MEASURING COMPARATIVE ADVANTAGE: A REVIEW OF CIMMYT'S EXPERIENCE WITH DRC ANALYSIS

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ABSTRACT

Domestic resource cost analysis provides a way of empirically measuring comparative advantage. Recent case studies carried out by economists with the International Maize and Wheat Improvement Center (CIMMYT) demonstrate the flexibility of the DRC approach and illustrate its strengths and weaknesses as a tool for applied policy analysis and research resource allocation.

1. INTRODUCTION

Knowledge of comparative advantage is important for developing countries, because potential welfare gains from specialization and trade can be used to foster economic growth. National income often can be increased in the short run through policies encouraging farmers to produce commodities that exploit existing patterns of comparative advantage. Over the longer run, additional welfare gains can be assured if research resources are used to strengthen comparative advantage in the future. This suggests that agricultural policies and allocation of research resources should be based at least in part on comparative advantage considerations.

One practical difficulty with using comparative advantage considerations for designing agricultural policies and/or allocating research resources is that comparative advantage is difficult to determine empirically. Simply comparing absolute levels of production costs between two regions or countries is inconclusive, because comparative advantage is not determined by absolute production costs. Even if relative production costs can be estimated, often these are distorted by government policies or market failures. Policy makers and research administrators thus require a way to "see through" market distortions in order to determine true underlying patterns of comparative advantage.

The domestic resource cost (DRC) framework of analysis provides one way of empirically estimating comparative advantage. The DRC method generates quantitative measures of the efficiency of using domestic resources to produce a given commodity, as measured against the possibilities of trade. At the same time, it allows measurement of the distortionary effects of market failures and government policies.

This paper evaluates the usefulness of the DRC framework of analysis as a tool for policy analysis and research resource allocation. Although space limitations preclude a detailed description of the DRC methodology, the paper presents examples from a series of case studies carried out by economists working at the International Maize and Wheat Improvement Center (CIMMYT).[1] These examples illustrate the flexibility of the DRC approach and serve as a basis for a discussion of its strengths and weaknesses as a tool for applied research.

2. A BRIEF REVIEW OF THE DOMESTIC RESOURCE COST METHODOLOGY

Applied comparative advantage analysis essentially seeks to answer the following question: which among a set of alternative production activities is *relatively* most efficient, given the removal of all distortions in the economy resulting from government policies and market

[1] For a more complete description of the DRC methodology, see [Author] (1989).

failures? Relative efficiency in production is determined by three factors: 1) the basic resource endowment; 2) technology; and 3) prices. Since all three of these factors change over time, comparative advantage can shift.

The DRC method estimates comparative advantage among production alternatives by generating several measures of relative economic efficiency. *Net social profitability* indicates the contribution of each alternative to national income, measured in terms of social net returns to land. The *resource cost ratio* indicates the efficiency of each alternative in using domestic resources to earn (or save) foreign exchange. Since both measures capture the ability of production alternatives to contribute to national income, comparison of social profitability or resource cost ratios provides an empirical measure of the underlying pattern of comparative advantage.

DRC analysis begins with the development of an enterprise budget for each production alternative. Typically production alternatives will consist of different crops which compete for resources. However, they may also consist of the same crop grown in different regions, for example when policy makers are trying to determine which of two regions within the same country enjoys a comparative advantage in the production of a given commodity. Alternatively, they may consist of the same crop grown using different levels of technology, for example when policy makers are trying to determine whether a country enjoys a comparative advantage in large-scale mechanized production of a crop or small-scale labor-intensive production.

After enterprise budgets have been constructed, inputs and outputs are classified as *primary factors* or *tradables*. This distinction is necessary because resource cost ratios are calculated as the ratio between the value-added to primary factors and the value added to tradables. Also, shadow prices are often determined differently for tradables and primary factors. For these reasons, the two categories of goods must be differentiated.

