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CHANGING COMPARATIVE ADVANTAGE IN PHILIPPINE RICE PRODUCTION: 1966 TO 1982†

Technical change can alter a country's comparative advantage in agricultural production by altering the social profitability of some crops relative to that of others. An example of such change was the introduction of short-statured, fertilizer-responsive rice varieties for the tropics in the late 1960s. These modern varieties are best suited to irrigated environments, and governments in rice-importing countries concerned about food self-sufficiency invested heavily in irrigation facilities (Siamwalla and Haykin, 1983). As a result, modern varieties were more widely adopted in the rice-importing countries of Asia than in traditional rice-exporting countries. Some Asian rice importers have completely replaced imports with domestic production and have reduced rice price protection at the same time (Flinn and Unnevehr, 1984), suggesting an increase in comparative advantage. The Philippines provide an example.

Between 1965 and 1982, modern varieties spread to 85 percent of rice area, fertilizer use on rice tripled, public investments expanded irrigation from 30 to 45 percent of rice area, and Philippine rice production doubled from 2.5 to 5 million tons. The trade balance shifted from net imports to net exports while rice price protection declined.

This article examines the causes of increased Philippine comparative advantage in rice from 1966 to 1982 and the response of government policy to that increase. Estimates of social profitability are used to measure comparative

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advantage. It is demonstrated that technological change has increased social profits by increasing the productivity of domestic factors in rice production.

In order to separate the influence of technology from prices, the total change in social profits is decomposed into the components due to changes in prices or inputs. Comparison of private and social profitability then indicates how Philippine government policy has influenced the levels of private profits. Policy has reinforced the tendency of technological change to benefit all consumers and producers on irrigated land.

TECHNOLOGICAL CHANGE IN PHILIPPINE RICE PRODUCTION

The introduction of modern varieties in 1966 and complementary increases in fertilizer use and irrigated area brought about rapid growth in Philippine rice yields and production.[1] From 1965 to 1980, production grew at an average annual rate of 4.5 percent, but this growth was not constant (Chart 1). Modern varieties were rapidly adopted after 1966 and covered 60 percent of cultivated area by 1970 (Chart 2). Fertilizer use, yields, and production all rose sharply after 1966. This growth was interrupted in 1972 by pest and typhoon damage. Modern varieties created an environment conducive to rice pests, and pest epidemics caused widespread crop failures in the early 1970s. Production returned to trend in 1973 as greater double-cropping on irrigated land increased planted area. Yields did not recover until 1975, but grew steadily thereafter and offset declining planted area after 1978.

Yield growth in the late 1970s reflects the greater productivity and sustainability of yields with newer modern varieties. Short growth duration (110 days), multiple pest and disease-resistant varieties were first released in 1976. These varieties are able to withstand pest pressure, and thus widespread crop failures due to pest attack have not recurred. Later varieties were also more tolerant to moisture stress and adverse soil conditions, leading to adoption rates of modern varieties in rainfed wetland (78 percent) close to those in irrigated areas (89 percent) by 1980.[2] The greater adaptability of second-generation rice modern varieties allowed sustained yield growth in irrigated areas and improved yields in rainfed areas.

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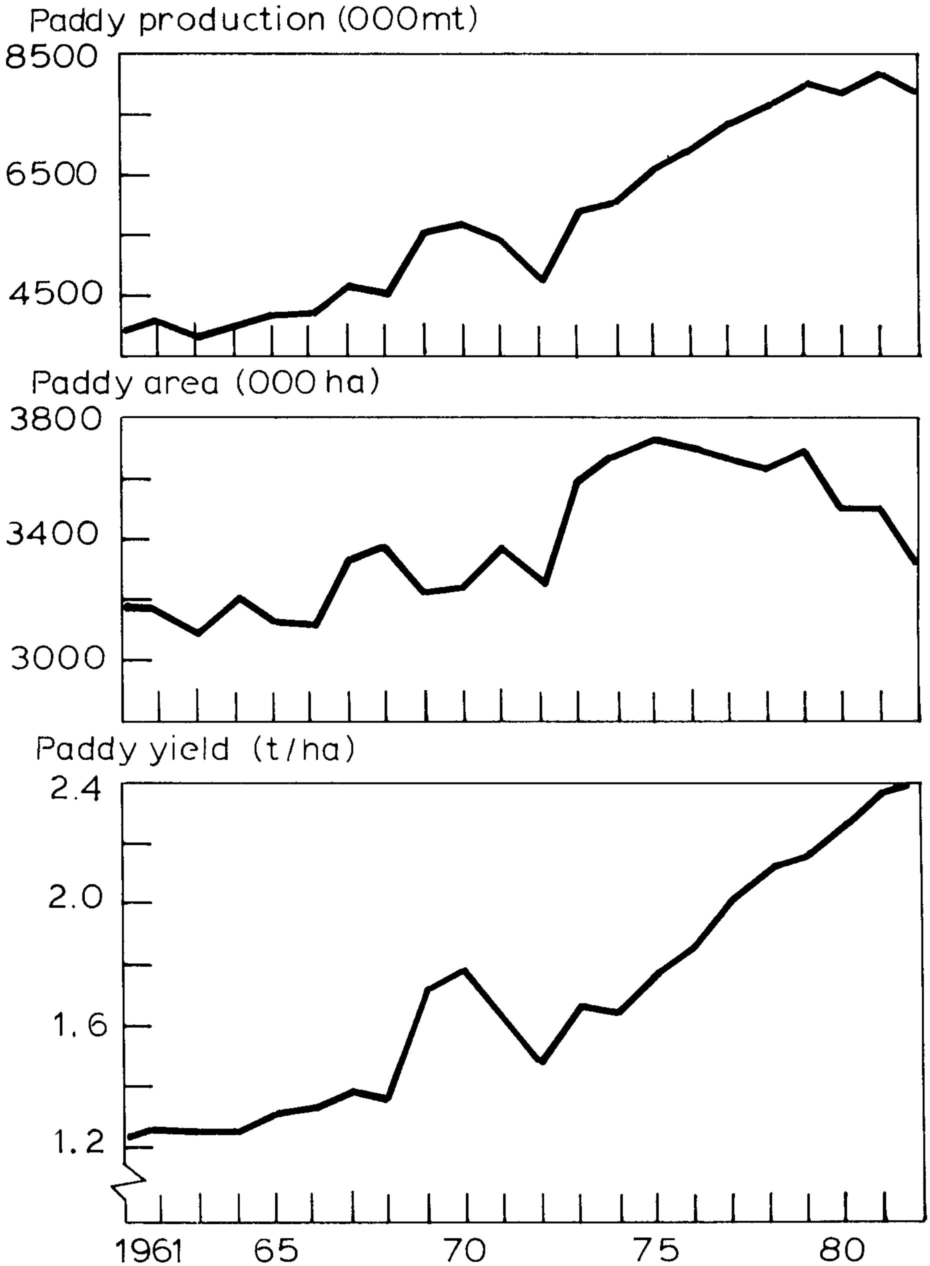
[1] Herdt and Capule used separate fertilizer response functions for modern varieties and traditional varieties under rainfed and irrigated conditions in order to simulate the production effect of holding each factor constant at its 1965 level. They estimate that modern varieties, fertilizer, and irrigation each contributed about one-third of the total growth in yields. It is not surprising that the contribution of each factor is roughly equal. As these three inputs are highly complementary, they tend to be adopted together.

