ERIC MONKE, SCOTT R. PEARSON, AND NARONGCHAI AKRASANEE*

COMPARATIVE ADVANTAGE, GOVERNMENT POLICIES, AND INTERNATIONAL TRADE IN RICE

The empirical analysis of comparative advantage is an extraordinarily difficult task. Traditionally, empiricists have begun with considerations of factor endowments and intensities and have then proceeded to analyze trade patterns at a high level of aggregation. But they often ended up devoting as much effort to the explanation of paradoxes as to the confident testing of hypotheses. The approach to the analysis of comparative advantage used in this collection of essays, the domestic resource costs of foreign exchange earned or saved (DRC), is less encompassing in scope that that of many traditional analyses.[1] The main advantages of this technique are, first, that differences in technologies and factor endowments are identified explicitly through a detailed examination of input-output structures and, second, that the technique permits analysis of the interactions between economic efficiency and government intervention.

Within countries, the usefulness of measures of comparative advantage is straightforward. In this context, the DRC allows a comparison of the relative efficiencies of regions of production or of alternative technologies.[2] Assessing the importance of comparative advantage at the international level, however, is a more complex task. The high degree of government intervention clearly limits the extent to which comparative advantage is allowed to dictate patterns of international trade in rice. At the same time, it seems unlikely that comparative

*The authors are Doctoral Candidate and Associate Professor, Food Research Institute, Stanford University, and Assistant Professor of Economics, Thammasat University, Bangkok, Thailand, respectively. They wish to thank Walter P. Falcon, Robert W. Herdt, and Leon A. Mears for valuable comments on an earlier draft.

[1] The DRC methodology is described in the first article in this collection of essays, "Comparative Advantage in Rice Production: A Methodological Introduction," by Scott R. Pearson, Narongchai Akrasanee, and Gerald Nelson.

[2] With its emphasis on the use of border prices for produced inputs and shadow prices for primary factors, the DRC approach draws many parallels to the Little-Mirrlees technique of benefit-cost analysis (2).

advantage plays no role in the production and trade of rice. To some degree efficiency and cost can be expected to be important to both actual and potential participants in rice trade.

In this essay we compare the DRC results for the United States, Philippines, Thailand, and Taiwan and investigate the role of government policies in influencing rice trade. The first two parts of the essay concentrate on the structure of comparative costs initially within the four countries and then internationally. The final section is then concerned with a comparison of incentives created by national government policies.

INTRAREGIONAL COMPARATIVE COSTS

The calculation of DRC coefficients for different regions or techniques within a country permits a ranking of relative efficiencies in production. Given a desire to expand production of rice within a country, the region with the lowest DRC is the most efficient avenue for expansion, and DRC rankings thus indicate where the country can expect the highest social rate of return on its investment. If governments initiating the expansion in production wish to maximize social returns, the region with the lowest DRC will be used first in any expansion of production and thus can be said to represent national comparative advantage.

Two caveats to the application of the DRC approach should be mentioned at the outset. First, while the calculation of DRC coefficients permits a ranking of relative efficiencies and thus may be helpful in formulating national rice policy, the existence of distributional and political objectives might be expected to modify the application of DRC results. A second caveat involves consideration of physical constraints on production. Land is a particularly important element in this sense, and it is necessary to consider the extent to which production, using a given technology, can be expanded in each region. More generally, calculation of DRC coefficients that measure comparative advantage involves the use of marginal rather than average costs.

The primary data and principal results of the four country studies are summarized in the first four tables of this essay. These tables, one for each country, contain entries for all of the regions and techniques investigated in the companion essays.

Data for the United States, presented in Table 1, are drawn from the five major producing regions—east Texas, the Mississippi Delta, northeast Arkansas, southwest Louisiana, and California. All calculations are based on the costs of producing long grain #2 (5 percent brokens) rice, except those for California where only medium grain rice is produced. The DRC coefficients, estimated by Mears, are based on an average 1974 world price of $590 per metric ton and range from a low of .28 in east Texas to .50 in California. Only minor differences exist in the levels of utilization of fertilizer, labor, and capital inputs, evidencing rather uniform technologies across regions. Most of the differences in costs among regions result from differences in rice yields and in the opportunity cost of land (i.e., the profitability of alternative crops varies among regions). Although California has the highest rice yields of the five regions, this advantage is more than offset by the high opportunity cost of land. In California the alternative crop

TABLE 1.—COST AND RETURN DATA AND INDICATORS FOR THE UNITED STATES, 1974, LONG GRAIN MILLED RICE, #2 QUALITY[a]

(U.S. dollars per kilogram, or as indicated)

Cost and return data and indicators	East Texas	Mississippi Delta	Northeast Arkansas	Southwest Louisiana	California
(1) Gross output, at domestic prices or at government support prices	.59	.59	.59	.59	.57
(2) Tradable inputs, at domestic prices	.21	.21	.17	.21	.14
(3) Value added, in domestic prices ((1)-(2))	.38	.38	.42	.39	.43
(4) Factor costs, other than capital, at domestic prices	.15	.13	.14	.15	.16
(5) Indirect taxes	.00	.00	.00	.00	.00
(6) Private profitability ((3)-(4)-(5))	.23	.25	.28	.23	.27
(7) Gross output, at world market prices	.59	.59	.59	.59	.57
(8) Tradable inputs, at world market prices	.21	.21	.17	.21	.14
(9) Value added in world market prices ((7)-(8))	.38	.38	.42	.39	.43

TABLE 1.—COST AND RETURN DATA AND INDICATORS FOR THE UNITED STATES, 1974, LONG GRAIN MILLED RICE, #2 QUALITY[a]

(U.S. dollars per kilogram, or as indicated)

(CONTINUED)

Cost and return data and indicators	East Texas	Mississippi Delta	Northeast Arkansas	Southwest Louisiana	California
(10) Domestic resource costs, other than capital, at opportunity costs	.10	.13	.14	.15	.21
(11) Social profitability ((9)-(10))	.28	.25	.28	.24	.23
(12) Domestic capital costs, at opportunity costs	.01	.01	.01	.01	.01
(13) Net social profitability, at official exchange rate ((11)-(12))	.27	.24	.27	.22	.22
(14) Ratio of shadow price of foreign exchange (SPFX) to official exchange rate (OER)	1.00	1.00	1.00	1.00	1.00
(15) Net social profitability, at shadow price of foreign exchange ((9)x(14)-((10)+(12))	.27	.24	.27	.22	.22
(16) Nominal protective coefficient on output (NPCO) ((1)÷(7))	1.00	1.00	1.00	1.00	1.00

(17) Nomical protective coefficient on tradable inputs (NPCI) ((2)÷(8))	.99	.99	.99	1.00	.99
(18) Effective protective coefficient on value added (EPC) ((3)÷(9))	1.00	1.00	1.00	1.00	1.00
(19) Domestic resource cost coefficient (DRC) ([(10)+(12)]÷(9))	.28	.37	.36	.42	.50
(20) Ratio of DRC to SPFX/OER ((19)÷(14))	.28	.37	.36	.42	.50
(21) Yield (*kilograms of paddy per acre*)	2,013	2,041	2,313	1,805	2,554
(22) Milling ratio (*kilograms of paddy per kilogram of milled rice*)	1.82	1.82	1.82	1.82	1.52

[a]California data apply to medium grain #2. See Mears (*10*).

to rice is safflower, and land has an opportunity cost more than twice as great as that of any other region. Rice land in California is several times as valuable as rice land in east Texas, where the best alternative to rice has recently been cattle grazing. In the three other regions the alternative is soybeans, a fact that contributes importantly to the similar land costs and DRC coefficients of these regions.

