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Scale Economies on Peanut-Rice Farms in Northeast Thailand*

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Scale Economies on Peanut-Rice Farms

in Northeast Thailand

Abstract

The relative technical and economic efficiency for small and large rice-peanut farm size classes in Northeast Thailand are compared. A theoretical model is developed and empirically tested with equal prices for inputs and products. Small farms, while more labor intensive, attain higher levels of both technical and economic efficiencies.

Scale Economies on Peanut-Rice Farms
in Northeast Thailand

Introduction

Two major classes of causes and/or inducements underlying the growth of farm sizes are hypothesized, i.e., socalled internal and external (pecuniary) economies of scale. The mechanical revolution is believed to have led to increases in internal returns to scale (Gardner and Pope, p.299) Pecuniary economies include the ability to command higher output-selling prices and/or lower input-buying prices; better access to market information and technical assistance; the legal and institutional structure (e.g. income tax laws, government farm programs) etc. (Krause and Kyle). Combined internal and pecuniary economies of scale are hypothesized to have resulted in a downward slope of the long run average cost curves (and possibly upward sloping average revenue curves) up to very large farm size.

Suppose that the various farm sizes obtain equal pecuniary economies of scale and, therefore, average costs and net revenue associated with increases in average farm size are determined only by pure internal economies of scale. If this were true, a policy which would attempt to limit the farm size would have to be abandoned if judged on the basis of efficiency criteria alone. In a less-developed economy, the question of optimal farm size is related to the land reform policy issue, i.e., policies proposed to redistribute wealth, income and property to the poor, landless and/or small farmers and yet, maintain the goal of growth in productivity and efficiency in the overall agricultural production. As the literature shows, whether redistribution of land into smaller units is or is not in conflict with efficiency and productivity goals is an issue of paramount importance in development strategy (see, for example, Bachman and Christenson, Parsons, Raup, Warriner, etc.).

The Specific Problem

In this paper an attempt is made to determine the relative economic returns to scale for large and small peanut-rice farms in Northeast Thailand. The dual of this is the average cost of production which, as will be seen later, is used as a measure of economic efficiency. For the purposes of this analysis, except for the differences in managerial ability of farm operators, it is assumed provisionally that other factors including external (pecuniary) economies of scale are inconsequential. That is, all farm size classes are assumed to have equal access to markets for both inputs and outputs, equal prices, information credit availability and other institutional factors.[1]

A three-equation model is developed in the next section. It is hypothesized that larger farms are more capital intensive and yet attain higher internal (nonpecuniary) returns to scale than smaller farms. Therefore, larger farms are hypothesized to incur a lower unit cost (or a higher profit per unit of output) compared to smaller farms. The hypotheses are subsequently tested utilizing data from a sample survey of 83 farms from two provinces in the Northeast region of Thailand (1973/74 crop year). Farming in the region has multiple enterprises and rice is the major wet season crop for the farms sampled. Peanuts is the prevalent crop in the season when rice is not grown.

The Empirical Model

Let the well-behaved homogeneous production function be specified as:

(1) $Y_i = f(X_{i1}, X_{i2}, X_{i3})$ group $i = 1,2$

where Y is the gross output either in physical units or monetary terms; X_1, X_2 and X_3 are variable inputs such as land, labor and capital etc. Subscript i represents the farm size class, i.e., small and large farms.[2] Under the maintained hypothesis of equal-price efficiency, an individual

[1] While we recognize that these assumptions may be partially invalid, as later evidence will show, this in no way invalidates our conclusions.

[2] Any farm with planted area of 25 rais or below is considered to be a small farm in this study. Twenty-five rais is approximately equal to 10 acres. This figure is adopted as the dividing line between large and small farms on the basis of prior knowledge of the land settlement pattern in Thailand.

producer equates the rate of technical substitution of every pair of inputs to its corresponding price ratio; i.e.,

$$fk/fj = rk/rj \qquad k,j = 1,2,3 \quad k \neq j.$$

The fitted production function from each size of farm class identify their optimal input combinations which directly gives us a measurement of optimal capital and labor intensity and capital-labor ratio.

Nevertheless, the comparisons of optimal capital and labor intensities and capital-labor ratio between farms with large and small land area do not give a statistical test of the differences in input-intensities hypothesis. To see whether large or small farms are capital intensive or labor intensive and vice versa, the test is performed on the estimated parameters of the relevant variables in the equation system (1).

The test of significant differences in the relative technical efficiency between the large and small farms can be performed on the pooled-regression model which is tentatively specified as;

(2) $Y = G(X_1, X_2, X_3, X_4)$

where Y, X_1, X_2 and X_3 are previously defined. X_4 represents a dummy variable taking the value of one for the small farms and zero for the large farms. The estimated parameter of the dummy variable measures the average difference in technical efficiencies between large and small farms.