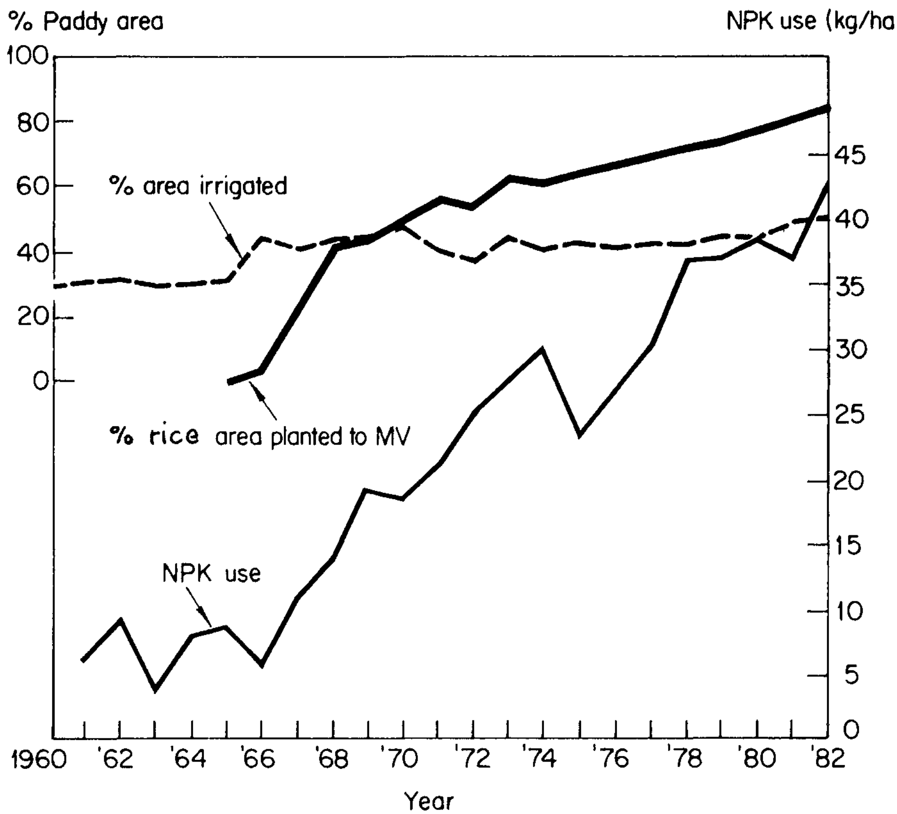
[2] In the Philippines, rainfed rice refers to rice cultivated under flooded conditions without water control. Upland rice refers to rice cultivated without any standing water in the field. In the late 1970s upland rice was only 12 percent of rice area, while rainfed rice accounted for 47 percent. The rest was irrigated.

Chart 1.—Production, Area, and Yield of Paddy in the Philippines, 1961–82



Source: Bureau of Agricultural Economics, Philippine Ministry of Agriculture, Manila.

Chart 2.—Trends in Adoption of Modern Varieties, Fertilizer Use, and Irrigated Area in Rice, the Philippines, 1961–82



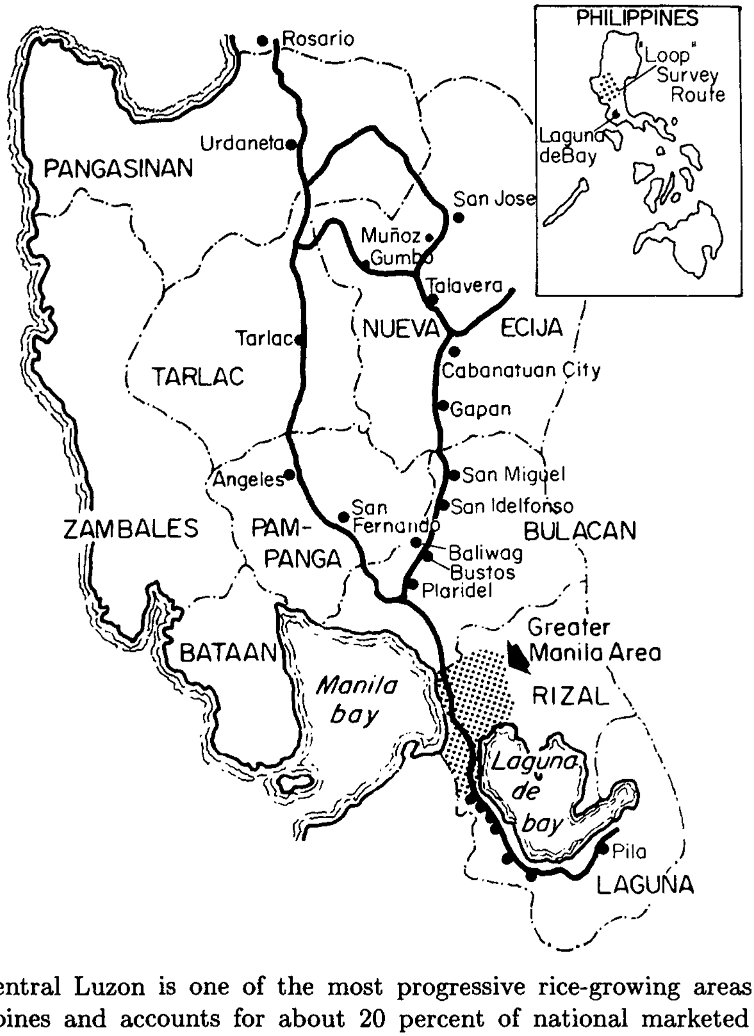
Source: Bureau of Agricultural Economics, Philippine Ministry of Agriculture, Manila.

Farm Level Changes

Data on costs and returns from IRRI surveys of Central Luzon farmers in 1966, 1970, 1974, 1979, and 1982 are used to analyze private and social profitability in rice production. The initial sample in 1966 was selected along a loop starting in Pila, Laguna, stretching north past Manila through the west of Central Luzon, turning east in Pangasinan province, reaching north as far as Rosario, La Union, and returning south through the eastern side of the Central Luzon plain (Map 1). In order to increase the homogeneity of the sample, the farms south of Manila were dropped from the survey in 1979, and additional farms were added in the Central Luzon area.[3]

[3] Farmers south of Manila have better water control and face different relative

Map 1.–Map Showing the Central Luzon "Loop" Survey Area, the Philippines



Central Luzon is one of the most progressive rice-growing areas in the Philippines and accounts for about 20 percent of national marketed supply (BAEcon, various years). Yields are higher and technological change occurred earlier in this region than in the Philippines as a whole. Changes in net social profitability estimated from these data should be indicative of the direction of change for the Philippine rice sector as a whole, because the Central Luzon survey farms reflect the national trends discussed above.

