identical to that formulated by Bruno, the two concepts are not the same because of the differing treatments of locally produced inputs.

A direct relationship between DRC and $NSP_j$ can be obtained by substituting (5) into (2):

$$NSP_j = (v_1 - DRC_j) \left( u_j - \bar{m}_j - r_j \right).$$  \hspace{1cm} (6)

The DRC measure can be subtracted from the shadow price of foreign exchange and the difference multiplied by net foreign exchange earned or saved to find net social profitability. Note that if net foreign exchange earned or saved is negative, $NSP_j$ must also be negative.

When $NSP_j$ is zero, the DRC measure is equal to the shadow price of foreign exchange. Similarly, when $NSP_j$ is positive, $DRC_j$ is less than $v_1$, and when $NSP_j$ is negative, $DRC_j$ is greater than $v_1$. In short, $NSP_j \geq 0$ as $DRC_j \leq v_1$. Hence, an activity is socially profitable if its DRC ratio, which measures its efficiency in transforming domestic resources into foreign exchange, is less than the shadow price of foreign exchange, which can be thought of as a weighted average of the efficiency of all tradable activities in the economy in transforming domestic resources into foreign exchange. In other words, $DRC_j$ is equivalent to an exchange rate for the $j^{th}$ activity, indicating how many domestic resources are required to earn a unit of foreign exchange in that activity, whereas $v_1$ is the exchange rate for the entire economy, measuring how many domestic resources the country is willing to give up to obtain a unit of foreign exchange. Therefore, if $DRC_j$ is less than $v_1$, fewer domestic resources are required to earn a unit of foreign exchange than the country on average is willing to pay for it. The result is a gain in welfare.

The relationship between DRC and comparative advantage is established by rearranging the terms of (3):

$$\text{comparative advantage} \iff \frac{\sum_{j=2}^{m} f_{sj} v_s}{u_j - \bar{m}_j - r_j} < v_1, \text{ or } DRC_j < v_1. \hspace{1cm} (7)$$

7 This concept, which was originally developed in Israel during the 1950s, has been introduced to a much wider audience of professional economists by Bruno (8, 9, 7) and by Krueger (14, 15).

8 If net foreign exchange earned or saved is negative, $DRC_j$ must be positive, causing $(v_1 - DRC_j)$ to be positive and the product of this term and $(u_j - \bar{m}_j - r_j)$ to be negative.

9 Bacha and Taylor (2, especially pp. 214-17) provide a comparative analysis of alternative measures of the shadow price of foreign exchange and suggest a formula for an equilibrium exchange rate which would be appropriate when trade restrictions are removed. This formula is equivalent to one derived independently by Balassa (5, pp. 326-31). An alternative formulation of the shadow price of foreign exchange is contained in Dasgupta, Marglin, and Sen (11) and in Roemer and Stern (26).
Hence, DRC, like NSP, is also a statement of comparative advantage. An export is socially profitable—or has a comparative advantage in international trade—if the social opportunity cost of domestic resources used in its incremental production per unit of net foreign exchange earned is less than the shadow price of foreign exchange. If the DRC ratio of the activity is less than this shadow price, the country has a comparative advantage in producing the incremental output of the activity.

Within a single country, the DRC concept can, of course, be used to evaluate a single project or several alternative projects. Two or more projects can be ranked according to their DRC ratios so long as they can be assumed not to alter relative prices in the economy. However, measurement of comparative advantage or of net social profitability requires that a project be compared with the shadow price of foreign exchange. The smaller the DRC of a project in relation to the shadow price of foreign exchange, the greater is that project’s relative degree of comparative advantage within an economy. If the correct shadow price of foreign exchange is not known, it is still possible to indicate the relative degree of comparative advantage among projects within a single country by comparing their DRC ratios (again subject to the qualification made above about relative prices). This kind of comparison is especially useful in determining the efficient location of competing projects in alternative regions within a country.

It is often of interest to contrast the degree of relative comparative advantage of producing additional amounts of a commodity in one country with that of other countries. For example, if one is undertaking a comparative analysis of rice projects in several countries, it would be useful, first, to measure how each country’s rice project compares with alternative domestic projects, and, second, to contrast these results among countries. For this purpose, the DRC of the rice project in each country (which is, of course, assumed to be the best incremental investment in rice in that country) is compared with that country’s shadow price of foreign exchange. The more closely the ratio of a project’s DRC to this shadow price approaches one, the smaller is the project’s degree of comparative advantage within the country. If this ratio exceeds one, the project is socially unprofitable and the country has a comparative disadvantage in producing the incremental output in question.

