COST-SIZE RELATIONSHIPS AND TRADITIONAL FARMERS' ECONOMIC BEHAVIOR*

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The degree of peasant response to innovations and prices has been a point of controversy among development economists. Some writers suggest that cultural and institutional factors restrain appropriate production adjustments [1]. Others maintain that peasants in traditional agriculture respond rapidly to market incentives and are fairly efficient in allocating their resources among production altneratives [2, 6]. The approach and kind of data employed in testing these hypotheses have, to a large extent, contributed to this controversy.

Most empirical works relate variations in output and acreage to changing prices without considering climatic conditions as a contributing factor. It should be noted that for most crops, variation in output depends mainly on climatic conditions and fixed factors such as operator's labor and other traditional inputs.[1] For food crops, the marketable surplus may be inversely related to price because of: (1) farmer's desire to remain near subsistance level; (2) his high propensity to consume and (3) his fixed cash income goal. Therefore, agricultural produce price increases may not lead to increased output since agricultural prices are affected by climatic conditions, and marketable surplus may be negatively related to price due to the farmer's high propensity to consume [5].

In many empirical analyses researchers use prices different from those used by farmers for planning their production, resulting in a distorted supply relationship. Lack of sufficient and accurate time series data to undertake a meaningful study of traditional farmers' supply response has also been a handicap in many cases.

The purpose of this paper is not to deal with shortcomings of earlier works, but to add knowledge of traditional farmers' economic behavior with respect to resource combination and size of crop enterprises. Cost function analysis, in relation to size and relative performance of large mechanized and small nonmechanized farms in a developing agricultural region of Iran, was used in this study. It differs from related studies in two respects: (1) it estimates a cost function and determines the actual resource combination on small farms using cross-sectional data, avoiding problems associated with time-series data and difficulties of supply response analysis mentioned above, and (2) it assumes a fixed cash income goal, tested as a hypothesis using break-even analysis. The need to break even and not exceed the break-even point is tested as a hypothesis of the lack of desire for profit or a fixed cash income goal.

A brief description of the region is presented first, followed by the study procedure. Finally, results and implications of the study are discussed.

THE REGION

South Central Iran is comprised of 48 villages within the Darius Irrigation Project which supplies needed water. This project extends from a point some 30 kilometers from Shiraz, Capital City of Fars

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[1] Such as animal power and local manures.

Province, to the upper end of the reservoir, some 100 kilometers northwest of Shiraz. The climate is hot, and annual rainfall is 250 millimeters.

Total irrigated land is about 35,000 hectares, of which approximately 53 percent is cultivated each year and the rest left fallow. In general, soils are clay loams and clay well-suited to irrigated farming. No significant differences are reported with respect to soil, drainage and water supply conditions.

The region has a population of approximately 12,000, and a work force of 4,600 man-years. About 63 percent of the work force is employed in farming. Organizational characteristics of nonmechanized farms were similar for different size of farms. Most farmers in the region still use traditional farming techniques with custom hiring of tractors for plowing. Prevalent crops in the region are wheat, barley, rice, sugar beets, cotton, sunflowers and alfalfa.[2] On some farms, wheat and barley are harvested by combine. Smaller farms, however, harvest their crops by hand and thresh by tractors. Sugar beets and other crops are mainly nonmechanized operations. Use of chemical fertilizer and pesticides is gradually increasing in the region.

Most farm units are small, average size being 10.53 hectares on nonmechanized, and 963.5 hectares on mechanized farms. Villages are not scattered; their distances from the main road rarely exceed a few kilometers.

STUDY PROCEDURE

In this study, the traditional cost model and break-even analysis procedure was followed in estimating cost per unit of output and break-even size.[3] For this purpose, a stratified random sample of 95 small farms and 10 large mechanized farms were selected in the region. Size of farms ranged from 2.8 to 29.7 hectares on the small farms and from 35.7 to 2035.7 on mechanized farms. Mechanized farms consisted of both private and corporate farms with owned machinery.[4]

Data on costs, returns and performance by size was obtained by interviewing the operators. Total revenue was used as an output measure, and both total cost per unit of total revenue and per unit of land were utilized as measures of cost.[5] Livestock enterprises are not included in this analysis. However, the usual organizational structure of farms with limited cropland typically includes supplementary livestock enterprises that more fully utilize labor, reducing the portion of this resource input to be allocated to crop enterprises. It was found that each full-time operator devotes, on the average, 90 days to livestock enterprises during winter months, and the rest of his labor time to crop enterprises during the growing season.