Primary factors are defined as goods that are not normally traded internationally and include chiefly land, labor, water, and capital. Tradables are goods that are traded internationally or potentially could be traded. Some non-traded production inputs will turn out to be composite goods comprising both a tradable component and a primary factor component; such composite goods must be decomposed into the tradable component and the primary factor component.

Next, a vector of economic (or shadow) prices must be constructed. Referred to here as "social prices", these prices are intended to reflect the true economic value of goods and services in the absence of taxes, subsidies, import tariffs, quotas, price controls, and other government policies.

Social prices are determined differently for primary factors and tradables. Primary factors are assigned social prices equal to their opportunity cost value (i.e., the returns in their most socially profitable alternative use). Tradables are valued at their world price equivalent, or the price at which they can be imported or exported, adjusted for transport costs and exchange rate anomalies. In the case of imported goods, domestic transportation and handling costs are added to the C.I.F. price to arrive at a social price equivalent to the import parity price; in the case of exported goods, domestic transportation and handling costs are subtracted from the F.O.B. price to arrive at a social price equivalent to the export parity price. In calculating social prices for tradables, it is often necessary to estimate a shadow exchange rate to correct for distortions between the domestic currency and international currencies.

The social profitability of each production alternative can now be calculated. This is a straightforward procedure involving use of the social prices to calculate net returns (usually to land) of each competing enterprise. Assuming social prices have been estimated accurately, the social profitability rankings provide a preliminary indication of comparative advantage. Social prices reflect the true economic scarcity value of inputs and outputs, so the enterprise with the largest positive net social returns represents the most profitable production alternative in terms of contributing to national income.

Social profitability is sometimes incomplete as a measure of comparative advantage because it provides no explicit information about the use of domestic resources in production. This can be a problem, because when three or more production alternatives are being compared, several can have the same social profitability while requiring very different amounts of imported inputs. Resource cost ratios thus represent a more complete measure of comparative advantage, since they provide an explicit indication of the ability of each production alternative to use domestic resources (i.e., primary factors) to generate or save foreign exchange.

Using data from the enterprise budgets, resource cost ratios can be calculated according to the following formula:

$$RCR_c = \frac{\sum W_p F_p}{\sum P_o T_o - \sum P_i T_i}$$

where:

RCR_c = resource cost ratio for crop c
W_p = opportunity cost prices of primary factors
F_p = primary factors of production
P_o = world price equivalents of tradable outputs
T_o = tradable production outputs
P_i = world price equivalents of tradable inputs
T_i = tradable production inputs

Interpretation of resource cost ratios is straightforward. A resource cost ratio below 1 indicates that the value of the domestic resources used in production is less than the value of the foreign exchange earned or saved; thus, a country has a comparative advantage in products associated with a resource cost ratio of less than 1, since the country earns or saves foreign exchange in their production. Conversely, a resource cost ratio above 1 indicates that the value of the domestic resources used in production exceeds the value of the foreign exchange earned or saved, and the country does not have a comparative advantage in production.

3. USES OF DOMESTIC RESOURCE COST ANALYSIS

The following examples drawn from CIMMYT case studies demonstrate how the DRC framework can be adapted to address a wide range of comparative advantage issues.

A. Revealing Distorting Effects of Government Policies

Before comparative advantage indicators are formally calculated and analyzed, private and social profitability of each enterprise can be compared to determine if and how government policies and market failures are influencing production incentives. (The private profitability of an enterprise is simply the net returns to land calculated using market prices; the social profitability is the net returns calculated using social prices.)

The purpose of comparing private and social profitability should be obvious. Whenever discrepancies exist between market and social prices, the interests of farmers and of the nation can diverge. A crop can be profitable to farmers (e.g., because of high producer prices or subsidies on inputs), even though its production may not represent an efficient use of resources from the point of view of the country. Conversely, a crop can be unprofitable to farmers (e.g., because of low producer prices or taxes on inputs), even though its production represents an efficient use of the nation's resources. Such divergence can be measured by comparing private profitability with social profitability. Not only can the overall effect of government policies be measured, but the influence of individual policies and/or market failures can be quantified by disaggregating the overall discrepancy into its constituent parts.

