Staff Paper Series

Staff Paper P75-28 November 1975

THE SOCIAL COST OF A CHEAP FOOD POLICY: THE CASE OF ARGENTINE CORN PRODUCTION

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A characteristic shared by many if not most of the world's developing countries is the relatively unfavorable price relationships faced by farmers. It is not uncommon for farm product prices to be held below world market levels by government imposed ceiling prices or by taxes on farm output or exports. In addition the prices of modern farm inputs such as fertilizer are frequently kept at artificially high levels through levies or embargoes on imports. Although there appears to be some awareness, at least among a few economists, that such policies have reduced the growth of food production in the world, there is little hard evidence on the magnitude of this reduction and the resulting social cost of these policies.[1/]

With this paper I shall try to make a modest contribution along these lines by measuring the social cost of a price policy which has made it unprofitable for Argentine farmers to utilize nitrogen fertilizer in the production of corn. This is not an attempt to single out Argentine policy for special criticism. The same type of analysis could (and probably should) be carried out for a number of other countries and commodities. The effect of unfavorable farm prices is especially revealing in Argentina, however, because of its rich agricultural land, skilled farmers, an established agricultural research system, and an industrial sector capable of supplying modern inputs to agriculture given the proper incentives.

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Relative Prices

Whether one chooses to say that corn is underpriced in Argentina or nitrogen is overpriced depends a great deal on the exchange rate used. For example, in the spring of 1972 Argentine farmers received about 25 old pesos per kilo for corn. As shown in table 1, this translates in $1.06 per bushel using the then official 600 peso per dollar rate of exchange. At this time U.S. farmers were receiving $1.10 per bushel. However, the official Argentine policy of overvaluing the peso relative to the dollar

Table 1. Dollar Prices of Corn and Nitrogen, Argentina and the United States (Farm Level, March 1972)

	Corn ($ per bu.)[a/]		Nitrogen ($ per lb.)	
Exchange rate	Argentina	U.S.	Argentina	U.S.
600 pesos/dollar	$1.06	$1.10	$.13	$.09
950 pesos/dollar	.67	1.10	.09	.09

a/ From urea.

Sources: Argentina corn prices from Buenos Aires market quotations (March 15, 1972) deducting 4 pesos per kilo from the price of corn for transportation and marketing charges. Argentine nitrogen prices quoted at Pergamino, 2001-400 kg. purchase of urea, payable in 180 days. U.S. prices from Agricultural Prices, Dec. 1972.

resulted in an unofficial or black market exchange rate of about 950 pesos per dollar. At this exchange rate the dollar price of corn turns out to be $.67 per bushel. In the case of nitrogen, the use of a 600 pesos per dollar exchange rate results in a relatively high price of nitrogen in Argentina compared to the U.S., whereas the use of 950 black market rate causes the price of pure nitrogen from urea to be the same in both countries.

Of course, regardless of the exchange rate used, the price of corn relative to the price of nitrogen remains unfavorable to Argentine farmers compared to U.S. farmers. In fact, the figures presented in Table 1 grossly understate the true difference in relative prices between the two countries because urea is a much higher priced form of nitrogen in the U.S. than anhydrous ammonia which is by far the main source of nitrogen for corn in the corn belt. In the spring of 1972 U.S. farmers paid about $.05 per pound for pure nitrogen from anhydrous ammonia compared to the $.09 price quoted in table 1 for urea. On the other hand, urea was about the only form of nitrogen available to Argentine farmers because of the special facilities required to store anhydrous ammonia. The main purpose of Table 1 is to illustrate how the comparison of output and input prices is affected by the use of different exchange rates.

A more accurate and long run picture of the difference in relative prices between the two countries is presented in Table 2. These figures denote the pounds of corn required to purchase one pound of pure nitrogen at the farm level from the cheapest source available. In the United States ammonium nitrate provided the cheapest source available during the 1950-54 period, and anhydrous ammonia during the remaining periods. Urea is used as the nitrogen source in Argentina for the entire 25 year period.