All farm operators must meet certain living expenses. Hence, that part of the operator's labor devoted to crops is considered fixed. It was also hypotheiszed that farmers have an income goal equal to their living expenses, which varies according to cost-of-living and employment opportunities (or opportunity cost). The size of unit needed to achieve this goal, defined as break-even acreage was determined as follows:

$$\text{Break-even acreage} = \frac{\text{total fixed cost} + \text{minimum living expenses}}{\text{total revenue} - \text{variable cost per hectare}}$$

Since about 47 percent of cultivable land in the region is left fallow annually, minimum acreages so obtained were increased by 47 percent to obtain the actual break-even size needed to meet the above production goal.

Cash costs per hectare are all actual calendar year outlays made by the operators. Fixed costs include the operator's fixed labor, buildings, machinery and equipment costs. Unpaid labor costs are derived from reported days of available operator and family labor valued at a hired man's daily wage rate of 250 rials.[6] An interest charge of six percent was made on all capital inputs using depreciated cost of buildings and machinery.

To determine the long-run cost function (long-run average cost) and the optimum size farm, three simple regression models—polynomial, hyperbolic and linear forms—were employed using cost per unit of

[2] Of total land actually cultivated each year, about 94 percent is in small grain (wheat, rice and barley). The rest is in summer crops on nonmechanized farms. Corresponding percentages for mechanized farms are 80 percent and 20 percent, respectively.

[3] The cost models used by agricultural economists to analyze cost-size relationships have focused upon market prices and a U-shaped short-run curve, and an envelope type curve for long-run analysis. For a detailed description see [4].

[4] Although the study largely deals with small farms, large mechanized farms were also included to study relative performance. The 10 large farms selected for this purpose consist of more than 50 percent of existing farms in the region.

[5] No external economies were present: That is, no pecuniary gains in buying of inputs and marketing of products were found.

[6] Sixty-eight rials equal one U.S. dollar.

money output and per hectare as dependent variables, and total revenue and acreage as independent variables.[7]

Finally, to determine the influence of size on the rate of adoption of new technology, degree of association between size and use of chemical fertilizer and pesticides was tested using both total revenue and acreage as measures of size, and quantity of fertilizer and pesticides used per hectare on each farm as a measure of adoption.

THE RESULTS

For most crops, yields per hectare were greater on small nonmechanized farms than large mechanized farms. Table 1 shows distributions of land by size of holding, cost and income per hectare on both types of farms.

As indicated, total farm income per hectare is greater for most nonmechanized farms than for mechanized farms, reflecting higher yields obtained in the former farm group. Total cost per hectare, however, is higher for smaller size groups. This is largely due to high fixed labor costs in nonmechanized farms, and spreading of machinery and other fixed cost over larger size on mechanized farms.

Net income per hectare is higher for mechanized farms than for nonmechanized farms. In terms of cost as a percentage of total revenue, however, some small farms appear to produce as efficiently as large farms. For example, the analysis indicated that on small farms (ranging from five to 16 hectares) total cost varied between 30 to 60 percent of total revenue, which is within the cost range of mechanized farms.

TABLE 1. DISTRIBUTION OF LAND BY SIZE OF HOLDING, COST AND INCOME PER HECTARE IN MECHANIZED AND NONMECHANIZED FARMS

Non-Mechanized Farms				Mechanized Farms			
Cultivated Land	Percent of Farms	Total Cost per Hectare	Income per Hectare	Cultivated Land	Percent of Farms	Total Cost per Hectare	Income per Hectare
hectares		rials	rials	hectares		rials	rials
1-5	44.2	36751	39926	1-300	50	14409	32318
5.5-9.5	48.4	25755	42136	201-600	--	--	--
10-14	4.2	16123	30567	601-900	10	15454	41029
14.5 & over	3.2	15941	30783	901-1200	40	10133	37657

EFFECTS OF SIZE ON UNIT COST OF PRODUCTION

Unit cost of production figures in relation to total revenue and cultivation area, indicate cost economies achieved when both acreage and labor are considered variable (Figures 1 and 2). Average total cost for crops follow the usual pattern of economic theory, with some exceptions. Small farms have the highest unit cost of production, largely because of high fixed labor costs distributed over smaller volume of output and land area.[8] Figure 2 indicates that except for the variation usually observed in data, unit cost in nonmechanized farms trends downward until farm size reaches about 14 hectares; but for farms over 14 hectares, unit cost seems to turn upward.

Cost structure variations, as related to size of farm, was also evident in the sample farms. Total cash cost per hectare is slightly higher for the larger farms, as more hired labor is added to supplement the fixed operator and his family labor.