Two irrigated rice crops were grown on only 14 percent of the cultivated area in the 1966 sample, but double-cropping of rice covered 57 percent of area by 1982 (Table 1). Adoption of modern varieties was equally rapid in all

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factor prices due to proximity to Manila.

environments, with the exception of one-crop irrigated farms in 1974. Modern varieties covered 94 percent of sample area in 1979 and 1982. Growth in fertilizer use was more rapid on irrigated farms, where 70 kilograms (kg) of nitrogen per hectare (ha) were applied in 1982. Because rice is less responsive to fertilizer under rainfed conditions, only 42 kg nitrogen per hectare were used on rainfed farms in 1982. Adoption of modern varieties and inorganic fertilizer was also accompanied by increased use of insecticides and herbicides.

Table 1A.—Technology and Techniques Used on Wet Season Rice Production by Central Luzon Sample Farms, 1966–82: Rainfed Farms

	1966	1970	1974	1979	1982
Number of farms	35	26	26	50	45
Average farm size (ha)	1.9	2.0	2.3	1.8	1.7
Paddy yield per ha (kg)	2,390	2,420	1,757	2,140	3,242
Labor days per ha[a]	72	67	70	76	79
Paddy per labor day (kg)	33	36	25	28	36
Elemental nitrogen (kg/ha)	10.7	26.2	26.9	40.8	41.6
Percent of farms using:					
Modern varieties	0	73	65	96	98
Insecticides	28	38	73	84	82
Herbicides	3	27	39	46	69
2-wheel tractors	0	8	8	14	20
4-wheel tractors	6	31	35	31	24
Small threshers	0	0	8	18	67
Big threshers	86	77	50	51	20

Source: International Rice Research Institute, Central Luzon Loop Surveys, Los Baños, 1966–82.

[a]See Table 3 for representative production systems.

The modern varieties planted changed over time. IR5 was the most popular variety in 1970 and covered 40 percent of sample area (Table 2). By 1974 it had been largely replaced by IR20, which has better grain quality than IR5. In 1979, IR36 and IR42 dominated, with 47 percent and 19 percent of area, respectively. Both varieties are resistant to the major rice pests and diseases that emerged in the early 1970s. IR42 has longer growth duration (135 days) than IR36 (110 days), but is tolerant of adverse soils and has better grain quality. These two varieties continued to be popular in 1982, although substantial areas were also planted to IR50 and IR54.

Irrigation, modern varieties, and fertilizer brought about a substantial increase in the productivity of land (as measured by yield) for irrigated farms between 1966 and 1982 (Table 1). Typhoon damage just before harvest in 1974 reduced yield in that year. It is interesting that yield did not vary by water

Table1B.—Technology Used on Wet Season Farms by Central Luzon Sample Farms in 1966-82: Irrigated Farms

	1966	1970	1974	1979	1982
	One-crop irrigated				
Number of farms	39	23	13	21	18
Average farm size (ha)	2.6	2.8	3.1	1.8	1.7
Paddy yield per ha (kg)	2,210	2,700	2,122	3,736	4,290
Labor days per ha[a]	57	66	—	74	—
Paddy per labor day (kg)	39	41	—	50	—
Elemental nitrogen (kg/ha)	8.4	33.1	42.4	68.2	68.5
Percent farms using:					
Modern varieties	0	65	39	100	94
Insecticides	33	56	92	86	89
Herbicides	18	48	77	48	78
2-wheel tractors	0	0	0	24	18
4-wheel tractors	36	48	31	33	24
Small threshers	0	0	0	19	59
Big threshers	97	87	39	62	35
	Two-crop irrigated				
Number of farms	18	13	19	78	73
Average farm size (ha)	1.5	3.0	2.4	2.0	1.8
Paddy yield per ha (kg)	2,249	2,530	2,458	3,990	4,394
Labor days per ha[a]	56	70	78	88	74
Paddy per labor day (kg)	40	36	32	45	59
Elemental nitrogen (kg/ha)	4.0	30.8	46.5	67.2	70.7
Percent of farms using:					
Modern varieties	0	69	89	99	100
Insecticides	22	62	90	97	97
Herbicides	22	46	68	86	88
2-wheel tractors	0	0	42	64	71
4-wheel tractors	22	38	37	14	21
Small threshers	0	0	5	23	79
Big threshers	17	23	26	8	7

Source: International Rice Research Institute, Central Luzon Loop Surveys, Los Baños, 1966–82.

[a]See Table 3 for representative production systems.

regime in 1966, before modern variety adoption, but was consistently higher on irrigated farms in the following years. The use of modern varieties and fertilizer allowed the full potential of irrigation to be realized, and wet season rice yields doubled on two-cropped irrigated farms between 1966 and 1982.

Yield on rainfed farms shows no clear trend over time, even though use

Table 2.—Changes in Rice Varieties Planted
on Central Luzon Survey Farms: 1966–82*
(Percent of sample area)

Varieties	1966	1970	1974	1979	1982
Total IR	—	67	61	92	92
IR5	—	40	2	0	0
IR20	—	14	35	0	1
IR36	—	—	—	47	31
IR42	—	—	—	19	27
IR50	—	—	—	0	12
IR54	—	—	—	—	9
Other IR	—	13	24	26	13
Other modern	—	3	6	2	2
Traditional	100	30	33	6	6

Source: International Rice Research Institute, Central Luzon Loop Surveys, Los Baños, 1966-82.

*Dashes indicate variety not yet released.

of inorganic fertilizers increased. This reflects the changing location of sample rainfed farms (as some of the original sample became irrigated) and the greater influence of weather and location on rainfed yields. Because of changes in the sample, the rainfed farms are not comparable over time.

Changes in the mechanization of rice production accompanied the adoption of yield-increasing technologies. Use of tractors and threshers is a substitution of capital for labor, but does not increase yields.[4] In Central Luzon there was a tendency to substitute labor for capital until 1974 and then a shift to substitution of capital for labor. In 1966 and 1970, many farmers used four-wheel tractors for plowing and carabao for harrowing. After 1970, irrigated farms made increasing use of the less capital-intensive, two-wheel power tillers (hand tractors) for both plowing and harrowing, while most rainfed farms continued to use carabao.

Large stationary (McCormick) threshers powered by tractors have been used in Central Luzon since before the Second World War. When only one crop of rice was grown, harvest took place during the dry season. Large threshers could then be moved easily into the fields where grain had been left to dry. Landlords also encouraged thresher use because it provided better control over the sharing of output (Hayami and Kikuchi, 1981). Land reform and more widespread double-cropping created incentives to shift to manual threshing. The harvest of modern varieties took place earlier during the wet season, and it was difficult to move the large thresher into muddy fields so that grain

[4] See Gill (1983, pp. 329–48), Agarwal (1983), and Jayasuriya et al. (1982) for evidence regarding the effect of mechanization on rice yields and factor inputs.

deteriorated due to the delay. Landlords no longer had an interest in controlling shares since rents were fixed. Manual threshing became common as the number of two-crop farms increased (Hayami and Kikuchi, 1981). The portable mini-thresher became available in 1975 and rapidly replaced the large thresher and manual threshing in both rainfed and irrigated environments. This smaller machine reduces threshing costs, can be moved easily into wet fields, and can thresh wet grain.