Table 2. Pounds of Corn Required to Purchase One Pound of Pure Nitrogen

Period	Argentina	United States
1950-54	--	4.8
1955-59	--	4.5
1960-64	13.3	4.3
1965-69	7.1	3.1
1970-74	8.2	2.0

a/ Fertilizer price data not available for the 1950-59 period. Also fertilizer prices based on 3-year averages for the remaining periods; prices were not available for 1960-61, 1965-66, and 1973-74.

Sources: Argentina prices from FAO Production Yearbook, various years. United States prices from Agricultural Prices, various years. All prices quoted at the farm level.

There can be little doubt that the relatively low and declining real price of nitrogen fertilizer in the United States has led to the widespread and relatively large application of nitrogen to corn acreage. In 1964 about 85 percent of the area planted to corn in the major corn producing states received an average of 58 pounds of pure nitrogen per acre (65 kilograms per hectare). By 1973 these figures had increased to 95.9 percent and 115 pounds per acre (129 kilograms per hectare) respectively.[2/] In sharp contrast is the situation in Argentina where virtually none (.2 percent) of the corn area receives any nitrogen.[3/] Since urea has been available to Argentine farmers we may infer, in view of the unfavorable price relationships depicted in Table 2, that they have not utilized nitrogen on corn because it has not been profitable to do so.

The profitability of nitrogen application depends upon two factors:
1. the physical response of the corn plant to nitrogen application and
2. the relative prices of corn and nitrogen. Unless the marginal pound (or kilo) of nitrogen adds at least as many pounds (or kilos) of corn required to pay for the nitrogen, there is no economic incentive to use this input.

Nitrogen Response

Before examining the available evidence bearing on the responsiveness of Argentine corn to nitrogen fertilization it will be useful to briefly call to mind the possible ways in which the corn plant may respond to additional nitrogen. There are two possibilities: 1. multiple ears, and 2. a larger ear size or weight. We can dismiss the first possibility as being very important, at least with current corn varieties. This means that in order for the corn plant to respond to additional nitrogen it must have the ability to produce larger and heavier ears.

In comparison to U.S. hybrids, Argentine corn varieties exhibit a uniformly small ear size and weight under increasing doses of nitrogen fertilization. As shown in Table 3, the average ear weight in terms of grain remains relatively stable at about 100 grams per ear between zero and 150 kilograms of pure nitrogen per hectare (134 pounds per acre). In 1972, corn plant populations in the U.S. corn belt averaged 18,175 plants per acre (44,892 plants per hectare).[4/] With a nitrogen application of 115 pounds per acre (129 kg. per ha.), yields averaged 98.8 bushels per acre. Assuming one ear per plant, this yield is equivalent to 138 grams of grain per ear. In corn yield contests ear weight appears quite responsive to higher levels of fertilization. For example, in 1975 a record breaking yield of 338 bushels per acre was obtained in Illinois with a per acre plant population of 33,000 and a nitrogen application of 400 pounds.[5/] Again assuming one ear per plant, ear weight in this case turns out to be 261 grams. Thus it appears that U.S. hybrids are capable of responding to nitrogen fertilization to a much larger extent than Argentine varieties.

Table 3. Average Ear Weight of Argentine Corn Varieties, INTA-CIMMYT-Ford Foundation Experiments, 1968-69.

(Grams of grain)

Soil organic matter	Nitrogen application (Kg/ha)			
	0	50	100	150
≤ 3.5 percent	99	101	105	104
> 3.5 percent	102	106	101	98

Source: First annual report of the cooperative INTA-CIMMYT-Ford Foundation Corn and wheat program, 1969. The experiments were conducted at 11 different locations under varying soil types and moisture levels. Plant population was held constant at 47,500 plants per hectare (19,230 per acre).