Of the three regression models used to estimate the cost function, the hyperbolic form resulted in a better fit. The estimating equation is

$$\hat{Y} = \underset{(0.0193)^{9}}{0.2828} + \underset{(0.29822)^{9}}{8.3188}\left(\frac{1}{x}\right)$$

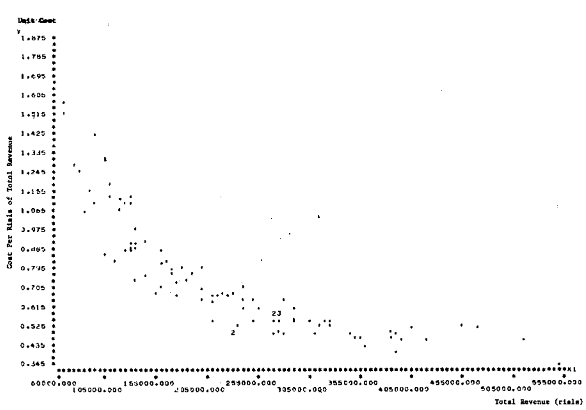

FIGURE 1. UNIT COST IN RELATION TO TOTAL REVENUE

[7] The theoretical basis for regression analysis is the traditional cost model mentioned above (the theory underlying economies of scale).

[8] Unit cost of production refers to production cost per unit of product as well as per unit of land.

[9] These are standard errors of estimates b_1 and b_2.

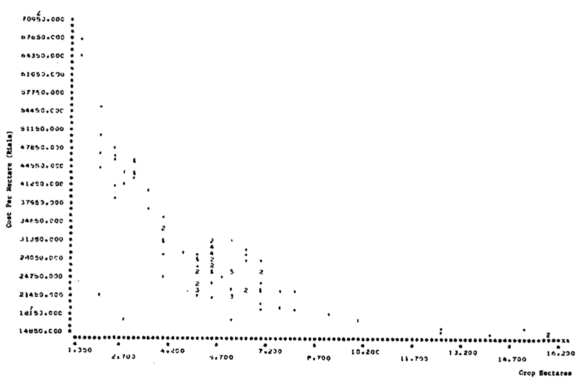

FIGURE 2. COST PER HECTARE IN RELATION TO SIZE

where

$\hat{Y}$ = total cost per unit of total revenue and
x = total revenue.

The Durbin-Watson statistic was 1.9926 and the coefficient of determination, R^2=0.8932, indicating that about 90 percent of variation in unit cost is explained by variation in size of farm when measured in terms of total revenue. The estimated equation indicates that as total revenue is increased, per unit cost tends to decline, largely because fixed labor cost is distributed over a larger volume of output. Since available sample data do not extend to farms with total output over 545,000 rials, no observation of either continued decreasing (or increasing unit costs) are available to support (or reject) the usual theoretical concept of increasing cost for larger farms.

However, when cost per hectare is related to size, measured in hectares, the polynomial regression model resulted in a better fit than other models. The estimating equation is

$$\hat{Z} = \underset{(2.452)}{61.9096} - \underset{(0.7007)}{8.1439x} + \underset{(0.04203)}{0.343x^2}$$

where

$\hat{Z}$ = cost per hectare and
x = hectares of land.

R^2 in this case is 0.72, indicating that in addition to size, other factors such as productivity affect average cost per hectare. Minimizing the estimated cost function, optimum size would be 11.86 hectares.[10] This shows that unit cost trends downward until farm size reaches 11.86 hectares, but for farms over 11.86 hectares unit cost seems to turn upward. The conclusion drawn from this estimate is that under existing technology, scale or cost economies do not extend beyond about 12 hectares. In other words, major cost economies in use of modest capital items and labor are largely exhausted as soon as relatively full employment is reached for labor.

To determine the effect of productivity on unit cost, a multiple regression analysis was run using cost per hectare as the dependent variable, and size of farm and total revenue per hectare as independent variables. The estimating equation is

$$\hat{Z} = \underset{(2.99)}{50.786} - \underset{(0.6184)}{7.7732x_1} + \underset{(0.0368)}{0.3378x_1^2} + \underset{(0.0411)}{.22x_2}$$

where

$\hat{Z}$ = cost per hectare
x_1 = hectares of land per farm and
x_2 = total revenue per hectare used as a measure of productivity.

R^2 in this case was 0.79 indicating that productivity partially explains the variation in long-run average cost.

The estimated equation indicates, given the size of farms, cost per hectare is expected to increase at a smaller rate than total revenue per hectare. Since cost per hectare is likely to turn upward for farms over 11.86 hectares (second equation), there seems to be a rational attempt on the part of some small farmers to increase total net income by increasing output per hectare (intensifying production) rather than bringing more land under cultivation (extensive production). This is likely to require more capital input.[11] There are indications that capital is a limiting factor for most small farmers in the region. Thus, it may be suggested that their factor combination is intended to maximize returns to capital resources rather than land, a portion of which is left fallow each year.[12]

[10] Optimum size was obtained by fitting a polynomial regression model. However, evidence to support the statement followed seems lacking from Figure 2.