A good example of the insights which can be obtained by comparing private and social profitability measures appears in Morris' (1988) study of wheat in Zimbabwe. Although this study was undertaken primarily to determine whether or not Zimbabwe has a comparative advantage in wheat production, the DRC framework of analysis at the same time also provided an opportunity to evaluate the claim made by commercial farmers that government policies strongly discriminate against the farming sector.

Table 1. Sources of difference between private and social profitability of irrigated crops in Zimbabwe, 1987

				Difference due to					
Crop	Private profit-ability (Z$/ha)	Social profit-ability (Z$/ha)	Net policy effect (Z$/ha)	Producer price policy (Z$/ha)	Farm machinery prices (Z$/ha)	Purchased input prices (Z$/ha)	Labor policy (Z$/ha)	Credit policy (Z$/ha)	Other policies and market distortions[a] (Z$/ha)
Wheat	178.34	682.31	(503.97)	(329.45)	(41.79)	(91.86)	(38.19)	24.48	(26.16)
Maize	176.89	678.50	(501.61)	(336.00)	(22.14)	(54.81)	(89.16)	20.10	(19.60)
Soybeans	143.69	255.42	(111.73)	0.00	(28.14)	(52.55)	(26.72)	15.22	(19.54)
Groundnuts	169.74	385.36	(215.62)	0.00	(25.93)	(55.96)	(137.87)	24.90	(20.76)
Cotton	751.11	1,549.94	(798.83)	(485.88)	(29.86)	(67.01)	(218.84)	29.33	(26.57)
Tobacco	2,783.37	8,702.70	(5,919.33)	(4,928.19)	(39.41)	(76.94)	(618.50)	86.51	(342.00)

a Includes effects of energy, transport, and insurance policies.

Source: Morris, 1988.

Table 1 presents data from the Zimbabwe study showing the effects of government policies on production incentives for six major commercial crops--wheat, tobacco, cotton, maize, soybeans, and groundnuts. The difference between the private and social profitability of each crop, appearing in column 3, represents the net effect of government policies on producer incentives. This overall policy effect is disaggregated into effects attributable to specific taxes and subsidies on producer prices, farm machinery prices, purchased inputs prices, labor policy, agricultural credit, and other policies. The data show how government policies affect private profitability, rarely positively (e.g., through subsidies to agricultural credit programs), and mostly negatively (e.g., through controlled producer prices, taxes on inputs, and wage policies). The data furthermore reveal which crops are most affected (tobacco and cotton), and they indicate which specific policies most influence producer incentives for each crop (producer price policy and labor policy, in most cases).

Comparing private and social profitability thus reveals that agricultural policies in Zimbabwe provide disincentives for commercial farmers, since private profitability is less than social profitability for all major commercial crops. In other words, government policies tax away a large portion of the social profits. However, this tax occurs across all commodities with similar incidence, so relative private production incentives among crops are not greatly distorted from their social pattern. This information on the size and incidence of policy effects can help the government adjust specific policies to effect desired changes in the commercial farming sector.

B. Revealing Comparative Advantage Between Enterprises

Once private and social profitability have been compared, attention turns to indicators of comparative advantage (social profitability measures and resource cost ratios). Probably the most common use of DRC analysis is to determine comparative advantage between alternative enterprises, whether cropping activities or other types of agricultural production activities. A good example of this use of DRC analysis appears in Byerlee's (1985) study of wheat in Ecuador. This study was motivated by the Ecuadoran government's concern over the sharp decline in wheat production which occurred during the late 1970s and early 1980s, at a time when wheat consumption was increasing rapidly. Policy makers were interested in determining whether or not wheat production represented an efficient use of the nation's resources and if so, why farmers were not planting more wheat.

