SHIFTS IN THE COMPETITIVE ADVANTAGE OF TRADITIONAL AND ENERGY INTENSIVE AGRICULTURE UNDER RISING ENERGY COSTS: THE CASE OF NICARAGUA

by

Philip F. Warnken
Associate Professor
Department of Agricultural Economics
University of Missouri-Columbia

A Contributed Paper
Group XVIII
AAEA Meetings
August 10-13, 1975
Columbus, Ohio

Agricultural Economics Paper 1975-26
Department of Agricultural Economics
University of Missouri-Columbia

SHIFTS IN THE COMPETITIVE ADVANTAGE OF TRADITIONAL AND ENERGY INTENSIVE AGRICULTURE UNDER RISING ENERGY COSTS THE CASE OF NICARAGUA

The transformation of agriculture from traditional to modern production systems has, to a great extent, been an energy transformation. Fossil energy has substituted for animal and human power and fossil substances have provided the chemical and energy basis for the manufacture of fuel, machines, inorganic fertilizers, and plant and animal protectants. Genetic improvements and enhanced managerial capability have also played important roles in the agricultural transformation process, although the potential of these innovations and skills could not have been fully realized without the complementarities of more intensive fossil energy use.

Modern agriculture is energy intensive agriculture (EIA) and agricultural modernization has implied the intensified use of fossil energy. This has been the historical pattern of twentieth century agricultural development and would appear to be the path that developing nations will be required to take to meet the present and future demands for increased food and fiber. But with the recent sharp rises in fossil energy prices, the future viability of EIA has come under serious question. On the one hand is the longer run question of the agricultural impacts of eventual fossil energy depletion while on the other is the immediate issue of whether the competitive position of EIA has been so eroded by increased energy prices as to make it uneconomical when compared with traditional production systems. Clearly, developing countries are faced with the potential of short run agricultural output declines and long term questions as to how future output increases are to be achieved.

That both questions must be given our most serious attention is obvious. This paper, however, focuses specifically on only the short run issue and examines the competitive advantage shifts of traditional agriculture versus EIA between 1972 and 1975 in one developing country - the Central American nation of Nicaragua.[1]

BACKGROUND

Nicaraguan agriculture is representative of much of Central America's agriculture. In general, export products are produced on relatively large energy-intensive farms while food crops are usually grown on small farms using traditional production methods.(5) There are, however, notable exceptions to this pattern. In the case of major food crops, examples can be found of small farms employing high levels of technology. These small energy-intensive farms use significant amounts of modern inputs and achieve crop yields and outputs per manday ranging to several times those of traditional farms (Table 1). These farms are found in all regions of the country interspersed with farms using traditional production systems. Aside from the energy intensiveness and higher yields and per manday outputs, no substantial differences exist between these farms and neighboring traditional farms. Both types of farms are very similar in terms of the degree of market orientation, average size, and land and labor resource base. (1, 2, 3, 4)

Between 1972 and 1975, there was a sharp rise in Nicaraguan farm input and output prices (Table 2). The country is very

TABLE 1
AVERAGE YIELDS* AND MANDAY
OUTPUTS** BY TECHNOLOGY LEVEL AND MAJOR FOOD
CROPS IN NICARAGUA, 1972

TECHNOLOGY LEVEL***	CORN		BEANS		GRAIN SORG.		RICE	
	YIELD	MANDAY OUTPUT	YIELD	MANDAY OUTPUT	YIELD	MANDAY OUTPUT	YIELD	MANDAY OUTPUT
TRADITIONAL I	15.1	.42	10.5	.24	14.0	.36	25.9	.38
INTERMEDIATE II	24.2	.56	12.6	.31	24.5	.59	30.3	.34
ENERGY INTENSIVE III	42.6	1.06	25.0	.96	34.1	.81	50.4	1.22

*Expressed in pounds hundredweight per manzana (1 manzana = 1.4 acres)

**Expressed in pounds hundredweight per manday (1 manday = 8 hours)

***For a definition of technology levels see page 3.

TABLE 2

PERCENTAGE PRICE CHANGES FOR SELECTED AGRICULTURAL INPUTS AND PRODUCTS BETWEEN 1972 AND 1975 IN NICARAGUA

ITEM	PERCENT PRICE CHANGE 1972 to 1975
AGRICULTURAL INPUTS	
Land	100.0
Labor	35.0
Animal Power	33.3
Machine Power	50.0
Fertilizer (Mixed)	351.1
Insecticide	129.0
Herbicide	13.4
Fuel	90.5
PRODUCTS	
Corn	64.2
Beans	133.1
Grain Sorghum	73.5
Rice	98.5

heavily dependent on international markets for most of the modern inputs used in its agriculture given that domestic industry is limited. Thus, domestic prices of fossil-energy based inputs such as fuels, fertilizers, and plant protectants followed world trends during the 1972-75 period. Output prices also generally followed international trends since the nation both exported and imported agricultural commodities (including food grains) under conditions of minimal governmental intervention.