The Philippines data, presented in Table 2, emphasize differences in technologies for producing rice. Herdt and Lacsina found that the most efficient systems are the small-farm technology of Laguna, characterized by inexpensive irrigation facilities, which has a DRC coefficient of .85, and the capital-intensive farm in Davao, with a DRC coefficient of .83. Some interesting results are obtained by altering the authors' assumption of equal yields, 3,000 kilograms of paddy per hectare, under all four technologies. If the mean of recent historical data is taken to represent average yield, the yields for Laguna, Luzon, and Davao become 2.9, 2.6, and 2.6 metric tons of paddy per hectare, respectively. With these yields the DRC coefficients of the three systems change to .89, 1.12, and 1.04. The Laguna technology remains the most efficient, but the DRC coefficients of Luzon and Davao exceed one, and hence both of those systems have negative net social profitability. The capital intensive system of Davao demonstrates a disadvantage in opportunity cost terms relative to the labor-intensive small farmer technology of Laguna, because the Davao system makes heavier use of fertilizers, herbicides, insecticides, and imported capital goods without a compensating increase in yields.

Data for Thailand are presented in Table 3. All areas considered by Narongchai and Atchana had very low levels of costs, and the DRC coefficients ranged from .29 to .46.[3] While the second crop regions have yields similar to or greater than those of the first crop regions, they also have proportionally larger costs, resulting in higher DRC coefficients.[4] The close similarity of production costs among areas reflects the competitiveness of internal markets. Producers have not expanded production in the face of low DRC coefficients largely because of the divergence between private and social profitability, which is maintained primarily through government control of foreign trade on rice and fertilizer. Moreover, the use of alternative techniques does not result in substantial variations of DRC

[3] With the exception of Chieng-mai (column 6), the data for Thailand are representative only of the Central Region. This region accounted for less than 20 percent of total Thai rice production during the period 1970-74 (*1*). It is unlikely, however, that other regions of Thailand have substantially lower DRC levels, and, hence, these results may be used for international comparisons without danger of substantial error.

[4] The DRC coefficients may be understated due to a failure to account properly for irrigation costs. This bias is particularly important for the results pertaining to second crops, for which irrigation is typically a prerequisite for production. But this omission probably does not substantially affect the results for international comparisons. For example, an increase in production costs of 30 percent raises DRC coefficients by at most 50 percent, and these adjusted results, though much higher than those for first crop production, are still well below one in value. Moreover, if irrigation costs are the same for the best alternative crop and for rice, these costs are included in the social opportunity cost of land. Then the problem is no longer one of undercosting but rather of the allocation of costs between tradables and primary domestic factors. In this instance the calculated DRC values will overstate their true values.

TABLE 2.—COSTS AND RETURNS DATA AND INDICATORS FOR THE PHILIPPINES, 1974

(Philippines pesos per kilogram, or as indicated)

Cost and return data and indicators[a]	Laguna	Central Luzon	Masagana 99	Davao
(1) Gross output, at domestic prices or at government support prices	2.70	2.70	2.70	2.70
(2) Tradable inputs, at domestic prices	.43	.36	.70	.88
(3) Value added, in domestic prices ((1)-(2))	2.27	2.34	2.00	1.82
(4) Factor costs, other than capital, at domestic prices	1.25	.97	1.07	.77
(5) Indirect taxes	0	.01	.02	.03
(6) Private profitability ((3)-(4)-(5))	1.02	1.36	.91	1.02
(7) Gross output, at world market prices	2.30	2.30	2.30	2.30
(8) Tradable inputs, at world market prices	.38	.51	.61	.78
(9) Value added in world market prices ((7)-(8))	1.92	1.79	1.69	1.52
(10) Domestic resource costs, other than capital, at opportunity costs	1.25	1.11	1.07	.77

TABLE 2.—COSTS AND RETURNS DATA AND INDICATORS FOR THE PHILIPPINES, 1974

(Philippines pesos per kilogram, or as indicated)

(CONTINUED)

Cost and return data and indicators[a]	Laguna	Central Luzon	Masagana 99	Davao
(11) Social profitability ((9)-(10))	.67	.68	.62	.75
(12) Domestic capital costs, at opportunity costs	.39	.55	.53	.49
(13) Net social profitability, at official exchange rate ((11)-(12))	.28	.13	.09	.26
(14) Ratio of shadow price of foreign exchange (SPFX) to official exchange rate rate (OER)	1.05	1.05	1.05	1.05
(15) Net social profitability, at shadow price of foreign exchange ((9)x(14)-((10)+(12))	.37	.21	.17	.33
(16) Nominal protective coefficient on output (NPCO) ((1)÷(7))	1.17	1.17	1.17	1.17
(17) Nominal protective coefficient on tradable inputs (NPCI) ((2)÷(8))	1.13	.71	1.15	1.13

(18) Effective protective coefficient on value added (EPC) ((3)÷(9))	1.18	1.13	1.18	1.20
(19) Domestic resource cost coefficient (DRC) ([(10)+(12)]÷(9))	.85	.93	.95	.83
(20) Ratio of DRC to SPFX/OER ((19)÷(14))	.81	.89	.91	.79
(21) Yield (*kilograms of paddy per hectare*)	3,000	3,000	3,000	3,000
(22) Milling ratio (*kilograms of paddy per kilogram of milled rice*)	1.50	1.50	1.50	1.50

[a]Cost items differ somewhat from the country study due primarily to differences in assumptions concerning processing and marketing costs.

TABLE 3.— COSTS AND RETURNS DATA AND INDICATORS FOR THAILAND, 1974

(Thailand bahts per kilogram, or as indicated)

Cost and return data indicators	Second crop								Traditional variety, transplanting		Modern variety, transplanting		Traditional variety, broadcasting	
	Non-tha-buri	Chai-nat	Ayud-hya	Supan-buri	Cha-choeng-sao	Chieng-mai	No-korn Nay-ok	Pa-thum-tha-nee	Chai-nat	Sing-buri	Chai-nat	Sing-buri	Chai-nat	Sing-buri
(1) Gross output, domestic prices or at government support prices	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76
(2) Tradable inputs, at domestic prices	1.41	1.24	1.33	1.22	1.26	.83	1.18	1.35	.77	.68	.76	.70	.81	.77
(3) Value added, in domestic prices ((1)-(2))	4.35	4.52	4.43	4.54	4.50	4.93	4.58	4.41	4.99	5.08	5.00	5.06	4.95	4.99
(4) Factor costs, other than capital, at domestic prices	2.53	2.88	2.88	3.05	3.05	3.35	3.29	3.35	2.43	2.24	2.09	2.13	2.26	2.35
(5) Indirect taxes	.02	.00	.01	.01	.02	.01	.01	.00	.01	.00	.01	.00	.01	.00
(6) Private profitability ((3)-(4)-(5))	1.82	1.64	1.55	1.48	1.43	1.57	1.28	1.06	2.55	2.84	2.90	2.93	2.68	2.64
(7) Gross output, at world market prices	11.17	11.17	11.17	11.17	11.17	11.17	11.17	11.17	11.17	11.17	11.17	11.17	11.17	11.17
(8) Tradable inputs, at world market prices	1.56	1.39	1.51	1.37	1.48	1.02	1.37	1.51	.96	.85	.92	.80	1.15	1.12
(9) Value added in world market prices ((7)-(8))	9.61	9.78	9.66	9.80	9.69	10.15	9.80	9.66	10.21	10.32	10.25	10.37	10.02	10.05
(10) Domestic resource costs, other than capital, at opportunity costs	2.53	2.88	2.88	3.05	3.05	3.35	3.29	3.35	2.43	2.24	2.09	2.13	2.26	2.35