In view of the rather small response of ear weight to nitrogen application, one might conclude that there is little to be gained by applying nitrogen to corn in Argentina. But this is not necessarily so. There is still the possibility of increasing the plant population with higher levels of fertilization. Even if each plant is limited in its response, the increase in level of plant nutrients still can be utilized if there are more plants. Experiments which hold plant population constant while measuring the impact of higher levels of fertilization in effect are holding too much constant. If Argentina farmers found it profitable to apply nitrogen they most likely would have increased plant populations similar to what U.S. farmers have done. Between 1964 and 1974 average plant populations in the corn belt increased by 33 percent, growing from 13,600 per acre (33,600 per hectare) to 18,175 (44,900 per hectare).[6/] This occurred even though U.S. hybrids respond to higher levels of fertilization by producing larger and heavier ears.

The importance of plant population to nitrogen response in Argentina is revealed by the figures in Table 4. At the 20,000 and 40,000 population levels the marginal product of nitrogen is relatively small. Unless the nitrogen/corn price ratio were less than 3.45 it would not pay to apply nitrogen at the 40,000 per hectare population level. Although there are no official statistics on actual Argentine plant populations, extension personnel estimate the figure to be in the neighborhood of 45,000 plants per hectare. With the nitrogen/corn price ratio averaging 9.5 over the 1950-74 period, there has been no incentive to utilize nitrogen. At the 50,000 population, the marginal product of nitrogen at the 30 kg./ha. level (10.47) is probably too close to the 9.5 price ratio to be worth taking the risk.[7/] Also the price ratio has fluctuated substantially between years which has added to the risk.

Table 4. The Marginal Product of Nitrogen on Corn in Argentina

(Marcos Juarez experiments, 1967-68)

Harvested Plant Population (per ha.)	Nitrogen (kg/ha)	Marginal Product of Nitrogen (kg. of corn)
20,000	30	1.70
	60	.85
	90	.58
40,000	30	3.45
	60	1.76
	90	1.18
50,000	30	10.47
	60	5.48
	90	3.76
60,000	30	10.65
	60	5.58
	90	3.83

Source: Lucio Reca, "Fertilizacion Ntrogenada en Maiz: Resultados e Implicaciones," Unpublished manuscript, Buenos Aires, Argentina 1970, p.7. Estimates made from a Cobb-Douglas production function.

Social Cost

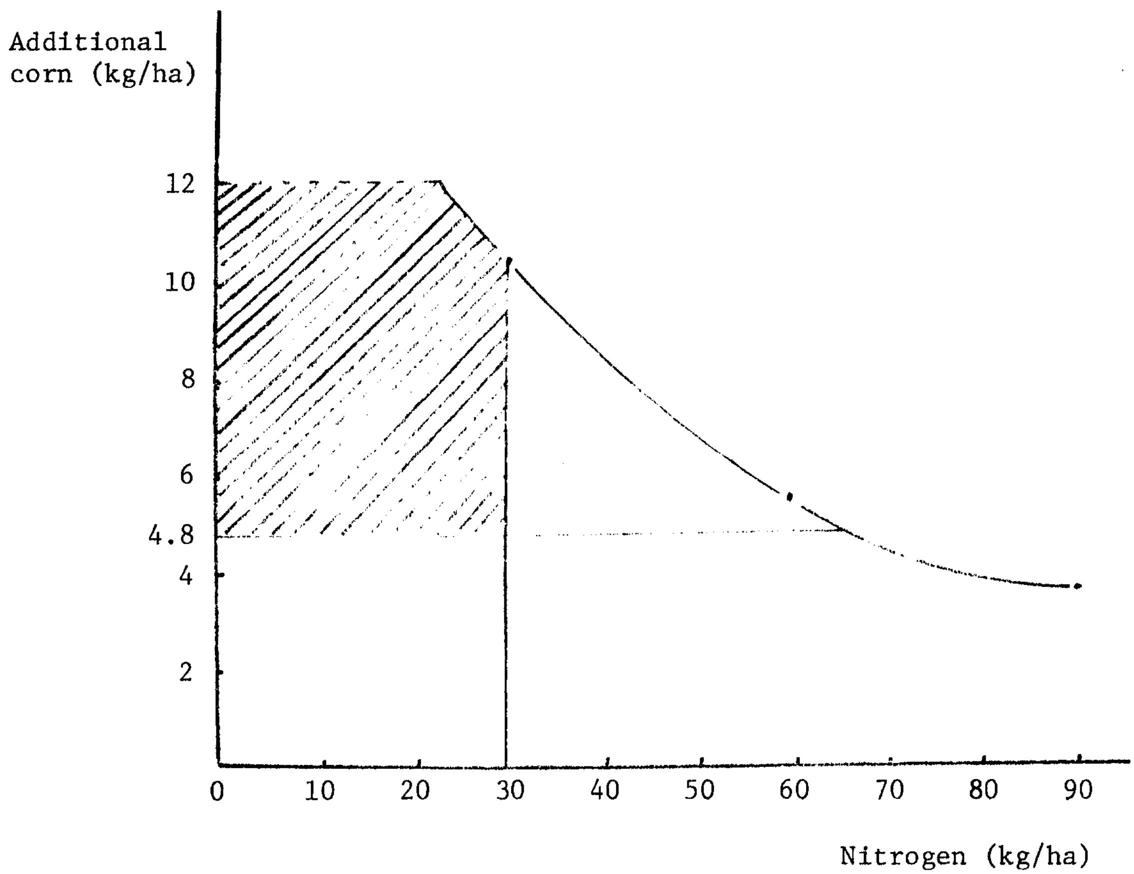
By maintaining an unfavorable nitrogen/corn price ratio to farmers, the Argentine government in effect made the decision to reduce Argentine corn production by millions of bushels over the 1950-74 period. Of course, this decision also meant that domestic resources or foreign exchange did not have to be allocated to the production or purchase of nitrogen fertilizer. However, as will now be shown, the value of corn given up by not allowing the use of nitrogen greatly exceeded the total cost of the nitrogen resulting in a substantial social cost to the country.