Changes in labor use and labor productivity for irrigated farms reflect both adoption of seed-fertilizer technology and changes in mechanization. The seed-fertilizer technology increased demand for labor in fertilizing, weeding, and harvesting, and this accounts for part of the rising labor use per hectare from 1966 to 1979. Labor productivity (kg paddy per man-day) declined from 1966 to 1970 as labor use increased. In 1974, the further decline was due to the higher labor input at harvest to rescue damaged grain. Increasing labor productivity on irrigated farms in 1979 and 1982 is the result primarily of higher yields, and also the widespread adoption of two-wheel tractors and mini-threshers that reduced labor input.

Representative rice production systems were chosen for each of the sample years (Table 3), and average costs for farms in these systems provide the basis for the social profitability analysis. The systems are categorized by environment (rainfed or irrigated) and techniques in land preparation and threshing.[5] The two-crop irrigated systems are taken as representative of the emerging technology in Philippine rice production. Rainfed systems are included for comparison between environments, but these farms are not comparable over time.

ANALYSIS OF SOCIAL PROFITABILITY

Two measures of comparative advantage are used. The first, net social profitability, is the difference between the social value of rice and the social cost of inputs to produce it. Border prices are used to value rice and tradable inputs. Domestic factors are valued at their social opportunity cost (see Appendix for details). The second measure is the resource cost ratio, which is the ratio of domestic factor costs to value added converted to pesos at the real equilibrium exchange rate. A resource cost ratio less than 1 results when the value of domestic resources expended is less than the foreign exchange earned in rice production. A decline in the resource cost ratio indicates an increase in comparative advantage.

To have a comparative advantage in production of rice, the social opportunity cost of domestic factors must be less than value-added at the long-run trend in world prices. The world price of rice fluctuates more than prices of other major grains. Its level in any given year might not reflect the long run social opportunity cost of rice. Two estimates of social profitability are made for

[5] One-crop irrigated systems are not included because they are a very small proportion of farms in later years and net social profitability estimates for wet season production do not differ substantially between one-crop and two-crop systems.

Table 3.—Representative Production Systems by Year
Central Luzon Loop Survey, Wet Season: 1966–82

Year	Environment	Land preparation	Threshing	Farm reporting Number	Sample (percent)
1966	Rainfed	Animal	Big thresher	29	32
	2 crops irrigated	Animal	Manual	10	11
1970	Rainfed	Animal	Big thresher	11	18
	2 crops irrigated	Animal	Manual	7	11
1974	Rainfed	Animal	Big thresher	10	17
	2 crops irrigated	Animal and 4-wheel tractor	Manual	7	12
1979	Rainfed	Animal	Big thresher	17	11
	2 crops irrigated	2-wheel tractor	Manual	25	17
1982	Rainfed	Animal	Small thresher	15	11
	2 crops irrigated	2-wheel tractor	Small thresher	25	18

Source: International Rice Research Institute, Central Luzon Loop Surveys, Los Baños, 1966–82.

each year in which production cost data are available—one with actual world prices in that year and the other with trend estimates of the world prices of rice and fertilizer, the major traded input. (See Appendix for details of trend estimates.) Estimates at trend prices verify that the change in comparative advantage measured at actual prices is not simply the result of unusual prices in particular years.

The results of both estimates show a net increase in comparative advantage for irrigated rice production over the entire period from 1966 to 1982 (Table 4). In 1966 irrigated rice production had negative social profitability, indicating that before modern varieties were introduced this production system was not a socially efficient means of import substitution. Estimates of net social profitability for irrigated farms differ between actual and trend world prices in 1970 and 1974.[6] In 1970, trend world prices were higher than actual and gave a larger net social profitability. In 1974 unusually low yields led to negative net social profitability at trend world prices, but unusually high actual world prices gave positive net social profitability. In 1979 and 1982 net social profitability was positive in both estimates. The trend world price gave higher net social profitability in 1982 because actual world prices were low by historical standards. The increasing comparative advantage for irrigated farms is clear,

[6] Philippine yields moved with world production in these years. Hence there is an inverse relationship between actual world prices and yields, which tends to offset the effect of yield on net social profitability. Net social profitability at actual world prices therefore shows a smoother trend than at trend world prices.

Table 4.—Changes in Comparative Advantage of Central Luzon Rice Production

	1966	1970	1974	1979	1982
Trend world price ($/ton)[a]	101	154	224	307	310
NSP (pesos/ton)[b]					
Irrigated	−264	117	−333	412	641
Rainfed	−133	343	12	433	828
RCR[c]					
Irrigated	1.81	0.86	1.28	0.78	0.72
Rainfed	1.37	0.62	0.99	0.78	0.68
Actual world price ($/ton)[d]	121	109	296	300	242
NSP (pesos/ton)[b]					
Irrigated	−186	−141	63	360	62
Rainfed	−55	78	393	360	235
RCR[c]					
Irrigated	1.46	1.24	0.96	0.80	0.96
Rainfed	1.13	0.88	0.77	0.82	0.88
Exchange rate[e] (pesos/$)	3.91	6.44	7.07	7.38	9.20
Yield (tons/ha)					
Irrigated	1.46	1.64	1.60	2.59	2.86
Rainfed	1.55	1.57	1.14	1.39	2.11

Source: See text and Appendix.

[a]See Appendix for details of estimation.

[b]Net social profitability is estimated from the social costs of production in Appendix Table 2.

[c]Resource cost ratio is estimated from the social costs of production in Appendix Table 2.

[d]Three-year average FOB or CIF values centered on survey year. The border price of rice in the Philippines is below the Thai 5 percent price because the Philippines imports or exports low quality white head rice (25 to 35 percent brokens).

[e]Official exchange rate as reported in International Rice Research Institute, *World Rice Statistics*, Los Baños, 1982.

[f]Paddy yield from Table 1 converted to rice equivalent with milling recovery assumed to be 65 percent.

however, in both sets of estimates.

Rainfed farms show greater social profitability than irrigated farms in most years in both estimates (Table 4). It would be tempting but wrong to conclude that irrigation investment was a mistake from a social efficiency point of view. Rainfed rice production in the relatively favorable environment of Central Luzon is socially profitable, but favorable lands are limited and additional production must come from more intensive systems.

Examination of the components of changes in net social profitability for irrigated rice give insight into why net social profitability for irrigated farms has increased over time. These components are estimated by taking the total differential of net social profitability, which is a function of the world price of rice, the shadow price of foreign exchange, tradable input costs, domestic factor prices, and domestic factor inputs. Increases in the world price of rice or real depreciation of the exchange rate will increase net social profitability, while increases in world prices of tradable inputs or in factor costs will reduce net social profitability.

A technological change shifts the production function outward and reduces the amount of at least one of the factors used to produce rice, thereby increasing net social profitability. In this sample, changes in amounts of tradable inputs or factors used to produce a unit of rice are primarily the result of technological change rather than changes in relative factor prices. Observed changes in factor productivity measure outward shifts in the production function, rather than movements along the function.

Components of change in net social profitability estimates based on actual world prices show different causes of change before and after 1974 (Table 5). From 1966 to 1974 the principal cause of increased net social profitability was the increase in value-added arising from the increase in world rice prices and the depreciation of the peso. Observed yields did not change much, although the use of labor and capital increased with more intensive crop care. Therefore, factor productivity gains were small.