(11) Social profitability ((9)-(10))	7.08	6.90	6.78	6.75	6.64	6.80	6.51	6.31	7.78	8.08	8.16	8.24	7.76	7.70
(12) Domestic capital costs, at opportunity costs	1.07	1.06	1.05	1.10	1.12	.99	1.13	1.09	.99	.92	.96	.92	.95	.93
(13) Net social profitability, at official exchange rate ((11)-(12))	6.01	5.84	5.73	5.65	5.52	5.81	5.38	5.22	6.79	7.16	7.20	7.32	6.81	6.77
(14) Ratio of shadow price of foreign exchange (SPFX) to official exchange rate (OER)	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
(15) Net social profitability, at shadow price of foreign exchange ((9)x(14)-((10) +(12))	8.51	8.38	8.24	8.19	8.04	8.45	7.93	7.73	9.44	9.84	9.87	10.02	9.42	9.38
(16) Nominal protective coefficient on output (NPCO) ((1)÷(7))	.52	.52	.52	.52	.52	.52	.52	.52	.52	.52	.52	.52	.52	.52
(17) Nominal protective coefficient on tradable inputs (NPCI) ((2)÷(8))	.91	.89	.88	.89	.85	.81	.86	.89	.80	.80	.83	.88	.70	.69
(18) Effective protective coefficient on value added (EPC) ((3)÷(9))	.45	.46	.46	.46	.46	.49	.47	.46	.49	.49	.49	.49	.49	.50
(19) Domestic resource cost coefficient (DRC) ([(10)+(12)]÷(9))	.37	.40	.41	.42	.43	.43	.45	.46	.34	.31	.30	.25	.32	.33
(20) Ratio of DRC to SPFX/OER ((19)÷(14))	.29	.32	.33	.33	.34	.34	.36	.37	.26	.25	.24	.20	.25	.26
(21) Yield (*kilograms of paddy per rai*)	500	580	540	440	400	360	400	450	418.30	480.30	606.40	622.30	406.50	402.10
(22) Milling ratio (*kilograms of paddy per kilogram of milled rice*)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50

coefficients. The modern variety, transplanting technology, for example, increases yields by 50 percent relative to the traditional variety, broadcasting technology. But this increase is accompanied by an almost proportional rise in input costs, resulting in only a slight gain in social profitability and a modest decline in the DRC coefficient.

Table 4 contains data and results for Taiwan. The data set compiled by Wu and Mao is the most comprehensive of all the country studies, covering all three major producing regions, first and second crops, and the use of modern and traditional varieties. The DRC coefficients range between .55 and 1.43.[5] While there is little apparent difference in production efficiencies between varieties, first crop production is much more efficient than second crop production, due largely to higher yields caused by more favorable environmental conditions during the growing season. Among first crop areas, the South is the most efficient producing region, because of lower input costs per hectare and higher yields, while the southern and central regions are nearly equally efficient among second crop areas.[6]

In conclusion, within each of the four countries the least efficient region has a coefficient of 1.5 to 2.5 times greater than the most efficient region. Production of rice within countries thus occurs with a wide range of relative efficiencies. However, the simultaneous occurrence of efficient and inefficient regions (characterized by DRC coefficients less than and greater than one) is observed only in Taiwan and the Philippines. As will be discussed in the following two sections, this outcome is the result partly of government policies toward rice, creating differences between private and social profitability, and partly of the high world prices prevailing in 1974 which, ceteris paribus, biased DRC results downward.

INTERNATIONAL COMPARATIVE ADVANTAGE AMONG THE FOUR COUNTRIES

We noted above that the regions or techniques with the lowest DRC coefficients within each country should be used for the determination of international comparative advantage. In this discussion we consider the Texas and Mississppi Delta regions of the United States and the Laguna and Davao techniques for the Philippines. For Thailand, we include the most efficient second crop region, Nonthaburi, and modern variety, first crop region, Singburi.

[5] Although broad in scope, the data for Taiwan have a weakness arising from a failure to evaluate irrigation costs fully. The data used by the authors include due fees for irrigation associations, but these costs are of a small magnitude. It therefore appears unlikely that they fully cover costs, implying that some degree of input subsidization was maintained by the government. Added costs of this type have little effect on the ranking of areas within Taiwan as long as irrigation facilities are distributed equally across regions. The ramifications for international comparisons, however, are more serious because the absolute levels of the DRC coefficients may increase substantially.

[6] Interestingly enough, land costs were higher in the North, suggesting that northern rice-growing regions may be more suitable to the growing of alternative crops than southern regions. Since Wu and Mao did not use the profitability of the best alternative crop in computing the opportunity cost of land, this inference requires the assumption of the existence of perfectly competitive land markets.

The first and second crops from the southern region of Taiwan represent the most efficient production alternatives in that country.

In Charts 1 through 4, the ratio of the DRC to the shadow price of foreign exchange is plotted against the world price of rice. This approach is useful for two reasons. First, it is possible to imagine a short-run world price high enough so that nearly all countries demonstrate comparative advantage indicated by positive net social profitability and a ratio of the DRC coefficient to the shadow price of foreign exchange of less than one. The high prices prevailing in 1974 demonstrate this point. A more pertinent consideration, however, hinges on the determination of comparative advantage under long-run prices. The graphical analysis does not identify long-run prices, but it does indicate the world price where comparative advantage disappears (at the point where the ratio of the DRC coefficient to the shadow price of foreign exchange equals one).

Second, this analysis allows for recognition of the product differentiation that characterizes the rice market. At any point in time, the relevant world price for any country depends on the grade of rice consumed or produced for export. For Taiwan and the Philippines, the relevant world prices pertain to grades of rice containing a high percentage of brokens, which command a substantially lower price than premium quality grades. With respect to Thailand and the United States, where comparisons are made for a similar grade (white rice, 5 percent brokens), price differentials may prevail due to perceived quality differences—U.S. rice generally commands a premium price relative to Thai rice of the same grade. Hence, determinations of comparative advantage at any given time for the countries in this study involve the use of parallel but different world prices. In this analysis, the average 1974 prices for the United States, Thailand, Taiwan, and the Philippines are \$590, \$550, \$360, and \$350 per metric ton, respectively.

After an allowance is made for price differences due to quality differentials, Thailand appears to have a substantial advantage over the remaining countries in this study. For first crop production, Thai producers demonstrate comparative advantage at world prices as low as \$150 per ton. While second crop production is less efficient, comparative advantage seems to prevail at prices as low as \$200 per ton. However, our inability to account adequately for irrigation costs in second crop production could mean that this result is somewhat understated. In the United States, east Texas is the most efficient producing area, and the break-even price is \$335 per ton. The relevant price is \$365 per ton for the Mississippi Delta, where most of the expansionary potential lies. While prices for U.S. rice were above this level during 1973-74, average prices for the preceding decade were below this price, suggesting the need for producer subsidies to maintain production levels if future world prices return to the levels prevailing before 1973.