When each side of (7) is divided by \( v_j \), the criterion for comparative advantage becomes:

\[
\frac{DRC_j}{v_j} < 1. \tag{8}
\]

10 In the ensuing discussion, the term project is used to underscore the incremental nature of the DRC concept. This choice of terminology is not meant to imply necessarily any investment by a government.

11 Any ranking of projects by DRC, NSP, or any other criterion can be justified only on empirical, rather than theoretical, grounds. To rank projects it must be assumed that the activities are small in relation to the economy so that their introduction would not alter relative prices. For a summary discussion of this point, see Bruno (7, pp. 31-32).
If the ratio of $DRC_j$ (where $j$ refers to a rice project in this illustration) to $v_i$ in one country is less than a similar ratio in a second country, it can be argued that the first country has a relative comparative advantage over the second in producing additional rice. In other words, given that the ratio of $DRC_j$ to $v_i$ for the first country is smaller than that for the second country, both countries have international comparative advantages in producing and exporting rice, but the first has a greater comparative advantage than the second. In this sense the first country is economically more efficient than the second in growing and marketing incremental amounts of rice. Provided that the rice project of the second country does not generate more net foreign exchange than that of the first country, global welfare, defined in terms of income generation, would increase more if the first country produces more rice than if the second country expands its rice output. Using superscripts to denote countries, one can rank the relative comparative advantage of rice projects in two or more countries with the ratio, $DRC_j/v_i^h$, where $h$ is the country index.

In empirical analysis, it is sometimes convenient to use a modified form of the DRC measure in which both the numerator and denominator are expressed in terms of domestic currency. This modified measure, which can be defined as $DRC_j^*$, differs from the conventional measure in equation (5) because the denominator, net foreign exchange earned or saved, is expressed in domestic currency through multiplication by the official exchange rate, $v_i^*$. With the modified measure, the criterion for comparative advantage is

$$\frac{DRC_j^*}{v_i/v_i^*} < 1.$$  \hspace{1cm} (10)

Correspondingly, the ratio for cross-country comparisons is

$$\frac{DRC_j^{*h}}{v_i^h/v_i^{*h}}.$$  

PRINCIPAL ASSUMPTIONS UNDERLYING THE MEASUREMENT OF COMPARATIVE ADVANTAGE

Methods of rice production in Asia vary widely within and between countries. Technologies range from traditional labor-intensive methods to modern capital- and fertilizer-intensive techniques. The choice of technology is influenced by unequal availabilities of suitable land.
natural differences in soil fertility, rainfall, and amount of sunlight and by relative factor endowments as well as by relative factor prices (which are often greatly distorted by government policies).

Four characteristics of rice production in Asia are of special interest in analyzing comparative advantage. First, as already noted, the production technology is not uniform across regions. Second, because much rice production is carried out by family units that consume part of the output, profit maximization may not be a good behavioral description of decision making. Third, political and social decisions generally affect production decisions, as a result of the overriding importance of rice in the food economy of Asian countries. Finally, the international price of rice is difficult to define and interpret because of the thinness of the international market, the existence of protective policies in many countries, and the variability of special trading arrangements. These characteristics, pertaining to rice, should be kept in mind in assessing the reliability of the empirical techniques under discussion.

As defined in this essay, NSP and DRC are based on a common set of basic assumptions. Among the most crucial of these assumptions are: (a) the world price of the output (rice) is given exogenously or is estimable; (b) incremental costs of production, determined by a given technology (with no substitution) and an assumed set of relative factor prices, are constant, subject to sensitivity analysis to reflect changed assumptions; (c) shadow prices of inputs and outputs, which are representative of the true opportunity costs of factors and of the true scarcity values of commodities, are calculable; and (d) the true foreign exchange costs of production can be calculated.

The empirical application of any technique will, of course, yield results that are useful only to the extent that the assumptions underlying the analysis are realistic. It is difficult to generalize about how restrictive the above list of required assumptions might be. The assumption of an exogenously determined world price for rice would presumably make sense for some countries (e.g., Philippines) but not for others (e.g., Thailand). Constancy of the input coefficients and unchanging relative factor prices are probably quite realistic assumptions at the margin, although the credibility of both may be strained if consumer welfare enters directly into rice production decisions.

Perhaps the most crucial assumptions in any analysis of social profitability or of comparative advantage concern the shadow prices, especially those for the major factors—labor, capital, land, and foreign exchange. No attempt will be made here to review the most important techniques available for estimating shadow prices. Briefly, shadow prices of factors of production in this study are defined in terms of the social opportunity costs of income foregone by not using the factor in its best alternative employment, while the shadow prices of material outputs and inputs are border prices (f.o.b. export prices or c.i.f. prices of comparable imports).