The first observed increase in yields among the sample farms occurred in 1979, followed by another increase in 1982. This contributed to the increase in productivity of land and labor observed from 1974 to 1982. Mechanization also increased labor productivity. Increases in tradable input costs from fertilizer and irrigation were small in comparison to the gains from factor productivity, demonstrating the social profitability of the technological package of modern varieties, fertilizer, and irrigation. Devaluation of the peso between 1979 and 1982 also increased social value-added, but the decline in the actual world price of rice reduced net social profitability.

The total change in net social profitability from 1966 to 1982 is much larger for estimates at trend world prices than for those at actual world prices, because actual world rice prices were low in 1982 (Table 5). Both estimates of the increase in net social profitability can be decomposed into the change due to social value-added, factor productivity, and factor prices. For both estimates there is a net social profitability increase due to factor productivity of about 400 pesos[7] per ton of rice and a decrease due to factor price increases of about 1,400 pesos per ton. The increase in social value-added due to the rising price of rice and depreciation of the peso is 1,300 pesos at actual world prices and 2,000 pesos at trend world prices. Inflation in domestic factor prices has been

[7] See Table 4 for peso to dollar exchange rates by year, 1966–82.

Table 5.—Components of Change in Net Social Profitability (NSP) of Central Luzon Irrigated Rice Production: 1966–82*
(Pesos per ton of rice)

	1966-70	1970–74	1974–79	1979–82	Total 1966–82 Actual world price	Trend world price
Change in NSP	45	204	297	−298	248	906
Due to:						
Social value added						
Rice price	−62	1,263	29	−481	749	1,372
Value of tradable inputs	2	−348	95	−15	−270	−307
Exchange rate	248	100	73	391	812	888
Total	184	1,015	197	−105	1,291	1,953
Factor productivity						
Land	20	−5	197	49	261	261
Labor	−9	−95	159	140	195	195
Capital	−7	−66	15	−3	−61	−65
Total	4	−166	371	186	395	391
Factor prices						
Land	−40	−120	−214	−121	−585	−584
Labor	−44	−105	−168	−168	−485	−486
Capital	−7	−38	39	20	14	15
Total	−91	−353	−343	−269	−1,056	−1,055
Other costs	−52	−292	72	−110	−382	−383

Source: See text and Appendix.

*Elements of the total differential of NSP, calculated from NSP estimates at actual world prices except where indicated. The following formula is used:

$$dNSP = v_1du - v_1dm + (u - m)dv_1 - \sum_{s=2}^{n} f_s dv_s - \sum_{s=2}^{n} v_s df_s - doc,$$

where d indicates the difference in a variable between years, u is the world rice price, v_1 is the exchange rate, m is the value of tradable inputs, f_s is the amount of factor inputs, v_s is the price of factor inputs, and oc is other costs, primarily irrigation and marketing.

Changes in social value added, factor productivity, factor prices, and other costs sum to the change in NSP.

less rapid than depreciation of the peso and inflation in either actual or trend world rice prices, and this has increased comparative advantage. Technological change has contributed to the total increase in comparative advantage, but has played a smaller role than might have been expected. Its contribution to increased factor productivity is only apparent after the introduction of second generation modern varieties in the mid-1970s.

It is interesting to compare the actual 1979 results with the forecast of Herdt and Lacsina (1976) based on the 1974 Central Luzon data. They assumed a 2-ton rice yield even though 1974 yields were only 1.6 tons, because they felt 2 tons would be feasible in the future. Even with this yield assumption, Herdt and Lacsina concluded that Philippine comparative advantage was slight and might easily disappear if world rice prices fell below the US$350 per ton that they used for the border price. Stryker (1981) reestimated Philippine comparative advantage with Herdt and Lacsina's data, using a lower world price of $300 per ton. He found negative net social profitability (Stryker, 1981, p. 418). Herdt and Lacsina's assumed potential yield turned out to be quite conservative because rice yields actually reached 2.6 tons per hectare in 1979. This yield helped to give Philippine rice production a large positive net social profitability and a resource cost ratio of .80 in 1979.

The Near Future

Net social profitability has varied with yields and world rice prices converted to domestic currency. Predictions about future comparative advantage of rice production should therefore focus on the likely values of these parameters. Further improvements in the yield potential of modern varieties are expected in the form of shorter time from planting to harvest (90 days rather than 110 to 140 days) and adaptability to adverse environments. These improvements will permit either greater cropping intensity or higher yields in rainfed areas. These kinds of productivity gains would not affect wet season production on irrigated farms. Therefore it is assumed that Central Luzon wet season irrigated yields will not increase above the 1982 level in the near future. Comparative advantage will then depend on the value of the world price of rice in domestic currency.

In 1984 the official peso exchange rate depreciated to 20 pesos to the United States dollar due in large part to the increased burden of foreign debt. This exchange ratio substantially increased the social valuation of rice in the Philippines. World rice prices in dollar terms were low by historical standards in the mid-1980s, reflecting technological change and production growth in other Asian rice-importing countries, notably Indonesia, and weak effective demand for rice in the newer markets of Africa due to foreign exchange constraints there. Although the real world rice price has declined since 1965, the trend estimate of $310 per ton in 1982 derived from the preceding analysis is much greater than the actual border price of $242. Prices in the mid-1980s are far below trend from 1965 to 1982, and thus unlikely to continue. The 1985 price of about $200 per ton may be taken as a lower bound for future world rice prices, and W. P. Falcon and E. A. Monke's 1979/80 estimate of $350 per ton as an upper bound.

Production data from 1982 are used to simulate the resource cost ratio for irrigated rice production in the Philippines with various exchange rates and world rice prices. At the 1982 exchange rate, Central Luzon irrigated rice production is not socially profitable at $200 per ton; at higher prices it is. As would be expected, the 117 percent depreciation of the peso from 1982 to 1984 led to a huge increase in measured social profitability (Table 6). Domestic factor costs will probably change, particularly after the general equilibrium effects of the devaluation are felt. The low resource cost ratios, however, show that factor costs can rise considerably before rice production will become socially unprofitable. It is therefore likely that Central Luzon irrigated rice production will continue to be socially profitable for several years.

Table 6.—Hypothetical Resource Cost Ratios for Future Central Luzon Irrigated Rice Production*

	$200	$242[a]	$310[b]	$350
Exchange rate (pesos/dollar)				
9.2[a]	1.25	0.96	0.70	0.61
20.0[c]	0.57	0.44	0.32	0.28

Source: See text.
*Based on the 1982 social cost estimates for irrigated farms.
[a]Actual values in 1982.
[b]Trend value in 1982.
[c]Actual official exchange rate in 1984.

SOCIAL AND PRIVATE PROFITABILITY

Government trade regulations, like tariffs and import or export quotas, can cause the domestic prices of tradable outputs or inputs to differ from their border prices. Government interventions in factor markets, like interest rate or land rent ceilings, and market failures can make factor prices differ from social opportunity costs. Market imperfections are unimportant in the Philippine rice sector; the following comparison therefore focuses on the impact of government policy on prices and hence on producer incentives. Table 7 shows the divergence between private and social costs and returns for Central Luzon rice farms caused by government policy.