In order to measure the social cost of this policy to Argentina, two pieces of information are required: 1. the potential nitrogen/corn price ratio which could have existed in the absense of market distortions, and 2. the response of Argentine corn varieties to nitrogen fertilizer. The U.S. price ratios presented in Table 2 are utilized as estimates of the potential ratios which could have existed in Argentina in the absense of market distortions. The nitrogen and corn prices faced by U.S. farmers are fairly close to world market prices after transportation and marketing charges are added to nitrogen and subtracted from corn. This assumes that storage facilities for anhydrous ammonia would have been constructed in Argentina if free importation of this product had been allowed, which does not seem unreasonable.

The marginal products presented in Table 4 which were obtained from the results of the Marcos Juarez experiments are used as estimates of nitrogen response at the various levels of nitrogen application. These experiments were conducted on actual farm locations under typical growing conditions so the results should be fairly representative of what one might expect under more widespread use of nitrogen. The results from the 50,000 plant population trials are used. Although the 50,000 plant population may be somewhat higher than what Argentine farmers actually harvested, it is likely that plant population would have increased if farmers had found it profitable to utilize nitrogen fertilizer. Also it is reasonable to believe that plant breeders would have focused their efforts on increasing the responsiveness of Argentine hybrids to commerical fertilizer if farmers had been using nitrogen. As a result the figures in Table 4 probably underestimate the nitrogen response that would have occurred under conditions of widespread use of nitrogen.

Because the marginal product estimates in Table 4 are reported for only three levels of nitrogen application (30, 60, and 90 kg. per ha.), the intervening figures are approximated by a freehand curve drawn through the three observations as shown by Figure 1. However, in order to avoid an excessive upper tail of the curve, it is "chopped off" at the 12 kg. level as indicated by the dashed line in Figure 1. [8/]

Figure 1. Marginal Physical Product Curve of Nitrogen on Corn



It is not reasonable to assume that all Argentine farmers always would have been at a profit maximizing equilibrium with respect to the use of nitrogen fertilizer. In the interest of obtaining conservative yet reasonable estimates of the social cost, it is assumed that farmers would have used less than the optimum amount of nitrogen for a given price ratio.

For example, the 4.8 price ratio that existed during the 1950-54 period gives rise to about a 65 kg. per ha. optimum nitrogen application. In the computations it is assumed that farmers used 30 kg. of nitrogen per ha. during this period. The application level is assumed to increase by 15 kg. per ha. during the four remaining 5-year periods, as shown in Table 5.