Table 2 presents data from the Byerlee study showing Ecuador's pattern of comparative advantage. Wheat in Ecuador competes with three alternative enterprises: barley, potatoes, and dairying. The resource cost ratios in Table 2 (calculated using 1983 data) reveal that potato production represents the most efficient use of Ecuador's domestic resources, followed by wheat production, dairying, and barley production.[2] This was an important finding at the time of the study, since the ranking of farmer profitabilities diverged sharply from this efficiency ranking.

Table 2. Resource cost ratios for competing enterprises in Ecuador, 1983

	Wheat	Barley	Potatoes	Dairying
Tradables				
A) Outputs				
Value of production	45,750	35,595	130,130	39,587
B) Inputs				
Machinery depreciation	5.232	5,232	4,155	2,770
Fuels and oils	1,379	1,379	1,421	948
Fertilizer	5,064	4,392	19,280	2,180
Other tradable inputs	1,711	1,556	20,741	3,682
Seed	2,379	2,057	8,470	3,951
Other miscellaneous costs	679	634	3,234	515
Primary Factors				
Capital - machinery	1,823	1,823	1,309	873
Capital - working	660	594	3,990	0
Capital - other investment	0	0	0	7,000
Labor	1,547	1.547	20,430	2,190
Fertilizer distribution	1,030	888	3,985	452
Machinery distribution	425	425	289	193
Other inputs distribution	495	450	6,000	1,065
Land[a]	45,295	45,295	18,850	45,295
Net cost--primary factors	51.275	51,022	54,853	56,003
Value added--tradables	29,306	20,345	72,829	25,541
Resource cost ratio	1.75	2.51	0.75	2.19

a Residual returns to land in best competing alternative valued at world price equivalent. Cost and returns for dairying adjusted to reflect six-month cropping cycle.

Source: Byerlee, 1985.

In the Ecuador study, government policies (including a vastly overvalued exchange rate) were found to be strongly discriminating against wheat, which was the least profitable of all crops from the farmer's point of view. The strong effect of the exchange rate distortion was particularly noteworthy, since it suggested that the most realistic way for Ecuador to increase self-sufficiency in wheat was through macroeconomic policy reform, rather than through technological change within the agricultural sector.

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2 Note that returns to potato production were not adjusted to reflect land constraints and limited marketing opportunities.

C. Revealing Comparative Advantage Between Regions

A second possible use of DRC analysis is to determine comparative advantage between different regions within the same country in producing the same crop. Even if the production technology is similar, regional differences in resource cost ratios can arise because of differences in local cropping patterns (which affect the alternate use value of primary factors), or because of differences in transportation and handling costs between the two regions (which affect the social prices of tradables).

The study carried out by Byerlee and Longmire (1986) focusing on wheat in Mexico illustrates this particular use of DRC analysis. Wheat is produced in two widely separated regions of Mexico: the northern irrigated Yaqui valley (located far from major consumption points), and the central rainfed high plateau or *altiplano* (located adjacent to major consumption points). A DRC study was undertaken to shed light on the influence of government policies on producer incentives and to determine Mexico's pattern of comparative advantage in wheat production.[3]

Table 3 presents data from the Byerlee and Longmire study relating to the efficiency of wheat production in two different areas of Mexico. The resource cost ratio calculated for wheat in Sonora (Yaqui valley) is slightly above 1, indicating that the net value-added to domestic resources invested in wheat production exceeds the net value-added to tradables. In contrast, the resource cost ratio calculated for wheat in Tlaxcala (*altiplano*) is below 1, indicating that the net value-added to domestic resources invested in wheat production is less than the net value-added to tradables.

These resource cost ratios suggest that wheat production in the *altiplano* region enjoys a slight comparative advantage over wheat production in the Yaqui valley. This finding came as a surprise, since the relative efficiency of wheat production in the *altiplano* is not widely recognized. While differences in production technologies in part account for the different resource cost ratios, differential transportation costs involved in getting wheat to the major consumption point (Mexico City) also significantly affect the comparative advantage rankings. These results would appear to justify increased investment in research to develop improved rainfed production technologies for the *altiplano*. In addition, they would appear to justify a government initiative to revitalize wheat production in an area where production has been declining in recent years.