DATA AND METHODOLOGY

Data used in this analysis were derived from two different surveys - one taken in early 1972 and another in early 1975.[2] The 1972 survey was a production cost/resource use sampling of some 667 Nicaraguan farms producing major food grains (Table 3) and the 1975 survey was an input/output price sampling of farms and farm supply houses (Table 2). In the 1972 survey, farms were stratified by different sizes, six geographical regions and three levels of technology. Although interesting results were revealed in the analyses of size and region stratifications, the focus here will be on the technological stratifications.

The three technological strata were traditional (Level I), intermediate (Level II) and energy intensive (Level III). Level I farms were defined as those using zero or extremely insignificant magnitudes of modern inputs in the production process. Level II farms were defined as those using any single modern input. In practice, this single input may have been fertilizer, improved seed, a plant protectant or even mechanization. Level III farms - the more energy intensive units -

TABLE 3

NUMBER OF FARMS IN 1972 SAMPLE
SURVEY BY TECHNOLOGICAL
LEVEL AND CROP, NICARAGUA

TECH. LEVEL	CORN	BEANS	GRAIN. SORG.	RICE
TRADITIONAL (I)	129	122	49	23
INTERMEDIATE (II)	135	96	36	23
ENERGY INTENSIVE (III)	29	2	9	14
TOTAL	293	220	94	60

were those using any two or more modern inputs in the production process. Although these definitions lacked complete precision, they were satisfactory measures for purposes of this analysis.[3]

The analysis concentrated on the four major traditional food crops - corn, edible beans, grain sorghum and upland rice. The procedure followed was to calculate average production costs and returns by technological strata for the 1972 crop year. (1, 2, 3, 4) Several different cost/return concepts were computed. For the determination of true economic costs, opportunity values were applied to all fixed factors. Land opportunity costs reflected actual cash or crop share rental costs (about half of the sampled farms were rented), while labor opportunity costs were the prevailing seasonal wage rates for farm labor. Cash costs were calculated as the actual cash outlay for all purchased inputs, hired labor, production loan interest and land rental costs. Cash costs for owner-operated farms also included a land rental opportunity cost. This procedure was followed because cropland demand is sufficiently great in Nicaragua that owner-operators do in fact have the option of renting their land to neighboring farmers.

The same cost and return concepts were computed for 1975 using current input and output prices. (6) In essence, the resulting 1975 cost-return data were simulated figures since all 1972 production coefficients were left unchanged. Hence, the purpose of the analysis was to determine shifts in the relative competitive advantage of different production systems due only to input and output price changes.

DATA ANALYSIS

Selected data from the production cost-return analysis for 1972 and 1975 are shown in Table 4. Considering first the 1972 total per unit production costs, it is interesting to note the remarkable similarity in costs from one technological level to another. The considerably lower unit cost for beans in Level III was the only exception and this is perhaps explained by the small sample size in this strata. This data would seem at least partially to explain why traditional and EIA could exist and compete side by side in spite of markedly different resource productivities and cost structures. Even though land and labor productivities of traditional agriculture were very low compared to EIA, so were total costs. Thus, it appears that a competitive equilibrium had been established as of 1972 in that total per unit costs for a given crop were, in general, very similar for all three technological levels. This is not unexpected given that input and output prices and price relationships had remained relatively stable for several years through 1972.

Had producers maintained the same resource mix in 1975 as in 1972, very considerable variation would have occurred in total unit production costs from one technological level to another. Both absolute and percentage cost variations were significantly greater in 1975 than in 1972. However, in terms of the relative shifts in total unit costs by technological level, the data show rather mixed results. Level III corn producers lost the small cost advantage of 1972, while the

TABLE 4

SELECTED COST AND RETURN CONCEPTS FOR MAJOR FOOD CROPS OF NICARAGUA, 1972 AND 1975 BY TECHNOLOGY LEVEL

(Expressed in Cordobas*)