The additional corn production that is obtained by the application of nitrogen is measured by the area below the nitrogen MPP curve bounded on the right by a vertical line extending up from the quantity of nitrogen that might have been used. This is illustrated for the 1950-54 period in Figure 1 by the entire area to the left of the line extending up from the 30 kg. nitrogen application.

The cost of obtaining this additional output is shown by the rectangle bounded by 4.8 and 30 on the vertical and horizontal axis respectively. With a 4.8 price ratio the equivalent of 4.8 kg. of corn is required to purchase (or produce) one kg. of nitrogen. Hence the cost of 30 kg. of nitrogen is equivalent to 144 kg. of corn (30 x 4.8). The net gain to Argentina of using the 30 kg. of nitrogen per hectare is equal to the difference between the total output or area under the MPP curve (378 kg. of corn in this case) minus the cost. The resulting quantity (234 kg. of corn per hectare annually during the 1950-54 period) is represented by the shaded area in Figure 1. The shaded area, therefore, represents the per hectare social cost to Argentina of following a policy which made it unprofitable for farmers to utilize nitrogen on corn. It is the net output foregone.[9/]

Estimates of the annual per acre loss of corn output and the annual net social cost to Argentina over the 1950-74 period are presented in Table 5. (To facilitate comparison with United States yields kilograms per hectare are converted to bushels per acre.)

Although these yield gains may not appear dramatic in comparison to the 44 bushel per acre yield increase that occurred in the United States between 1950-54 and 1970-74, one must bear in mind that everything is assumed constant except the increased use of nitrogen. If more favorable price relationships had existed in Argentina we can expect that many other investments would have been undertaken. As mentioned, plant breeders no doubt would have developed varieties more responsive to nitrogen. We also

Table 5. Annual per Acre Loss in Corn Yield and Social Cost Resulting from Failure to Utilize Nitrogen on Corn (Argentina, 1950-74)

Period	Assumed Nitrogen Application (kg/ha)	Yield Loss (bu/acre)	Social Cost (bu/acre)
1950-54	30	6.0	3.7
1955-59	45	7.8	4.6
1960-64	60	9.5	5.4
1965-69	75	11.0	7.3
1970-74	90	12.7	9.9

can expect Argentine farmers to have utilized phosphorous and potassium fertilizer along with nitrogen. Similarly more favorable farm prices would have made it profitable for the Argentine farm supply industry to produce and for farmers to adopt other modern inputs including herbicides, insecticides and irrigation facilities. More favorable prices also would have given farmers an incentive to adopt improved cultural practices such as soil and moisture conservation measures. It is likely that these inputs and practices would have been complements to nitrogen, thereby shifting the MPP curve of nitrogen to the right and increasing the output attributable to nitrogen.