Wu and Mao's data for Taiwan indicate that first crop production is efficient at world prices of \$200 per ton; second crop production becomes inefficient at world prices below \$350 per ton. Because of the likelihood of undercosting of irrigation, the critical world prices were probably higher, perhaps not much different from those of the Philippines, where the relevant world price falls in the \$275-350 per ton range. Consequently, both countries demonstrate comparative advantage at world price levels prevailing in 1973-74 (top grades of broken rice

TABLE 4.—COSTS AND RETURNS DATA FOR TAIWAN, 1974

(New Taiwanese dollars per kilogram, or as indicated)

Cost and return data indicators	Northern region				Central region				Southern region				Taiwan	
	First crop		Second crop		First crop		Second crop		First crop		Second crop		First crop	Second crop
	Ponlai	Native	Ponlai	Native	Ponlai	Native	Ponlai	Native	Ponlai	Native	Ponlai	Native		
(1) Gross output, at domestic prices or at government support prices	14.82	14.82	14.82	14.82	14.95	14.95	14.95	14.95	14.76	14.76	14.76	14.76	14.86	14.85
(2) Tradable inputs, at domestic prices	1.39	1.50	2.29	2.30	1.84	1.43	2.44	2.44	1.26	1.36	2.91	2.69	1.49	2.58
(3) Value added, in domestic prices ((1)-(2))	13.43	13.32	12.53	12.52	13.11	13.52	12.51	12.51	13.50	13.40	11.85	12.07	13.37	12.27
(4) Factor costs, other than capital, at domestic prices	9.77	9.44	11.51	14.28	8.10	7.39	9.43	9.28	6.08	6.24	9.11	9.29	7.85	9.79
(5) Indirect taxes	.07	.10	.12	.13	.08	.08	.12	.11	.05	.05	.10	.08	.07	.11
(6) Private profitability ((3)-(4)-(5))	3.59	3.78	.90	-1.89	4.93	6.05	2.96	3.12	7.37	7.11	2.64	2.70	5.45	2.37
(7) Gross output, at world market prices[a]	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68
(8) Tradable inputs, at world market prices	1.42	1.58	2.49	2.20	1.94	1.51	2.54	2.55	1.26	1.37	2.90	2.62	1.54	2.65
(9) Value added in world market prices ((7)-(8))	12.26	12.10	11.19	11.48	11.74	12.17	11.14	11.13	12.42	12.31	10.78	11.06	12.14	11.03
(10) Domestic resource costs, other than capital, at opportunity costs	9.77	9.44	11.51	14.28	8.10	7.39	9.43	9.28	6.08	6.24	9.11	9.29	7.85	9.79
(11) Social profitability ((9)-(10))	2.49	2.66	-.32	-2.80	3.64	4.78	1.71	1.85	6.34	6.07	1.67	1.77	4.29	1.24
(12) Domestic capital costs, at opportunity costs	1.14	1.43	1.64	2.12	1.15	1.09	1.51	1.47	.71	.68	1.35	1.18	1.02	1.48

(13) Net social profitability, at official exchange rate ((11)-(12))	1.35	1.23	(-1.96)	(-4.92)	2.49	3.69	.20	.38	5.63	5.38	.32	.59	3.27	(-.24)
(14) Ratio of shadow price of foreign exchange (SPFX) to official exchange rate (OER)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(15) Net social profitability, at shadow price of foreign exchange ((9)x(14)-((10) +(12))	1.35	1.23	(-1.96)	(-4.92)	2.49	3.69	.20	.38	5.63	5.38	.32	.59	3.27	(-.24)
(16) Nominal protective coefficient on output (NPCO) ((1)÷(7))	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
(17) Nominal protective coefficient on tradable inputs (NPCI) ((2)÷(8))	.98	.95	.92	1.04	.95	.95	.96	.96	1.00	.99	1.00	1.03	.97	.97
(18) Effective protective coefficient on value added (EPC) ((3)÷(9))	1.10	1.10	1.12	1.09	1.12	1.11	1.12	1.12	1.09	1.09	1.10	1.09	1.10	1.11
(19) Domestic resource cost coefficient (DRC) ([(10)+(12)]÷(9))	.89	.90	1.18	1.43	.79	.70	.98	.96	.55	.56	.97	.95	.73	1.02
(20) Ratio of DRC to SPFX/OER ((19)÷(14))	.89	.90	1.18	1.43	.79	.70	.98	.96	.55	.56	.97	.95	.73	1.02
(21) Yield (*kilograms of paddy per hectare*)	3,898	3,740	2,958	2,379	5,608	5,440	4,238	4,079	6,210	5,703	3,760	3,530	5,103	3,683
(22) Milling ratio (*kilograms of paddy per kilogram of milled rice*)	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45

[a]The world market price used here in $360 per metric ton rather than the $400 per metric ton used in the Wu and Mao study. The latter price applied to an April 1975 time perioJ, when Taiwanese prices were roughly 10 percent above 1974 averages. The price used by Wu and Mao was adjusted downward to approximate a 1974 standard.