Government rice price policies protected producers in importing years and taxed them in exporting years. During the 1960s domestic prices were above border prices because strong producer interests in the legislature frequently delayed the approval of funding for government-controlled imports (Bouis, 1982).

Table 7.—Differences Between Private and Social Costs and Profits for Central Luzon Rice Production: 1966–82
(Pesos per ton of rice)

	1966	1970	1974	1979	1982
	Irrigated farms				
Net private profitability[a]	61	267	11	533	464
Net social profitability[b]	−186	−141	63	360	62
Effect of policy on:[c]					
Receipts	113	196	−628	−133	−22
Tradable input costs					
Fertilizer price policy	1	10	−56	19	36
Other input price policies	0	1	10	56	65
Total	1	11	−46	75	101
Domestic factor costs					
Land	12	−47	−123	−208	−262
Capital	−9	−5	−26	103	97
Total	3	−52	−149	−105	−165
Irrigation costs	−138	−171	−381	−276	−360
Profits (NPP−NSP)[d]	247	408	−52	173	402
	Rainfed farms				
Net private profitability[a]	12	250	−176	185	452
Net social profitability[b]	−55	78	393	360	235
Effect of policy on:[c]					
Receipts	113	196	−628	−133	−22
Tradable input costs					
Fertilizer price policy	2	8	−61	20	30
Other input price policies	2	2	9	15	12
Total	4	10	−52	35	42
Domestic factor costs					
Land	52	18	22	−4	−274
Capital	−10	−4	−29	11	−8
Total	42	14	−7	7	−282
Profits (NPP − NSP)[d]	67	172	−569	−175	−218

Source: See text and Appendix.

[a]Estimates based on private costs and returns in appendix tables available from author.

[b]Estimates at actual world prices from Table 4.

[c]Difference between private cost or return and social cost or return.

[d]Also equal to the effect of policy on receipts minus the efffects on tradable input costs and domestic factor costs.

In 1966 and 1970 domestic rice prices were about 20 percent above border prices, and this increased producer receipts (Table 7). Domestic prices did not follow the sharp increase in world prices in 1974 because the government subsidized imports and rationed rice to consumers. Domestic supply grew rapidly in the late 1970s, and domestic prices fell to border price levels and below. The government marketing agency was hesitant to export the rice surplus, in part due to the limited world market for low quality Philippine rice. Lack of domestic price incentives for quality improvement forced the market intervention agency to incur reprocessing costs in order to provide consistent quality exports (Unnevehr, 1983). From 1977 to 1982, rice price policy taxed producer receipts slightly as domestic rice prices were held below border prices. Increasing domestic supply combined with the limitations on exports led to a decline in rice price protection from 20 percent above the CIF price to 1 to 6 percent below the FOB price.

Although rice price protection declined from 1966 to 1982, tradable inputs were taxed. Government import controls on fertilizer generally held domestic fertilizer prices about 25 percent above border prices, except in 1974 (David, 1983), a policy designed to encourage domestic manufacture of fertilizer. Other agricultural chemicals and machines were also taxed for similar reasons, making farmers' tradable input costs higher than social costs, and the difference became larger as more tradable inputs were used after technological change (Table 7). Commodity-specific price policies, first as regards rice, later as regards manufacturers, increasingly reduced incentives in rice production over the entire period.

There were two important exceptions to the general tendency of government policies to reduce incentives. First, government investment in irrigation increased the productivity of land for farmers who occupied land within public irrigation schemes. In the Philippines most of the increased irrigation was provided by public construction of gravity systems: government expenditures for irrigation in real terms grew at an annual rate of 40 percent between 1965 and 1980 (Guino et al., 1984). Irrigation fees collected from farmers were less than 20 percent of total construction and operation costs. As public irrigation costs grew larger, so did the size of the irrigation subsidy (Table 7).

Second, enforcement of the Agricultural Land Reform Code after 1971 broke up the large haciendas in Central Luzon (Hayami and Kikuchi, 1981). In 1966, 75 percent of sample farms were operated by share tenants, but by 1982 only 8 percent were share tenants while 79 percent had a fixed rent lease. Because land rents were fixed before yields on irrigated farms increased, rents declined sharply from 27 percent of the value of output in 1966 to 11 percent in 1982. Land reform substantially increased private profitability for irrigated farmers as shown by the increasing divergence between shadow and private rents (Table 7). Rainfed farms did not benefit as much from fixed rents because yields did not increase until 1982.

The importance of different policies has changed over time, and the difference between net private profitability and net social profitability (at actual border prices) shows the net impact of policy. Irrigated producers were subsidized as net private profitability was greater than net social profitability in all years except 1974 (Table 7). The source of the subsidy to irrigated production changed over time. Before 1974, rice price protection and irrigation subsidy reduced private costs. Other policies had only minor effects.

The unusually high world prices of 1974 were not passed on to producers despite poor domestic yields. This led to an even lower net private profitability for irrigated farms than the already low net social profitability caused by low yields. Although fertilizer was subsidized relative to the high border prices in that year and land reform had begun to reduce factor costs, these input subsidies did not offset the rice price taxation.

After 1974 price policies lowered domestic profitability of rice production. For irrigated farms, the continuing imposition of fixed rent leases and the subsidization of irrigation reduced input costs, however, and offset the negative effects of price policy. The net effect of policy was to subsidize irrigated rice producers in 1979 and 1982. The overall increase in net social profitability of irrigated rice production from 1966 to 1982 was 248 pesos, while the increase in net private profitability was 403 pesos. The net policy effect for irrigated farms from 1966 to 1982 was to increase the incentives to rice production arising from technological change and increasing rice prices.

The net private profitability of rainfed farms was less than that of irrigated farms in all years, even though net social profitability was greater. Rainfed farms have been less protected than irrigated farms in all years, because they did not benefit as much from factor market interventions. They receive no irrigation subsidy, and fixed rent leases did not reduce rents as yields did not increase. Declining rice price protection and increasing taxation of inputs hurt rainfed production much more than irrigated production in 1979.

With the decline in rice price protection, government policy transferred some of the gains from technological change in rice to consumers in the form of lower prices. Border prices fell from CIF to the FOB equivalent, and declining nominal protection for rice then led to a decline in real domestic rice prices after 1976 (Flinn and Unnevehr, 1984). Yet at the same time rice producer profits increased. Land reform in Central Luzon ensured that the gains from technological change accrued to farmer-operators rather than to landowners. Irrigation subsidies further increased private profitability for farmers within public irrigation projects.

It might seem that Philippine rice policy has found a balance between producer and consumer interests. While all consumers benefit from the lower rice price, however, not all producers benefit from the factor market interventions. The implementation of land reform has not been so successful in some regions outside Central Luzon (Floro, 1984). Rice producers on the 50 percent of rice area that is still rainfed do not benefit from the irrigation subsidy. Producers in regions where there has been no technological change see declining prices without any compensating increase in yields. Thus the benefits of government policy in the late 1970s and early 1980s accrued to rice consumers and producers in the most productive regions, while other rice producers saw a decline in profits.