COST/RETURN CONCEPT	TECH. LEVEL	CORN 1972	CORN 1975	BEANS 1972	BEANS 1975	GR. SORG. 1972	GR. SORG. 1975	RICE 1972	RICE 1975
Total Cost/ Manzana	I	327.00	536.00	453.00	741.00	314.00	544.00	571.00	927.00
	II	573.00	1,123.00	569.00	1,077.00	578.00	1,064.00	847.00	1,683.00
	III	841.00	1,609.00	717.00	1,666.00	873.00	1,704.00	1,234.00	2,254.00
Total Cost/ cwt.	I	21.60	35.26	43.17	70.48	22.39	38.62	22.03	34.84
	II	23.69	46.37	45.23	85.12	23.63	43.45	27.98	54.07
	III	19.71	37.75	28.68	66.65	25.59	49.96	24.50	44.71
Total Cash Cost/cwt.	I	16.03	19.87	29.58	46.61	12.20	20.55	15.30	23.38
	II	15.62	32.42	31.07	60.58	14.77	28.29	20.53	40.99
	III	14.12	28.30	19.42	51.32	19.20	38.84	17.54	32.83
Per Manzana Rate of Return to Investment (%)	I	26.10	26.70	41.70	102.50	0.40	1.20	53.80	91.70
	II	18.40	-0.60	33.70	70.70	0.60	-5.10	49.50	52.10
	III	31.00	12.50	19.80	200.80	-13.00	-22.70	55.30	69.50
Return After Cash Cost Paid	I	217.67	378.15	331.68	1,010.97	144.17	261.41	481.97	1,155.27
	II	300.68	332.00	393.35	1,071.60	220.38	316.58	647.95	1,283.96
	III	499.28	603.05	1,664.48	3,728.65	104.52	-7.51	1,033.32	2,166.15
Net Income/ Manzana	I	85.27	143.10	189.05	759.84	1.39	6.70	307.45	850.33
	II	105.62	-7.13	215.12	761.17	3.71	-54.73	422.23	876.75
	III	260.77	200.68	1,432.98	3,345.35	-113.69	-386.82	682.77	1,567.25

*7 Cordobas = $1.00 U.S.

competitive position of traditional grain sorghum and rice producers was further enhanced. Traditional producers of beans continued to have a cost disadvantage compared to energy intensive producers, but this disadvantage was considerably narrowed in 1975. Thus, when all factors were paid their opportunity costs, it can, as a general statement, be said that traditional agriculture gained relative to EIA.

Total unit costs, however, are not the only appropriate measure of competitive advantage shifts. Cash costs and returns after cash costs may provide a better basis, especially in developing countries, for measuring competitive position changes over time. Yet, observing these figures (Table 4), it is clear that the position of EIA was eroded vis-a-vis traditional agriculture between 1972 and 1975. This same conclusion also applies to still another measure - the rate of return to investment - where the return to traditional agriculture gained relative to EIA.

Although on a relative basis, the competitive advantage shifted in favor of traditional agriculture between the two periods, this does not imply that EIA became unprofitable. In fact, measured in terms of net income and/or returns after cash costs were paid, EIA as well as the other two technology levels showed greater returns except in grain sorghum production in Levels II and III. Furthermore with the same exception, the absolute income levels - both cash and net income - continued to be substantially greater for Level III production than for production at Levels I or II.

COMMENTS

Initially, these results were somewhat surprising in that it was hypothesized that the relative competitive advantage of EIA would be more sharply eroded by the rapid price rise of fossil-based inputs. However, upon analysis of the changes in cost structures of the farms studied, the reasons for the fairly small competitive advantage shifts became apparent. At the heart of the explanation is the fact that land and labor costs increased equally for producers in all three technological levels. But because traditional agriculture relied so heavily on these two resources, the relative impact of land and labor price increases was, of course, much greater for traditional producers than for energy intensive producers (Table 5). For example, in the case of corn producers, land and labor cost increases accounted for 84 percent of the total cost rise for traditional farms, but only 24 percent of the increase for EIA.

Labor prices rose because of national legislation increasing the national minimum wage. The explanation for the dramatic rise in Nicaraguan land prices is explained by the capitalization of increased output prices into land values. Although the land price increase appears excessive, it is reflective of the increased product prices (Table 2). Land rentals are paid in either crop shares or cash and if one assumes only a crop share payment system, then a product price rise of 100 percent will increase the renter's land costs by an equal percentage. Thus, the increased product prices essentially "caused" the increase in land costs.[4]

TABLE 5

PERCENTAGE CONTRIBUTION OF SELECTED INPUTS TO PRODUCTION COST INCREASES OF MAJOR FOOD CROPS OF NICARAGUA, BY TECHNOLOGY LEVEL BETWEEN 1972 AND 1975