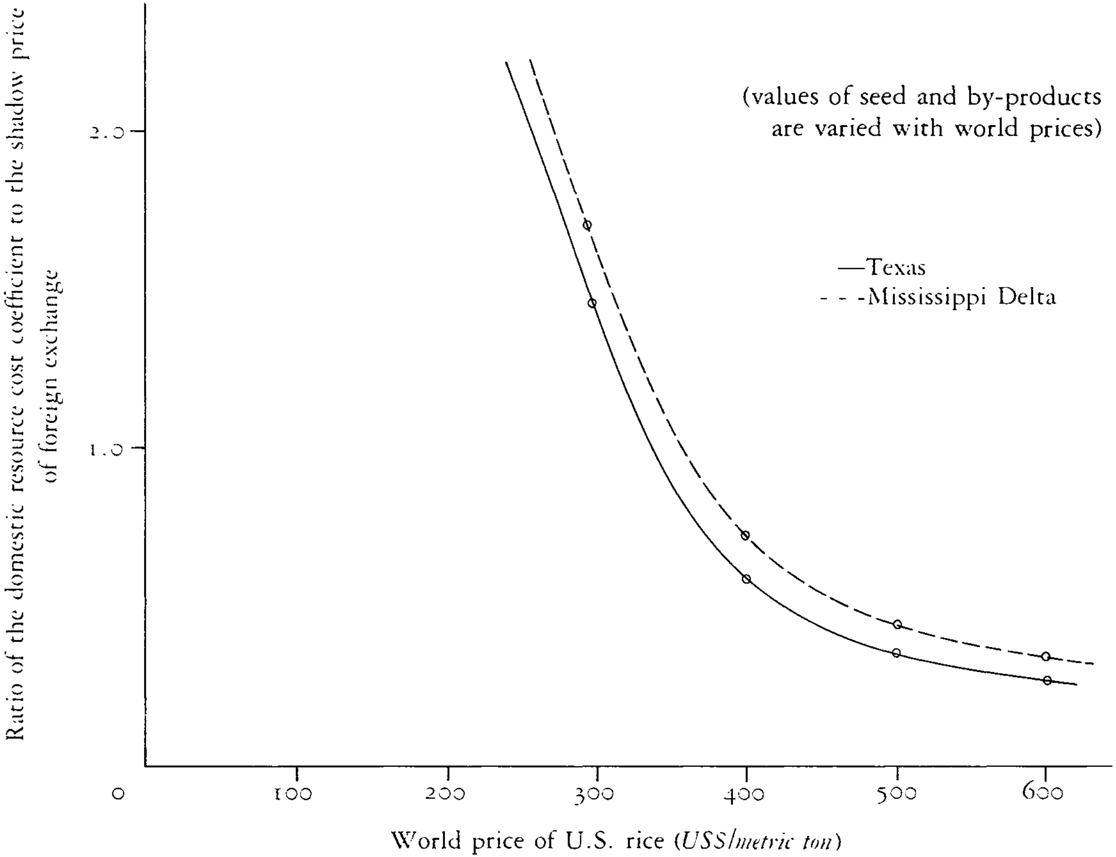

CHART 1.—COMPARATIVE ADVANTAGE AT ALTERNATIVE WORLD PRICES FOR RICE, UNITED STATES

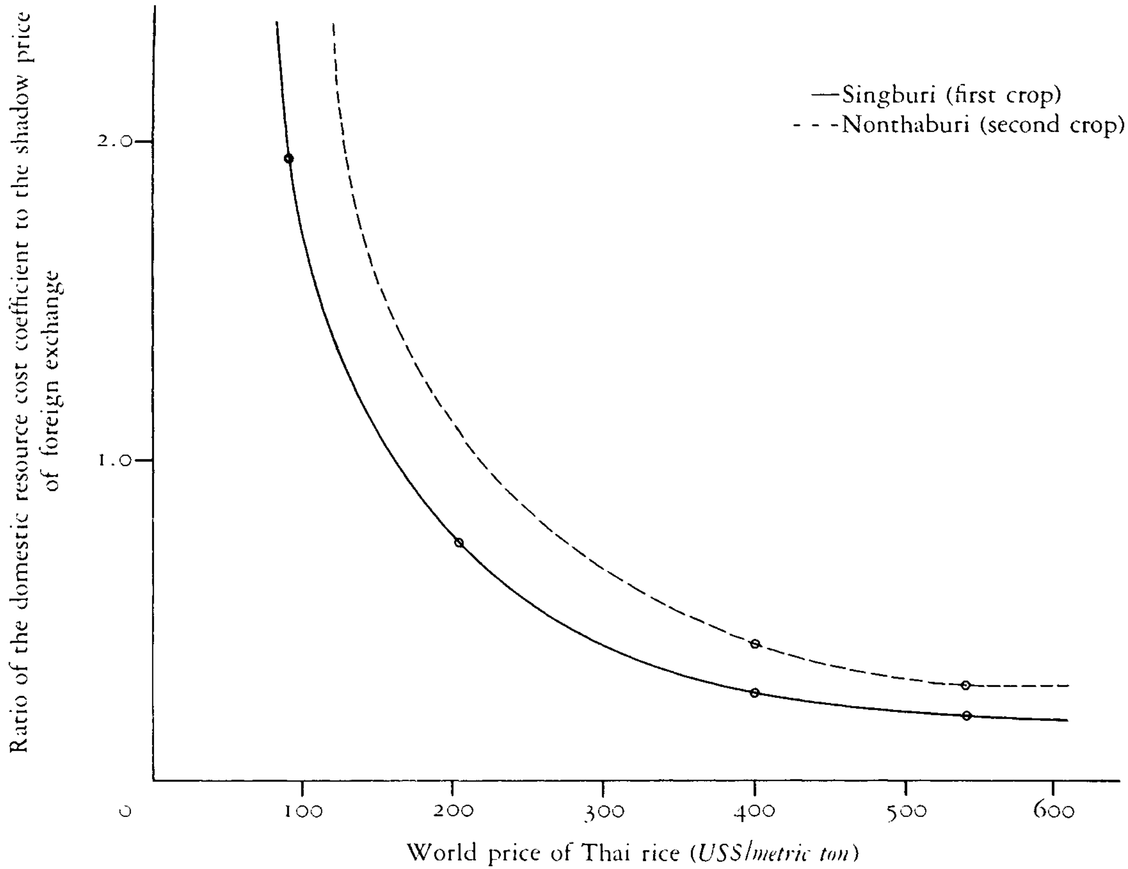

CHART 2.—COMPARATIVE ADVANTAGE AT ALTERNATIVE WORLD PRICES FOR RICE, THAILAND

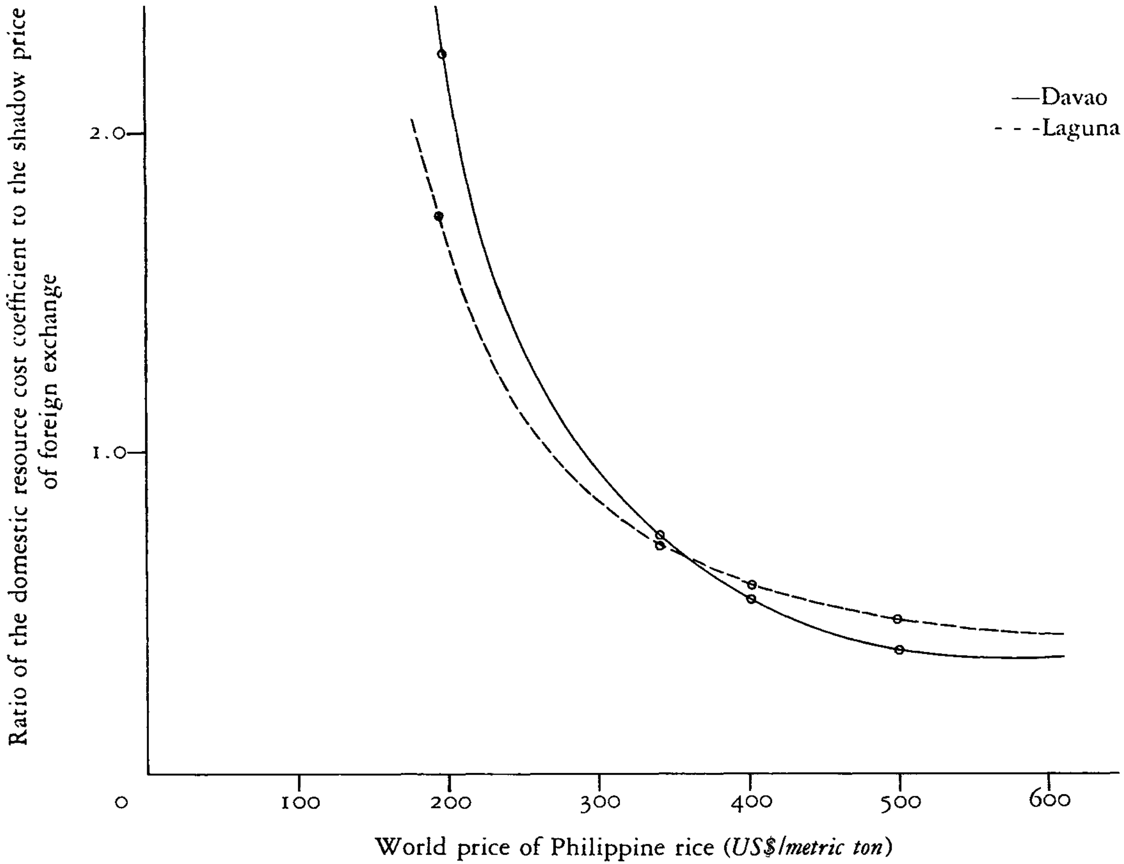

CHART 3.—COMPARATIVE ADVANTAGE AT ALTERNATIVE WORLD PRICES FOR RICE, PHILIPPINES

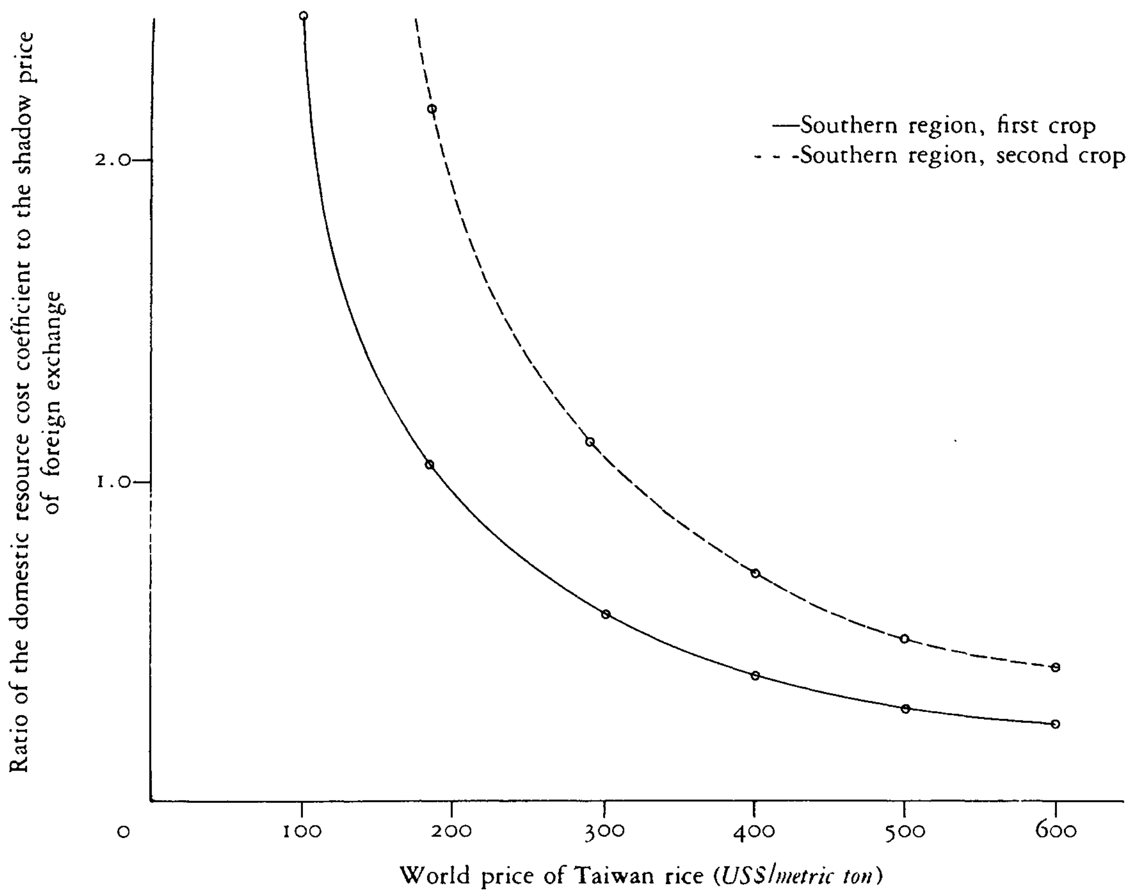

CHART 4.—COMPARATIVE ADVANTAGE AT ALTERNATIVE WORLD PRICES FOR RICE, TAIWAN

were sold on commercial markets for $300-350 per ton during this period). But at prices more in line with long-run averages, both countries would appear to have a comparative disadvantage in production. Hence, programs that encourage production in these two countries, using technologies examined here, could well incur efficiency costs if world prices fall to earlier levels.

DRC elasticities, defined as the percentage change in a parameter required to cause a one percent change in the DRC coefficient, assist in assessing comparative costs across countries. These elasticities are calculated with respect to six underlying parameters—the opportunity costs of labor, land, domestic capital, fertilizer, and processing and transport, and the levels of rice yields. This technique allows both for comparisons of the relative importance of various parameters in the determination of the DRC coefficient and for changes in underlying assumptions with respect to important parameters.

Results of the estimation of DRC elasticities are presented in Table 5. In this form, the larger the value of the DRC elasticity, the less effect the relevant parameter has on the DRC coefficient. For example, if the DRC elasticity with respect to fertilizer is 25, this result implies that a 25 percent increase in the social opportunity cost of fertilizer creates a 1 percent change in the value of the DRC coefficient.