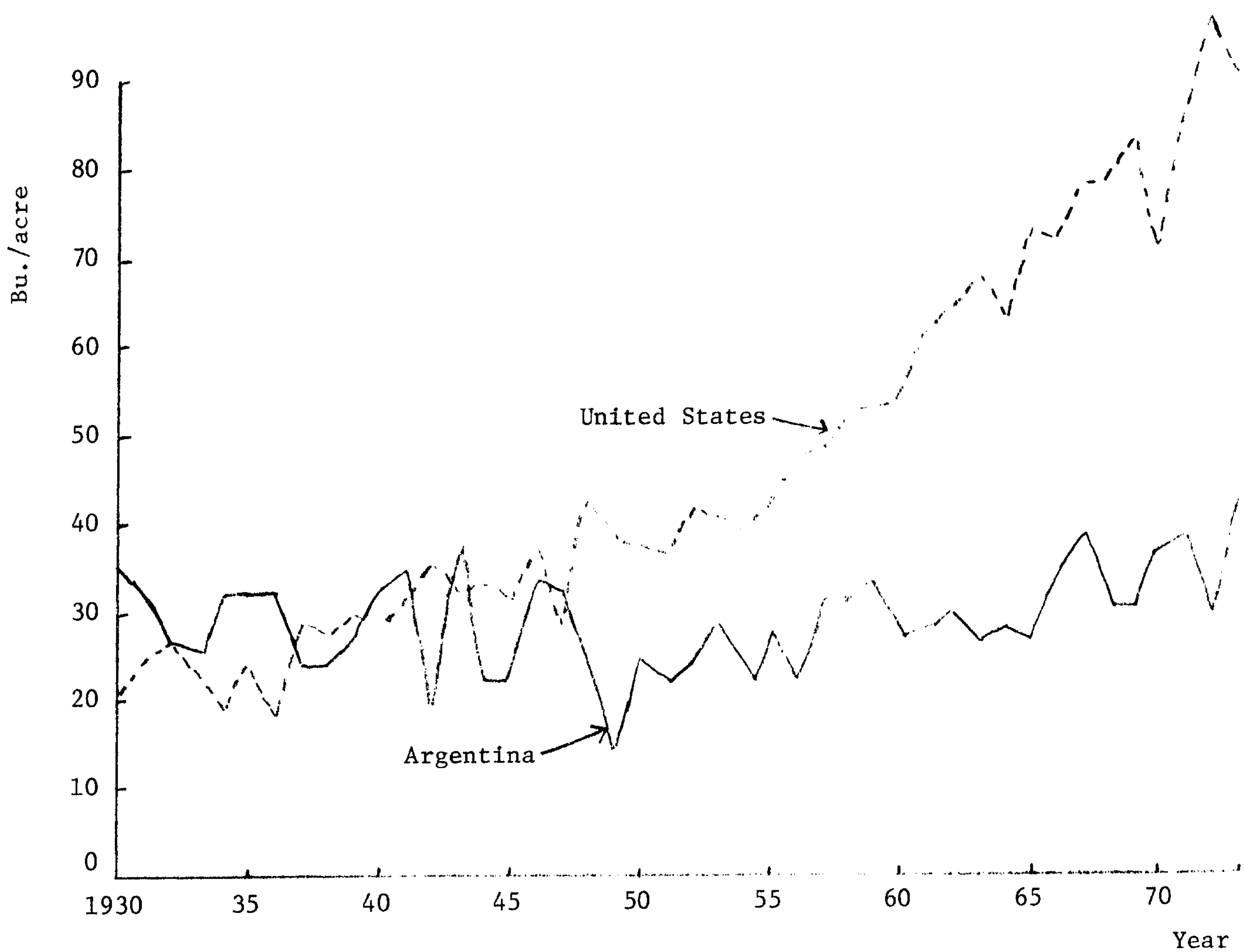
Indeed it is not unreasonable to believe that under the price relationships which existed in the United States, Argentine corn yields would have kept pace with U.S. yields. As shown in Figure 2, Argentine and U.S. yields were about equal until the late 1940's at which time U.S. yields began a steady climb while Argentina yields stagnated.

Although foregone yields provide an indication of losses stemming from a so-called "cheap food" policy, a more telling measure is the total loss in output to the country. As shown by the total of Column two in Table 6, the estimated loss of total corn output from 1950 to 1974 that resulted just from the failure to utilize nitrogen fertilizer exceeded 1.7 billion bushels. Considering that Argentina exported about 2.6 billion bushels of corn during this entire 25 year period, the utilization of nitrogen alone could have enabled Argentina to increase corn exports over 50 percent.

As shown by the total of the third column, the net gain to Argentina after paying for the nitrogen would have been over 1.1 billion bushels of corn; this is the net loss in total output to the country, or the net social cost, just from the failure to utilize nitrogen fertilizer on corn. Even if all the nitrogen were purchased on the world market, foreign exchange earnings would have increased in net by the value of this 1.1 billion bushels. Thus the argument that fertilizer could not be imported because of a lack of foreign exchange is invalid. Foreign exchange earnings would have been increased, not decreased, by purchasing nitrogen and other modern inputs on the world market and selling the increased output on the world market. It is not necessary, of course, for the increased output to be marketed in the form of corn. The extra corn could have been converted to livestock or poultry products. Or the same amount of corn could have been produced

Figure 2. Argentine and United States Corn Yields, 1930-1973

(bu. per acre)



Sources: "Grain Production and Marketing in Argentina" U.S. Dept. of Agr. Foreign Agricultural Service, FAS-M222, December 1970, p.9; FAO, *Production Yearbook*, respective years; U.S. Dept. of Agr. *Crop Production*, respective years.