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[3] Different levels of production technology were also considered in the Byerlee and Longmire study, but these are not discussed here.

Table 3. Resource cost ratios for two wheat-producing regions in Mexico, 1985

	Sonora (Yaqui Valley)	Tlaxcala (*Altiplano*)
Tradables		
A) Outputs		
Value of production	221,990	69,040
B) Inputs		
Machinery depreciation	8,330	7,020
Fuels and oils (net)	8,540	3,860
Spare parts	6,660	5,570
Purchased inputs	50,720	12,950
Other miscellaneous costs	9,210	9,700
Primary Factors		
Capital (interest)	30,590	20,760
Labor	9,580	2,060
Maintenanace	2,220	1,860
Water	17,160	0
Land	81,060	1,070
Net cost--primary factors	140,710	25,750
Value added--tradables	138,530	29,940
Resource cost ratio	1.02	0.86

Source: Byerlee and Longmire, 1985.

D. Revealing Comparative Advantage Between Technologies

A third use of DRC analysis is to determine comparative advantage between alternative production technologies used for a single crop. Even though in this case the crop remains the same, social profitability measures and/or resource cost ratios may differ considerably between production technologies if the technologies require different types and quantities of inputs.

Longmire's and Lugogo's (1989) study of wheat in Kenya provides a good example of this use of DRC analysis. Wheat is produced in Kenya on large-scale commercial farms using high levels of purchased inputs and machinery. The Kenyan government is interested in expanding wheat production into the smallholder sector, which would necessitate a shift to less resource-intensive production technologies characterized by greater use of draft power and/or human labor. A DRC analysis was used to assess the relative efficiency of smallholder production technologies under a range of farm sizes. Since no wheat is currently grown in Kenya using labor-intensive technologies, prototypical enterprise budgets for the various small-scale technologies were estimated based on technical input-output parameters from Pakistan.

Table 4 presents data from the Longmire and Lugogo study relating to the relative social profitability of alternative wheat production technologies under a range of field sizes. The net social returns figures indicate that for the smallest sized fields (0.5 ha and 1 ha), labor-intensive production technology represents the most socially profitable use of domestic resources, whereas on the larger sized fields (>4 ha), fully mechanized production technology represents the most socially profitable use of resources. Interestingly, none of the intermediate-scale mechanized production technologies represent a socially profitable use of resources on any size fields.

Table 4. Social profitability of wheat production technologies by average size of field, Kenya, 1987

	Average field size				
Wheat technology	**0.5 ha**	**1 ha**	**4 ha**	**10 ha**	**40 ha**
	Ksh/ha	**Ksh/ha**	**Ksh/ha**	**Ksh/ha**	**Ksh/ha**
Ox plow and labor intensive	355	39	-544	-683	-781
Small motorized	-355	-568	-1,059	-1,175	-1,255
South Asian	- 63	-622	-854	-924	-974
Large reaper and large thresher	-739	-678	-878	-939	-981
Fully mechanized	-473	- 39	544	683	781

Source: Longmire and Lugogo, 1989.

These results suggest that labor-intensive production technologies would be socially profitable in Kenya for smallholder wheat producers with restricted access to land. However, in the absence of constraints on farm size, wheat production would remain most efficient on larger landholdings where high levels of mechanization are feasible. This information is potentially useful for Kenyan policy makers, who are currently grappling with the complex issue of land reform. Knowledge of the likely efficiency cost of breaking up large landholdings for redistribution to smallholder farmers will help inform the policy debate.

E. Setting Agricultural Research Priorities

A fourth use of the DRC framework is to help research managers decide how to allocate scarce resources between commodities, regions, or technologies. By using sensitivity analysis to vary technical parameters in the enterprise budgets, research managers can estimate the productivity gains needed to alter existing comparative advantage rankings. This information can be weighed against the probability and likely cost of achieving such productivity gains.