[11] Highest total revenue was obtained in a medium size farm (six and one half hectares), and about 75 percent of those earning over 300,000 rials had farms ranging from five and one half to nine hectares. These findings seem to support the last conclusion.

[12] Unpublished studies in 1972 and 1974 by the Department of Agricultural Economics, Pahlavi University indicated that most small farmers in the region faced capital constraint. A considerable portion of their land is left fallow each year partly due to this constraint.

SIZE AND THE RATE OF ADOPTION OF NEW TECHNOLOGY

Analysis showed a significant association between size, measured in terms of total revenue, and use of fertilizer and pesticides with correlation coefficients being 0.46 and 0.224, respectively.[13] However, tests of association between size, measured in hectares, and use of fertilizer and pesticides revealed no influence of size on use of these inputs.[14]

A rather interesting result of the analysis is correlation between size and productivity. As measured by association of acreage and income per hectare, the correlation coefficient was −0.287. This indicates that small farms have performed better than both large mechanized and nonmechanized farms in terms of productivity. One could conclude that when custom hiring of machinery is made possible, small farms are able to demonstrate high levels of performance with respect to production per unit of land by using relatively more fertilizer, pesticides and other variable inputs. There are indications that small farms in other regions of the country have been able to operate as efficiently as large farms as a result of the individual farmer's know-how and hard work [3]. The only advantage of large farms over small farms appears to be cost-economies achieved through distribution of machinery and other fixed costs over a large volume of output and land area.

BREAK-EVEN ANALYSIS

The break-even analysis indicated that all mechanized farms and about 80 percent of the small farms studied were operating at above break-even acreage. The remaining 20 percent had smaller cultivated land than is required to provide sufficient income to cover their production and living expenses. Livestock enterprises and nonfarm employment provide supplementary income for these farms. Thus, the break-even results indicate that most farmers in the region have a desire to exceed the break-even acreage and obtain some profit. Average cultivated and total land per farm in the area was 5.58 and 10.73 hectares, respectively, while the break-even cultivated and total land per farm were 3.25 and 6.24 hectares, respectively.

Farmers with greater than the break-even crop acreage are operating at higher levels of efficiency, and better resource combinations, than those with smaller than break-even acreage. Since a portion of their land is left fallow annually, the gap between actual and minimum economic size in the latter group appears to be due to the capital constraint rather than irrational behavior regarding resource combination.

SUMMARY AND CONCLUSION

The objective of this paper was to investigate small farmer's economic behavior with respect to resource combinations and size of crop enterprises, and study the relative performance of small nonmechanized and large mechanized farms in a developing region of Iran. Analysis indicated, given the existing population and labor force in the region, the optimum size farm (in terms of cultivated land) should be around 11.86 hectares. In terms of total revenue, however, the study revealed existence of cost-economies beyond 545,000 rials. Since available sample data in the case of nonmechanized farms do not extend to farms with total revenue beyond 545,000 rials, no observation of either continued decreasing or increasing unit cost are available to support or reject the usual theoretical concept of increasing cost for larger volumes of output.

It was shown that small farms in the selected region behave rationally with respect to factor combination and demonstrate high levels of performance with respect to production per unit of land. The conclusion drawn is that considerable gain in productivity can be attained without major changes in the man-land ratio, provided an adequate supply of inputs representing modern technology, sufficient credit and incentives are available to them. The belief that small holdings inhibit adoption of modern technology and agricultural development in less developed countries appears to be contrary to findings of this study. This is particularly true when population pressure and man-land ratio is not favorable to large mechanized farms. One advantage of large mechanized farms is cost-economies achieved by distributing fixed machinery costs over larger output. When the man-land ratio cannot be improved to provide full use of machinery for lack of nonfarm alternative opportunities or other reasons, custom hiring may provide an alternative solution. Custom harvesting and seed-bed preparation are common in the region studied. The higher unit cost of production for small farms is, in part, due to high rental charge for custom hiring.

In this analysis, cost per unit of output and production per unit of land were used as measures of performance of various farm units. Other relevant

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[13] Both coefficients are significant at 0.10.

[14] The correlation coefficients between size and use of fertilizer and pesticides were -0.1148 and 0.06426, respectively.

efficiency measures such as production per unit of fertilizer, per unit of labor or total output-input ratio can also be employed. However, these measures could not easily be computed.

The agricultural situation in the region is characterized by a large number of small size farms and a few large mechanized farms. This is a common characteristic of many other regions of Iran and other developing countries. Thus, applicability of the findings can be extended to other areas with similar conditions.

Finally, insufficient data prevented a more rigorous analysis of the relationship between size and rate of adoption of technology. The problem merits further investigation because of its important policy implications.

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