The opportunity cost of labor is one of the most significant cost parameters in all countries. Perhaps more surprising, considering the varied levels of agricultural development represented here, the importance of labor costs is of a similar

TABLE 5.—DRC ELASTICITIES*

Region	Labor	Land	Domestic capital	Fertilizer	Processing and transport	Yields
United States						
Mississippi Delta	1.7	3.1	3.3	10.9	35.0	-1.1
Texas	1.1	23.8	4.1	5.5	35.0	-1.1
Thailand						
Nonthaburi[a]	1.4	18.0	3.4	15.8	1.6	-2.3
Singburi[b]	1.9	5.8	3.5	35.0	1.4	-2.1
Philippines						
Laguna	2.3	4.2	3.1	25.0	3.1	-1.3
Davao	3.0	3.8	2.6	4.5	2.8	-1.1
Taiwan						
South[c]	1.6	4.1	12.2	24.5	35.0	-1.4
South[d]	1.5	4.6	8.3	13.9	35.0	-1.3

*Tables 1 through 4 and authors' calculations.
[a]Second crop.
[b]First crop.
[c]Ponlai, first crop.
[d]Native, second crop.

magnitude across all four countries; the elasticities are in a range of 1.1 to 3.0. For the three developing countries considered here, the sensitivity of the DRC coefficients to changes in labor costs suggests that technological change will be necessary to preserve present levels of comparative advantage as economic growth gradually causes the relative price of labor to rise.

Since the rent from the best alternative crop to rice is used in determining the opportunity cost of land, changes in prices and profitabilities of alternative crops affect the comparative advantage of rice production. The DRC elasticity with respect to the opportunity cost of land allows consideration of this possibility. With the exception of second crop production in Thailand and the Texas region of the United States, changes in land costs are of similar magnitude across the countries and exert only slightly less influence on the DRC than changes in labor costs. A 20 percent change in the profitability of alternative crops will change the DRC by about 3 percent in first crop production in Thailand, 5 percent in the Philippines and Taiwan, and about 7 percent in the Mississippi Delta region of the United States.