Table 6. Total Reduction in Corn Output, Net Social Cost, and Internal Rate of Return Foregone to Argentina by Not Utilizing Nitrogen Fertilizer

Period	Gross reduction in corn output (Mil. bu)	Net Social Cost (Mil. bu.)	Average IRR (%)
1950-54	145.1	89.5	161
1955-59	220.8	130.1	143
1960-64	317.6	180.4	131
1965-69	454.4	301.4	196
1970-74	580.2	452.2	353
Total	1,718.1	1,153.6	204

with fewer conventional resources (land, labor, and capital) releasing these resources for the production of other products, farm or nonfarm, depending on their relative profitability.

An alternative method of presenting the social cost is to calculate the internal rate of return (IRR) that Argentina could have obtained by allowing its farmers to invest in nitrogen fertilizer.[10/] As indicated in the right hand column of Table 6, the social rate of return that Argentina could have obtained by the utilization of nitrogen on corn has averaged over 200 percent annually over the 1950-74 period. Indeed, the rate of return has been increasing in recent years, exceeding 350 percent annually during the 1970-74 period, because of the reduction in the real price of nitrogen and the consequent increase in the gap between what was and what might have been. Moreover it is not unreasonable to believe that other modern inputs would have yielded comparable rates of return, not only in Argentina but in many other developing countries. Rates of return of this magnitude are those that really matter when it comes to acheiving economic growth. As long as these countries persist in following such policies there can be little hope of ever solving the world food problem.

Footnotes

1/ See T. W. Schultz (1968) for some of the commonly held myths which attempt to rationalize the unproductive nature of agriculture in these countries, and the expected effect of unfavorable prices on agricultural output. The adverse effect of unfavorable prices on agricultural output in Argentina is documented by Fienup, Brannon, and Fender (1969), see especially pp. 353-354. D. Gale Johnson (1975) reminds us of the continuing problem of inadequate incentives for farmers in developing countries and observes, "What is surprising is that there has been so little analysis of these policies that exploit farmers and so little criticism of governments that put them into practice" (p. 75).

2/ U.S. Dept. of Agriculture, ERS, Fertilizer Situation, December 1972, p. 14.

3/ U.S. Dept. of Agriculture, "Argentina: Growth Potential of the Grain and Livestock Sectors" Foreign Agricultural Economic Report No. 78, May 1972, p. 42.

4/ U.S. Dept. of Agriculture, Crop Reporting Board, Crop Production, November 1972, p.B-17 The states include Ohio, Ind., Ill., Wisc., Minn., Iowa, Mo. and Neb.

5/ Farm Journal, November 1975, p. 23.

6/ Crop Production, November issues respective years.

7/ See de Janvry (1972) for a detailed account of the effect of risk on decisions to apply nitrogen fertilizer to corn and wheat in Argentina.

8/ Theoretically the MPP curve of an input in a Cobb-Douglas production function extends up to infinity, never reaching the vertical axis.

9/ This analysis assumes that Argentina is a price takes in the world markets for corn and nitrogen. The assumption is not unreasonable in view of the fact that Argentine corn exports amount to about 1.6 percent of the world's corn output and its imports of nitrogen fertilizer would have amounted to about 1 percent of world nitrogen production at the 90 kg. per ha. rate.

10/ The internal rate of return is that rate of interest which makes the discounted present value of the returns equal to the cost. In this case it is assumed that the returns are forthcoming one year after the cost. Thus $C = \frac{1}{(1+r)} \times R$ where C (the cost) is the difference between the gross reduction in output and the net social cost, R (the return) is the gross reduction in output, and r is the internal rate of return.

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