An example of this particular use of DRC analysis appears in Morris' (1988) study of wheat in Zimbabwe. Under a drought scenario in which water was assigned a high opportunity cost to reflect its alternative use value in tobacco production, Zimbabwe was found to lose its comparative advantage in wheat production. By implication, the introduction of more water-efficient wheat production technologies might allow the country's comparative advantage in wheat to be maintained even in periods when water is scarce. Sensitivity analysis was used to test the effect on the comparative advantage rankings of reduced irrigation requirements. Specifically, the variable costs associated with irrigating wheat were gradually lowered to determine the irrigation level at which wheat would become competitive with other crops. Break-even analysis revealed that Zimbabwe's comparative advantage in wheat production would be maintained even during periods of drought if the crop's irrigation requirements could be reduced from the present 720 mm (gross) to around 420 mm (gross). Research managers can use this information to help decide whether or not to allocate increased resources to irrigation management research or breeding for more drought-resistant varieties.

4. LESSONS FROM THE CIMMYT CASE STUDIES

CIMMYT's original decision to undertake a series of applied comparative advantage studies was motivated by an interest in developing methods to help the decision-making of research administrators in national agricultural research systems (Longmire and Winkelmann, 1985). The idea was that research administrators would be able to allocate resources more efficiently if they had knowledge of patterns of comparative advantage--between crops, between regions, or between alternative production technologies. Thus, DRC analysis was seen as a way of generating the sort of information which would help the director of a national research program decide whether to launch a new project in small grains or in oilseeds, whether to build a research station for wheat in Region A or in Region B, or whether to hire an irrigation specialist or a rainfed crops specialist.

To what extent have the CIMMYT comparative advantage studies been able to generate this sort of information? While most of the case studies have produced results which could help inform research resource allocation, many of the studies apparently have failed to elicit the anticipated interest among research administrators in the national systems. Although the reasons for this apparent lack of interest have not been analyzed in detail, three factors are probably at work: 1) CIMMYT scientists may not have been effective in publicizing the findings of the studies; 2) research administrators may often be influenced by political considerations in allocating research resources (allowing them to pay only limited attention to economic efficiency arguments); and 3) researchers may simply not be in a position to affect policy decisions.

Whatever the reason, it has become clear that the main users of the case studies has not been the research managers for whose benefit the studies were supposedly undertaken.

But if the CIMMYT comparative advantage studies have failed to generate the expected interest on the part of research managers, they have been well received by others. The results generated by individual case studies (both the comparative advantage rankings and especially the results of comparative profitability analysis) frequently have been seized by producer groups and/or government officials to be introduced as evidence in the policy dialogue. This has happened even though the authors have made little effort to publicize the policy implications of the research findings, since CIMMYT has not sought to participate directly in domestic agricultural policy debates.

Our experience suggests that comparative advantage studies can help inform the policy dialogue in two important ways. First, social profitability analysis reveals how government policies influence agricultural production incentives. Knowledge of the distribution and strength of policy-induced price distortions can be extremely valuable in helping policy decision-makers make desired adjustments, especially knowledge about the relative importance of targeted taxes and subsidies (e.g., producer price controls, subsidies on inputs) vs. general economy-wide policies (e.g., labor policy, exchange rate policy). Very few other analytical methods reveal these effects in such easily intelligible terms.

Second, social profitability measures and resource cost ratios provide quantitative indicators of comparative advantage which can help decision-makers to assess the cost of promoting one set of productive activities at the expense of another. It is important to recognize, of course, that comparative advantage rankings are based on economic efficiency alone and fail to take into account non-efficiency considerations which often figure prominently in the policy debate (e.g., income distribution, food security, sustainability). In this respect, DRC analysis clearly must be seen as only one tool for applied policy analysis. Nevertheless, most agricultural policy decisions start with an assessment of the economic costs and benefits of alternative courses of action, and the advantage of the DRC framework is that it provides quantitative measures of the opportunity cost of pursuing different alternatives. The DRC framework thus represents an important element--although certainly not the only element--in the policy analyst's conceptual tool kit.

5. REFERENCES

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