CONCLUSIONS

Philippine comparative advantage in rice production increased from 1966 to 1982, as measured by the net social profitability of irrigated rice that provided additional supply. Before 1974 net social profitability increased due to rising rice border prices. These prices were the result of higher world rice prices and the increased value of traded goods relative to non-traded goods in the Philippine economy, as reflected in depreciations of the peso. Higher border prices provided incentives for government investment in irrigation (Kikuchi and Hayami, 1978), that facilitated adoption of the new seed-fertilizer technology.

Technological change in the form of modern rice varieties, fertilizer, and irrigation, was the principal cause of increased comparative advantage after 1974, through increasing the productivity of both labor and land. Although the process of technological change began in the late 1960s, the contribution of technology toward increased net social profitability only became apparent after the introduction of second-generation modern varieties in the mid-1970s. These newer modern varieties are resistant to pests and disease, which allowed sustained yield growth in the late 1970s and early 1980s.

Technological change tends to increase supply, reduce prices, and redistribute producer surplus in favor of adopters (Ruttan, 1978). In the Philippines government policy reinforced these distributional effects. As rice supply grew, the government allowed rice prices to fall, transferring some of the welfare gains from producers to rice consumers.

Implicit taxes on tradable inputs increased costs for all rice producers, but irrigation subsidies and land reform reduced factor costs for farmers on irrigated land. Producers in regions where there has been no technological change, public irrigation investment, or land reform have seen a decline in profits due to unfavorable price policies. The gains from technological change would have been more equitably distributed if government price policies had not implicitly taxed nonadopters.

Whether the Philippines' increased comparative advantage will continue depends on future technological change and world prices. The Philippines was an early adopter of modern varieties because IRRI is located there. Low world rice prices in the 1980s reflect the wider impact of technological change in other Asian countries. This suggests that some of the Philippine gains in net social profitability due to technological change from 1966 to 1982 might be innovator's rents that will be competed away after new technologies are fully adopted elsewhere.

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APPENDIX
METHODOLOGY AND SOCIAL PRICE ASSUMPTIONS

Net social profitability (NSP) is defined as follows (Pearson et al., 1976):

$$NSP = (u - m)v_1 - \sum_{s=2}^{n} v_s f_s \qquad (1)$$

where

u = border price of rice in foreign currency,

m = total value of tradable inputs used in the production at border prices in foreign currency,

v_1 = the real equilibrium value of foreign exchange,

v_s = the shadow price ofthe s^{th} domestic factor, and

f_s = the amount of the s^{th} factor used in rice production.

All terms are defined per unit of rice produced. This formulation requires that all nontradable inputs be decomposed into tradable inputs and primary domestic factors. It is assumed that there are no market failures in the rice sector.

The resource cost ratio (RCR) of Page and Stryker (1981) is also used:

$$RCR = \frac{\sum_{s=2}^{n} f_s v_s}{v_1(u - m)}. \qquad (2)$$

If the RCR is less (greater) than 1, the activity has positive (negative) NSP.

Net private profitability (NPP) is defined as follows:

$$NPP = (u^* - m^*)v_1^* - \sum_{s=2}^{n} v_s^* f_s, \qquad (3)$$

where

u^* = the market price of rice at a consumption center,

m^* = the value of tradable inputs at domestic market prices,

v_1^* = the official exchange rate, and

v_s^* = the market price of the s^{th} factor.

The f_s and the amounts of tradable inputs are assumed the same as in Equation (1).[1]

[1] Following Pearson et al. (1976) and other empirical applications of this methodology, input quantities are derived from surveys of actual production techniques under private prices. It is assumed that inputs would remain fixed if private prices changed to equal social prices. In this study, inputs for different production techniques vary across years, primarily due to changes in technology.

In order to decompose the observed change in NSP, the total differential of Equation (1) is taken:

$$dNSP = v_1 du - v_1 dm + (u - m)dv_l - \sum_{s=2}^{n} f_s dv_s - \sum_{s=2}^{n} v_2 df_s. \quad (4)$$

The first three terms on the right-hand side give the changes in NSP arising from changes in u, m, and v_1. The fourth and fifth terms give the change in NSP due to changes in the v_s and the f_s.

The border prices of rice and tradable inputs like fertilizer, insecticides, herbicides, fuel, tractors, and threshers are taken to be the social prices. Many of the estimates of social prices are drawn from earlier studies of Philippine government policy by Power (1971), Herdt and Lacsina (1976), and David and Balisacan (1981) (see Appendix Table 1). Trend prices are also estimated for rice and fertilizer. A simple time trend is regressed against the real world prices (deflated by an index of world inflation) of Thai 35 percent rice and urea prices. Both prices have significant downward trends from 1965 to 1982. Addition of a squared time trend improved the fit of the rice equation, perhaps due to the impact of second generation modern varieties in the late 1970s. The predicted values of real prices were reinflated to nominal terms to provide trend estimates for the survey years.

Social costs and prices are presented in Appendix Table 2. The value of machine services in cultivation and threshing is decomposed into the tradable components of fuel, oil, and machine depreciation, and the domestic components of interest and labor, with data from Johnson (1969), Herdt and Lacsina (1976), Maranan (1981), and Juarez and Pathnopas (1981). The marginal value of irrigation services is the construction and maintenance cost per cropped hectare for medium-sized gravity systems from Sison and Guino (1984). Although construction costs on individual projects have been higher, scope exists for further construction of gravity systems. Following Herdt and Lacsina (1976), the irrigation costs are decomposed into domestic and tradable components with the assumption that two-thirds are domestic factor costs (primarily labor and capital), and one-third are tradable input costs (equipment and materials).

Marketing costs to the consuming center (Manila) are assumed to be 25 percent of paddy price at the farm. This spread between Central Luzon and Manila wholesale prices has remained stable over time. The value of this spread is representative of marketing costs estimated by Mears et al. (1974) and field observations in 1981. A milling recovery rate of 65 percent is assumed for all years. Average milling recovery has improved over time as hullers were replaced with disc-cone mills. Data concerning this change are not available, but if available would tend to reinforce the trend toward increased comparative advantage.

Devaluations of the official exchange rate have followed closely the decline in peso purchasing power relative to the U.S. dollar. Differential inflation explains the major devaluations in 1962, 1970, and 1982. Inflation does not

Appendix Table 1.—Nominal Protection Rates (NPR) for Rice and Rice Production Inputs in the Philippines: 1966–82*
(Percent)

	1966	1969	1974	1979	1982
Rice[a]	24	28	−30	−6	−1
Fertilizer[b]	20	34	−25	15	26
Insecticides and herbicides[c]	15	15	20	28	28
Fuel[d]	13	13	25	86	86
Oil[d]	13	13	25	25	25
Four-wheel tractor[e]	—	—	8	—	—
Two-wheel tractor[e]	—	—	—	30	30
Big thresher[e]	10	10	4	10	—
Small thresher[e]	—	—	—	—	0

*Nominal protection rate is equal to ((domestic price ÷ border price) − 1) times 100. All nominal protection rates are three-year averages centered on the survey year, except where indicated in footnotes. Dashes indicate item not used in that year.

[a]Domestic price is Manila wholesale price reported by the Central Bank. World prices are FOB or CIF values or Thai Board of Trade 35 percent brokens price if no quantities are traded.