With the exception of the Philippines, the DRC coefficients are less sensitive to changes in domestic capital costs than to changes in labor costs.[7] Changes in fertilizer costs appear to affect comparative advantage significantly only in the Texas region of the United States and in Davao in the Philippines. Fertilizer cost is less significant in the other regions, even in Taiwan where its use receives strong governmental encouragement. Processing and transport costs are insignificant in Taiwan, due to its small geographical size and in the United States, because of the high value placed on by-products. In Thailand and the Philippines these costs are relatively important, but for Thailand this result reflects in part the small absolute magnitude of other costs as much as the importance of processing and transport.

The DRC elasticities with respect to yields are similar across countries and very significant, particularly in the Philippines, Taiwan, and United States, where values range between -1.1 and -1.4. This result underscores the importance of yield assumptions in the determination of comparative advantage. Not suprisingly, the reliability of DRC calculations depends directly on the quality of yield information.

Two assumptions used in DRC analysis—constant cost technologies and zero elasticities of input substitution—are critical in the evaluation of the above results. The use of a fixed-coefficient production function is restrictive, particularly from an agricultural perspective. While these assumptions emphasize the static nature of the DRC concept, they do not compromise the validity of its use to measure comparative advantage, at least at the commodity level. The assumption of constant cost technologies can be circumvented with the use of the common linear-programming technique of adding more technologies. This procedure is analogous to approximating a continuous supply function with a noncontinuous step function, and the regional differentiations made in the country studies represent a step in this direction. The assumption of zero elasticities of input

[7] These figures do not consider the overall capital intensity of production, because many capital goods are tradable. Only primary domestic capital is considered here.

substitution emphasizes the short-run nature of both the DRC concept and comparative advantage itself. Empirically, it is only possible to identify patterns of comparative advantage at a given moment in time.

A dynamic evaluation of comparative advantage is a much more complex and speculative task. In a dynamic context, comparative advantage in the production of a commodity is dependent upon the process of technological change, which alters input mixes and output yields, upon the patterns of economic development, which change the opportunity costs of domestic factors of production, and upon the interaction of these two processes. Hence, considerations of dynamic comparative advantage involve movements along the production function as well as shifts of the production function itself.

To translate these effects into a DRC framework, we begin by restating the definition of the DRC as a ratio of the opportunity costs of domestic factors of production per unit of value added in world prices:

$$\text{DRC} = \frac{D}{P^{w} - TI^{w}}$$

where D equals opportunity costs of primary domestic factors of production per unit output, P^{w} equals world price of output, and TI^{w} equals tradable inputs per unit output, evaluated in world prices. If we ignore effects on output prices, technological change will alter DRC coefficients (and comparative advantage) by altering input mixes and thus changing the relevant values of D and TI^{w}, while economic growth will exert its influence primarily on D. Interactions between these two effects will be important as well. Increases in D resulting from increased labor costs, for example, may encourage changes in technique which place increased emphasis upon the use of tradable capital inputs, thus causing a decline in D and an increase in TI^{w}. Both the numerator and the denominator of the DRC are decreased, and only in the case of a continuous, well-behaved production function would the DRC be expected to remain unchanged.

The case of fertilizer serves to illustrate the points of the previous four paragraphs. Much of the earlier work of the Stanford Rice Project has demonstrated the importance of fertilizer in rice production—both in terms of its price relative to the price of rice and of its importance as an input in the expansion of rice production (*4*, *5*, *6*). While the DRC coefficients presented here appear relatively insensitive to changes in fertilizer costs, this result does not imply that fertilizer is an unimportant input. First, the financial incentives that influence farmers' decisions on input use may deviate a great deal from social costs; decisions to use more or less fertilizer may be sensitive to total expenditure on marketed inputs, for example. Second, the DRC analysis may miss the potential importance that fertilizer expenditures could play in a dynamic sense. The introduction of technological innovations that increase fertilizer use could drastically alter both the relative importance of fertilizer and the comparative advantage of the rice economy of a given region or country.

To reiterate, the DRC technique compares prevailing technologies within and across countries at a given point in time. Accordingly, the assumptions of constant costs and fixed production coefficients emphasize that comparisons of DRC coefficients and the determination of comparative advantage are valid in a dynamic sense only if production technologies and growth patterns do not substantially alter input mixes and domestic factor costs. The DRC does not capture the effects of technological change. Rather, technological change determines the patterns of comparative advantage (and DRC coefficients) in the future.

With these considerations in mind, the international comparisons made in this section indicate that, except for Thailand, the technologies surveyed here are inefficient at world prices below 1973-74 levels, implying that subsidization and/or the introduction of new technologies will be necessary for the United States, Philippines, and Taiwan to maintain current production levels. The second and more surprising result is the similar importance of labor costs across countries in influencing comparative advantage. This result lends support to the contention that increases in per unit labor costs and decreases in labor usage have been largely offsetting throughout the process of technological change in the production of rice.

COMPARATIVE COSTS AND GOVERNMENT POLICIES

Given the extensive involvement of governments in their rice economies, it is of interest to delineate the mechanisms by which private incentives are created by the application of government policies. The analysis presented below can be used to determine whether actual policies reflect the stated aims of governments toward their rice sectors. For example, in light of low or negative social profitabilities in rice production, is the stated objective or self-sufficiency reflected through the creation of effective private incentives for producers, either through intervention in input markets, output markets, or both?

To examine the relationships between government policy and the rice economy this analysis relies on calculations presented in Tables 1 through 4 for the net protective coefficient on output (NPCO), the net protective coefficient on inputs (NPCI), and the effective protective coefficient (EPC). The NPCO is the ratio of the domestic output price, inclusive of government subsidies and taxes that discriminate between foreign and domestic production, to the world market price of output and thus represents the incentive structure on the output side of the market. The NPCI is a ratio similar to the NPCO, except that the comparison involves tradable inputs rather than outputs. The NPCI thus represents the incentive structure on the input side of the market. The EPC, which considers the input and output incentives together, is a ratio of value added in domestic prices to value added in world prices. In short, NPCO equals P^d/P^w; NPCI equals TI^d/TI^w; EPC equals $(P^d - TI^d)/(P^w - I^w)$ where P equals the value of output; TI equals the value of tradable inputs; and the superscripts d and w refer to domestic and world market prices, respectively.

Of the four countries considered in this study, the United States demonstrates the lowest level of government interference on both the input and output sides of the rice economy in 1974. The NPCO, NPCI, and the EPC all approximate unity. The limited involvement of the government in the rice market in 1974 was due to the relatively high world prices for rice that prevailed at that time. This noninterference was historically unusual, since the previous decade saw concessionary sales in the form of PL 480 contracts comprise between 35 and 55 percent of export sales per year and subsidies making up as much as 75 percent of the concessionary sales value. In addition, subsidies as high as 35 percent of the selling price were granted on commercial export sales (*7*, *9*). Consequently, for many of the years since 1960, the NPCO was substantially greater than one. The NPCI was also greater than one in this earlier period, reflecting primarily the protective effect of petroleum import quotas. But since fuel costs were only about 20 percent of farmer input expenditures, the NPCI was only slightly greater than one, leaving the EPC greater than one. The result was both more output and a larger role in world rice trade than a free market outcome would dictate.