INPUT OR INPUT GROUP	TECH. LEVEL	CORN %	BEANS %	GR. SORG. %	RICE %
LAND	I	33.8	23.5	31.5	26.6
	II	18.7	17.9	21.5	15.2
	III	13.8	7.9	12.5	14.6
LABOR	I	50.5	52.1	44.3	52.1
	II	25.7	29.4	23.5	26.6
	III	11.7	32.0	20.0	12.6
MACHINE ENERGY	I	0.7	0.1	0.6	0.0
	II	2.4	0.9	6.8	1.5
	III	8.1	8.5	9.7	11.3
ALL PURCHASED INPUTS	I	6.5	17.3	15.5	13.4
	II	45.0	44.1	39.5	48.5
	III	59.0	45.9	51.6	61.2

If product prices were to fall with no decline in the prices of fossil-based inputs, the competitive advantage would shift very sharply toward traditional agriculture. For example, purchased input and mechanical energy price rises accounted for 67 percent of the increase in corn production costs for EIA, but less than one percent for traditional producers (Table 5). Although data are not shown, if output prices fell about 12 percent for corn, 30 percent for beans and rice, EIA would become uneconomical (it is already uneconomical in the case of grain sorghum). Should this occur, aggregate output of these crops would fall by an estimated 25 to 35 percent.

This poses a set of serious dilemmas for Nicaraguan policy makers. In order to maintain or expand a viable EIA, output prices must remain near present levels. Yet, much lower food prices are critically needed in order to enhance real consumer income. If prices are lowered via imports, EIA will likely cease to exist or at best revert back to traditional agriculture with a subsequent decline in aggregate agricultural output. This would only serve to exacerbate the already slow process of agricultural modernization.

If output prices are maintained at present levels and assuming no major rises in fossil-based input prices, there are strong income incentives for traditional producers to shift toward EIA except in the case of grain sorghum production. As shown in Table 4, traditional producers can considerably enhance both their cash and net incomes by shifting to EIA. This might well result, however, in lowered output prices and lead to a highly unstable cobweb-like disequilibrium involving sharp year to year variations in aggregate output, product prices and modern input usage levels.[5]

The only apparent solution to these various dilemmas would appear to be a set of policies designed to enhance resource efficiency in the agricultural sector. While this paper cannot dwell on specific policies, certainly they would include agronomic research, more efficient input and output markets and efforts to enhance farm managerial skills. Unless such policies are implemented, high output prices and/or substantial subsidies for using modern inputs would seem the only alternatives.

FOOTNOTES

[1]The term "competitive advantage" as used in this paper is intended to connote a series of comparative measures of production costs and returns among different types of agricultural production systems producing the same product within a given country.

[2]Data shown in tables are point estimates of population parameters and subject to the usual sampling errors. For results of the statistical analysis see references 1, 2, 3 and 4.

[3]Various other approaches were attempted to provide a more objective measure of technology levels, but none were as satisfactory as the method discussed above.

[4]Land costs obviously pose the usual difficult conceptual problems. For example, if rent is paid on a crop share basis and the shares remain unchanged as product prices change, the real "in kind" cost to the renter is constant.

[5]Space does not permit a full analytical treatment of the short and long run disequilibria resulting from product price and/or output changes when production is derived from technologically different production systems. In essence, the supply function is discontinuous since EIA would cease production below a certain product price level while traditional agricultural

production would continue at quite low product prices. The degree of price and output instability would depend on the position of the demand curve relative to the discontinuous supply curve and on the elasticities of the two curves.

REFERENCES

(1) Finley, Robert M., "Analysis of Maiz Production in Nicaragua: A Detailed Study of Costs and Returns," A Report Presented to AID/Nicaragua, December, 1973.

(2) Finley, Robert M., "Analysis of the Production of Frijoles in Nicaragua: A Detailed Study of Costs and Returns," A Report Presented to AID/Nicaragua, January, 1974.

(3) Finley, Robert M., "Analysis of Arroz Production in Nicaragua: A Detailed Study of Costs and Returns," A Report Presented to AID Nicaragua, February, 1974.

(4) Finley, Robert M., "Analysis of Sorgo Production in Nicaragua: A Detailed Study of Costs and Returns," A Report Presented to AID/Nicaragua, February, 1974.

(5) Warnken, Philip F. and Walter L. Swenson, "An Analysis of Agricultural Production in Nicaragua," Final Report for AID Contract AID/CM/la-C-73-21, Department of Agricultural Economics, University of Missouri-Columbia, June, 1974.

(6) Warnken, Philip F., "Production Costs and Returns for Major Agricultural Products of Nicaragua: Data Tables For 1972 and 1975," A Report to the Agency for International Development, February, 1975