13 For a thorough discussion of assumptions underlying use of these concepts, see, among others, Chenery (10), Prest and Turvey (25), Bruno (9), and Gittinger (12).

14 Useful sources on this topic include Bacha and Taylor (2), Balassa (3, 4), Dasgupta, Marglin, and Sen (11), Little and Mirrlees (16), and Roemer and Stern (26).
Another central element of the DRC technique is the division of nontradable input costs into tradable input costs and primary domestic factor costs. Problems may arise with respect to the classification of tradable and nontradable materials and services. Moreover, whether or not an input-output table is available, the breakdown of inputs classified as nontradable into (direct plus indirect) tradable input and primary domestic factor costs can be troublesome.

The DRC measure contains an inherent bias because of the difficulty of correctly classifying locally produced inputs as tradable or nontradable. Tradable (or nontradable) inputs are defined as goods that would (or would not) be traded if the country were implementing optimal economic policies, thereby causing market prices to equal social prices. Since actual government policy departs from optimal policy in virtually all countries, it is not possible to be sure whether an input, which is produced locally under existing policy, would continue to be produced domestically under optimal policy. A strong presumption exists that, given optimal policy, fully traded local inputs would be tradable, but it is not clear whether nonfully traded inputs would be tradable or nontradable. In the absence of information, nonfully traded inputs are treated as if they were nontradable. To the extent that they are not, a bias is introduced because some tradable input costs are incorrectly counted as primary domestic factor costs.

If tradable input costs are erroneously counted as primary domestic factor costs, or vice versa, the measured DRC ratio suffers from a systematic bias. As Bruno (9, p. 114) has shown, the degree of bias can be demonstrated with the following formula:

$$DRC_j' = \frac{DRC_j + \alpha v_j}{1 + \alpha}$$

where $DRC_j'$ is the measured value, $DRC_j$ is the true value and $\alpha$ is the ratio of the amount of tradable costs, erroneously counted as domestic factor costs, to net foreign exchange earned or saved. If $\alpha$ is small, $DRC_j' \approx DRC_j + \alpha(v_j - DRC_j)$. For $\alpha > 0$ and $DRC_j < v_j$, $DRC_j' > DRC_j$, i.e., when tradable costs are counted as domestic factor costs and the $j^{th}$ activity is efficient, the measured DRC ratio will exceed the true value. Conversely, for $\alpha > 0$ and $DRC_j > v_j$, $DRC_j' < DRC_j$, and the observed value will have a downward bias. Hence, either bias results in an observed value which is closer to $v_j$ than the true value would have been. In both instances, the bias will increase with an increase in the size of $\alpha$.

A major difficulty in attempting to measure comparative advantage—or for that matter in carrying out any type of social profitability analysis—stems from the overriding importance of dynamic elements. Chenery (10) has described the adjustments which have to be made in order to incorporate elements of growth theory with those of trade theory. Bruno (9, 6) has carried out several innovative empirical analyses of the Israeli economy, incorporating growth aspects in a dynamic linear programming model in order to determine dynamic comparative advantage for sectors in that one country.

In the absence of data required for a programming approach, sensitivity analyses can be undertaken on major variables in an effort to approximate the effects of dynamic changes. Variables which might usefully be subjected to
sensitivity analyses include: the world price of rice; the input-output coefficients, reflecting different assumptions on changes in technology (for example, the use of new varieties or techniques) and/or in factor productivity; the shadow prices of domestic factors, allowing for changing opportunity costs as factor supplies or policies are altered; the external effects; and the shadow price of foreign exchange, as a result of changing comparative advantage of other domestic activities or of alterations in policies. By changing assumptions in this manner, it is possible to ascertain the sensitivity of the empirical results to particular assumptions.

CONCLUDING COMMENTS

The interrelationships between a government's macroeconomic policies and a rice farmer's microeconomic decisions are highly complex and therefore difficult to analyze. Yet these effects lie at the heart of understanding the political economy of rice in Asia. One interesting way of gaining insight into certain aspects of this question is to measure the comparative advantage, or net social profitability, of rice production among regions of a single country and across several Asian countries. Relative comparative advantage across countries is conveniently measured by forming (for each country) the ratio of the domestic resource costs per unit of foreign exchange earned or saved to the shadow price of foreign exchange and then ranking these ratios. The likely effects of alternative government policies on relative comparative advantage can be tested within the framework of the analysis. Major strengths of the approach include the comparatively light data requirements—a single year cross section is sufficient—and the relative ease with which results can be explained to policy makers. Principal weaknesses are the restrictive nature of certain assumptions and the difficulty of estimating consistent sets of shadow prices.

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