It is not clear what pattern these coefficients will assume in the future if world prices return to their pre-1973 levels. The recent lowering of support prices and the elimination of marketing allotments suggests, in the short run at least, a reduced level of governmental interest in maintaining producer incomes.[8] In terms of the indicators used in this study, this policy change is evidenced through a lower NPCO. The abolition of petroleum import quotas has similarly reduced the NPCI, resulting in a convergence of social and private profitability. These changes in policy could result in a diminished U.S. role in world trade relative to recent historical performance.

Thailand has traditionally been a major exporter of rice. The involvement of the Thai government in the rice economy is unique among the countries in this study because the government plays a taxing rather than a subsidizing role. Through a mixture of quotas and export taxes, the Thai government is able to control foreign trade and maintain a large degree of control over domestic price levels. In 1974, world prices were nearly double domestic prices, resulting in a NPCO of .52. On the input side, tariffs are relatively small, and the major differences between world and domestic prices for tradable inputs results from the availability of seed rice at domestic prices. The NPCIs vary from .69 to .91, depending on the relative importance of the cost of seed in the producer's total purchases of tradable inputs. The resulting EPCs are substantially less than one, ranging between .45 and .50. The NPCO used in this study is consistent with recent historical conditions; between 1961 and 1972, f.o.b. export prices averaged 75 percent above Bangkok wholesale prices (*1*). In addition, the historical values of the NPCI and EPC are roughly consistent with the results based on recent data.

The protective structure of the Thai economy suggests that the share of Thai producers in world markets is currently below free market levels. In addition, the relative importance of Thailand as a rice exporter implies that world prices are above their free market levels. The actual magnitude of these differentials is difficult to estimate, but some indicative calculations are possible. Using Narongchai's elasticity of supply of rice exports of .45, a 75 percent increase in rice prices for farmers would bring forth a 35 percent increase in exports. At annual levels of production and exports of 10 and 1.5 million tons, respectively, exports would thus increase by 0.5 million tons. This figure represents a 6 percent

[8] Legislation passed in 1976 abolished marketing quotas and set target and loan prices of $8.25 and $6.25 per hundredweight (cwt.) rough rice, respectively (*12*). Under the new system, payments are made only to allotment holders and are set at a maximum of $2.00 per cwt. If prices declined to $6.25 per cwt. rough rice, the NPCO would be 1.3 for allotment holders and 1.0 for nonallotment holders.

increase in world exports. In view of the price inelastic nature of the demand for rice, a decline in world prices of perhaps 10 percent or more seems possible. Although it is unlikely that the Thai government would permit such changes, Thailand's comparative advantage in rice would be robust with respect to price changes of this magnitude.

In the Philippines both outputs and inputs receive protection. At world prices of $350 per metric ton, the NPCO is estimated at 1.17. The application of tariffs on inputs is heavier in the Philippines than in the other countries under study, and NPCIs range from 1.12 to 1.15. Central Luzon has the highest EPC of the four Philippine cases, 1.31, because a government subsidy on irrigation more than offsets the tariffs on other tradable goods. The EPCs of the other regions range from 1.18 to 1.20.

In Taiwan, the estimates of incentives indicate that only output receives net nominal protection. At a world price of $360 per ton the NPCO is estimated at 1.08. Tariffs on inputs account for 15 percent of farmer expenditures on tradable goods, but in most cases they are more than offset by a government subsidy on fertilizer consumption. The NPCIs range from 0.92 to 1.04, and the NPCI exceeds one in only two cases. Due to the failure to account for irrigation subsidies, the NPCI is no doubt overestimated, implying underestimation of the EPC. As a result, the EPC is probably greater than the 1.09 to 1.12 range implied by Wu and Mao's data.

Both Taiwan and the Philippines are avowedly pursuing self-sufficiency in rice production. It is therefore of interest to compare the effectiveness of government policy in these two countries in furthering this objective. The historical record indicates that Taiwan has been the more successful of the two countries in realizing self-sufficency. Average annual imports for the period 1959-74 were 190,000 metric tons for the Philippines and only 10,000 metric tons for Taiwan.

The average EPC for Taiwan is 1.1, only slightly below the result for the Philippines.[9] Because Taiwanese data overstate the NPCI, the level of protection afforded to rice in Taiwan may be substantially more than that provided to the Philippines' rice economy. Moreover, the incentives at the farm level are more disparate than the above calculations suggest due to differences in processing and postfarm transport costs. In the Philippines, the excess of domestic over world prices can be attributed to processing and transport costs because the farmer received a government controlled price equal to 60 percent of the value of final output, or about US$.22 per kilogram milled equivalent.[10] Based on Herdt and Lacsina's cost of production data, profitability at the farm-level appears negative when market wages are imputed to family labor. Since most of the tariff burden is applied to inputs used at the farm level, the EPC for paddy production is less than one in the Philippines.

Taiwanese farmers, on the other hand, have recently received nearly 98 percent of wholesale value, or US$.38 per kilogram milled equivalent. Based on Wu and Mao's data, farmers earn a positive financial return of US$.05-.10 per kilogram

[9] Alterations in the yield assumptions for the Philippines data affect coefficient values by less than 2 percent and are therefore ignored in this discussion.

[10] Mears et al. (3) estimated the farmer's share of retail prices for the period 1958-69 at 64 percent for Wagwag first class. Shares accruing to farmers were somewhat higher for lesser grades.

milled equivalent. Hence, in Taiwan positive effective protection is present at all levels of the rice economy, and this protection is likely to be greater than that given to the Philippines' rice sector, particularly at the production level where Taiwanese policy offers farmers stronger incentives on both inputs and output. While the emphasis on output price incentives has increased in Taiwan in recent years with a corresponding decline in the emphasis on input subsidies, input subsidization on fertilizer and irrigation remains a crucial element of Taiwan's protective structure. These subsidies serve to offset the disincentive effects of tariffs on inputs.

In conclusion, this section serves to illustrate the rather obvious but nevertheless crucial role that comparative advantage plays in the framing of government policy. Clearly, the most efficient countries have the widest range of policy options. They are the only countries that can simultaneously tax output and maintain domestic prices below world levels, causing an EPC less than one. For relatively inefficient countries the choice of policies is more restrictive. Regardless of whether the objective is self-sufficiency or higher producer incomes, positive incentives must be provided to all segments of the rice economy through a system of input or output subsidies. As the Philippine case demonstrates, positive effective protection is not a sufficient condition to guarantee the attainment of a given objective. The level of effective protection and its distribution among the various segments of the rice economy are also important. Among producing countries with comparative advantage, the least efficient countries (those with the highest DRC coefficients) must provide the highest effective rates of protection. In this circumstance, governmental budgetary considerations may form an added constraint on the choice and implementation of policy.

CONCLUSION

The four country studies compared here demonstrate the wide range of relative efficiencies of production that exist both within and between rice-producing nations. In most instances, government policies in the form of trade intervention or subsidization of domestic rice production allow these differences in efficiency to be maintained. While efficiency differences may have limited explanatory power in international trade, they enter indirectly into the establishment of government policies because they largely determine the costs of intervention. Consequently, comparative advantage partially dictates the choice of policies to achieve given objectives, while both comparative advantage and governmental objectives influence a country's participation in international trade. Finally, this essay, like previous papers in the Stanford Rice Project, demonstrates that detailed studies of rice economies at the national level are essential in the formulation of international perspectives. Clearly, the four country studies included in this set of essays are only a beginning in this effort.

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