[b]Import values and domestic prices for urea, 21-0-0, 14-14-14, and 16-20-0 are taken from appendix tables of Cristina C. David and Arsenio M. Balisacan, "An Analysis of Fertilizer Policies in the Philippines," paper presented at a Workshop on the Redirection of Fertilizer Research, Manila, 1981, and Cristina C. David, "Economic Policies and Philippine Agriculture," Working Paper 83-02, Philippine Institute of Development Studies, 1983. The NPR is a weighted average of NPRs for different fertilizers. The weights are derived from quantities used by farmers in the Central Luzon Loop Survey.

[c]1966 and 1970 are average rate for agricultural chemicals reported by John H. Power, "The Structure of Protection in the Philippines," in Bela Belassa et al., *The Structure of Protection in Developing Countries,* The Johns Hopkins University Press, 1971. 1974 is from Robert W. Herdt and Teresa A. Lacsina, "The Domestic Resource Cost of Increasing Philippine Rice Production," *Food Research Institute Studies,* Vol. XV, No. 2, 1976. 1979 and 1982 are based on legal tariff rates.

[d]1966 and 1970 are from John H. Power, op cit.; 1974 is from Robert W. Herdt and Teresa A. Lacsina, op cit.; 1979 and 1982 are from Joyotee Smith and Bart Duff, "Efficiency or Equity: The Mechanization of Rice Threshing in the Philippines," Agricultural Economics Paper 83-29, International Rice Research Institute, 1983.

[e]Based on legal tariff rates except 1974 which is from Robert W. Herdt and Teresa A. Lacsina, op cit. The small thresher is assumed to have no protection since small numbers of machines are exported.

Appendix Table 2.—Social Costs and Returns of Central Luzon Wet Season Rice Production: 1966–82

	1966	1970	1974	1979	1982
			Irrigated farms		
Value added					
Pesos/ton rice[a]	406.68	591.00	1,606.16	1,803.38	1,697.77
Exchange rate (pesos/$)[b]	3.91	6.44	7.07	7.38	9.20
World price ($/ton)[c]	121.00	109.00	296.00	300.00	242.00
Tradable inputs ($/ton)[d]	16.99	17.23	68.82	55.64	57.46
Domestic factor costs					
Pesos/ton rice[e]	593.01	732.12	1,543.39	1,444.10	1,635.80
Land input (ha/ton)[f]	0.68	0.61	0.62	0.39	0.35
Shadow rent (pesos/ha)[g]	241.75	303.50	645.25	1,068.50	1,395.00
Capital input (pesos/ton)[h]	62.05	95.26	289.38	249.40	259.54
Shadow interest (percent)[i]	15.80	24.40	43.90	29.30	21.40
Preharvest labor (days/ha)[j]	16.65	22.90	27.61	19.35	15.35
Preharvest wage (pesos/day)[k]	2.72	3.68	6.55	10.88	13.44
Harvest labor (days/ha)[l]	13.10	11.90	18.10	12.20	8.20
Harvest wage (pesos/day)[m]	8.30	10.30	12.50	16.90	29.00
Other costs (pesos/ton)[n]	264.80	316.90	609.20	537.60	647.90
			Rainfed farms		
Value added					
Pesos/ton rice[a]	433.62	644.64	1,740.63	1,954.96	1,972.48
Exchange rate (pesos/$)[b]	3.91	6.44	7.07	7.38	9.20
World price ($/ton)[c]	121.00	109.00	296.00	300.00	242.00
Tradable inputs ($/ton)[d]	10.10	8.90	49.80	35.10	27.60

Appendix Table 2.—Social Costs and Returns of Central Luzon Wet Season Rice Production: 1966–82 (Continued)

	1966	1970	1974	1979	1982
Domestic factor costs					
Pesos/ton rice [e]	488.38	566.81	1,348.00	1,594.50	1,737.92
Land input (ha/ton)[f]	0.64	0.64	0.88	0.72	0.47
Shadow rent (pesos/ha)[g]	257.00	290.50	456.75	557.00	1,029.25
Capital input (pesos/ton)[h]	69.90	84.90	318.70	357.40	322.50
Shadow interest (percent)[i]	15.80	24.40	43.90	29.30	21.40
Preharvest labor (days/ha)[j]	19.25	19.85	31.45	29.44	27.43
Preharvest wage (pesos/day)[k]	2.72	3.68	6.55	10.88	13.44
Harvest labor (days/ha)[l]	15.40	13.90	18.50	14.30	8.30
Harvest wage (pesos/day)[m]	4.50	5.70	9.90	18.10	31.00
Other costs (pesos/ton)[n]	191.20	207.90	417.00	509.60	559.20

[a]World price minus tradable input costs, times the exchange rate.

[b]Official exchange rate.

[c]Three-year average of CIF or FOB values centered on the survey year.

[d]Sum of costs of seed, agricultural chemicals, and the foreign components of irrigation and machine services.

[e]Sum of factor input per ton of rice times factor cost per unit.

[f]Inverse of the rice yield in Table 4.

[g]25 percent of output value.

[h]Sum of costs of seed, preharvest hired labor, agricultural chemicals, and irrigation operation costs divided by two because working capital is only used for six months.

[i]Shadow interest per annum. It is equal to the social rate of discount (10.4 percent) plus the rate of inflation in the survey year.

[j]Labor used in crop-care activities.

[k]Average wage paid for crop-care activities.

[l]Labor used in harvesting and threshing.

[m]Value of average share payment for harvesting and domestic component of threshing, divided by harvest labor days.

[n]Includes the domestic component of land preparation and irrigation services, and marketing costs.

explain the devaluation in 1984, which was triggered by the increased burden of foreign debt repayment as foreign loans came due. As the official exchange rate is a good indicator of the real equilibrium rate up to 1982, it is used to estimate social profitability. The sensitivity analysis considers the impact of the 1984 devaluation.

A nominal shadow interest rate is estimated by adding the rate of inflation to the social rate of discount of 10.4 percent estimated by Manalaysay (1979). This rate is used to value working capital for buying chemicals and hiring labor or for investing in machines. In the estimation of private profitability, the average interest payment for all farmers with a particular production system is used. This is generally greater than the social estimate, because interest rate ceilings on formal loans have tended to reduce credit availability in agriculture and to increase the cost of informal credit to farmers (David, 1982).

The social opportunity cost of land is taken to be the rent paid by share-tenants before land reform. This is closer to the true economic scarcity value than the fixed rent. As land rental markets were well developed before land reform, this rental should reflect the value of producing alternative crops such as sugar (Herdt and Lacsina, 1976), or the alternative of leaving the land idle and engaging in non-farm employment. Furthermore, measuring rent as a share of output means that land value rises directly with irrigation investment and technological change. As technical change has been more rapid for rice than for other crops (David et al., 1984), the social value of riceland should rise directly with increased rice productivity. Under land reform non-saleable certificates were issued to share tenants that fixed the value of land rents. Tenants became leaseholders and thus retained all of the increased income resulting from yield increases. Use of the share rent corrects for the effects of government intervention in land markets.

Widespread interregional migration suggests that rural labor markets adjust to changes in labor demand and supply (Kikuchi et al., 1982). Therefore, the shadow price of labor is assumed to equal the actual agricultural wage. This wage is also used to value family labor in both private and social profitability estimates.