If the hypothesis testing in (2) above suggests that there are significant differences in technical efficiencies, the economic relationship represented by (3) provides a test of relative economic efficiency between the farm sizes. The model is specified as;

(3) $R = H(Z_1, Z_2, Z_3, Z_4)$

where R = Average costs of production associated with the levels of the independent variables for each farm ($= \sum^{3} rXi/Y$).

Z_1 = Capital intensity (X_3/X_1), measured as the annual cash out flow (bahts/rai)[3]

Z_2 = Labor intensity (X_2/X_1), measured as labor man-days/rai.

Z_3 = Managerial ability, measured as years of experience in farming.

Z_4 = Dummy variable taking a value of one for small farm and zero otherwise.

The variable R (= $\overset{3}{\Sigma} rX_i/Y$) is used as a proxy variable for the relative economic efficiency of a farm. If Y is measured in monetary terms, R represents the average cost of producing 1 baht worth of output which is assumed to be variable from farm to farm. The variable R is actually the measure of the total returns to scale of a farm but has been interpreted as an average cost. The following argument will prove the proposition.

Under the maintained hypothesis of allocative efficiency, the value of marginal physical product of an input i is $(VMP_i) = r_i$. Hence, the partial production elasticity of an input i, $\frac{\partial Y}{\partial X_i} \cdot \frac{X_i}{Y}$, can be written as $\frac{r_i X_i}{Y}$ where Y is in monetary terms. In the three inputs case, the sum of all partial elasticities of production gives a measure of total returns to scale. Hence, for any farm sample, the total returns to scale could be measured by calculating the quantity $\overset{3}{\Sigma} r_i X_i/Y$ which was previously defined as average cost of producing 1 baht worth of output.

Thus, we use the quantity $\overset{3}{\Sigma} r_i X_i/Y$ to compare returns to scale, since the smaller this value is (i.e., the more closely it approaches zero),

[3] 1 baht = 5 cents U.S.

the larger is the total returns to scale of the farm. The more technically efficient farm is able to produce at a lower unit cost and, thus, with a larger unit profit and more economic efficiency.

The variables Z_1 and Z_2 are included in the model in order to test for significant differences between the average cost of production and the production techniques applied. In general, a negative and positive linear relationship between the variables R and Z_1, and, R and Z_2 are expected to hold, respectively.

It is hypothesized that not only the positive variables such as Z_1 and Z_2 affect the relative economic efficiency of the various farms, but qualitative variables such as level of education and level of experience in farming of a farm manager (Z_3) affect the level of the R also. Because of the homogeniety of the educational level of all family and hired labor, the years of experience in farming, measured in number of years engaged in farming, is used as a single proxy variable for the level of managerial ability. We hypothesize a negative relationship between the variables R and Z_3.

The variable Z_4 is included in order to test for the hypothesized-higher economic efficiency of large over small farms. The relationship of economic efficiency and particular farm sizes should correspond with what we obtained from hypothesis testing in the model (2). That is, suppose small farms have been found in (2) to be more technically efficient than large farms, we hypothesize that they are also more economically efficient in the model (3).

Empirical Results

The simple models (1) and (2) have been specified as Cobb-Douglas production functions, whereas estimated equations are of the following respective forms;

(4) $\log Y_i = a_0 + a_1 \log X_{i1} + a_2 \log X_{i2} + a_3 \log X_{i3} + e_i$

(5) $\log Y = b_0 + b_1 D_s + b_2 \log X_1 + b_3 \log X_2 + b_4 \log X_3 + e.$

The empirical results from the ordinary least squares regressions which are linear in common logarithms for equations (4) and (5) are presented in Table 1.[4,5] Equations (4) and (5) are well specified in the sense that the results of estimation in Table 1 have been shown significant and consistent. All of the coefficients (output elasticities with respect to all inputs) have the correct signs and are consistent with our particular hypothesis.

Regression number 3 for the pooled observations is reported in Table 1 for comparison. The regression results for the small and large farms are subjected, first of all, to the statistical test of equality of the two regression equations (Kmenta, p.373). The analysis of variance gives an F-ratio of 3.185 with 4 and 75 degrees of freedom, which is highly significant at 99% level. Therefore, the hypothesis that the parameters of the separated equations are equal [i.e., output elasticities

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[4]Customarily in the literature, the least squares regressions linear in natural logarithms have often been used to obtain the estimates. In this study, we found that the OLS linear in common logarithms gives exactly the same estimates of the regression coefficients (except for the constant term) but the standard error for the entire equation is lower for every regression equation in Table 1. Hence, for the purpose of increasing the precision of prediction, the OLS linear in common logarithms has been used in this analysis.

[5]Use of the single equation model for agricultural production function has been justified by many researchers. See, for example, Griliches (4), Mundlack and Hock (10), Zellner, Kmenta and Dreze (16), and Sindhu (14) etc.

with respect to all inputs as well as the technical coefficient(constant) terms are the same for separated equations is rejected. Thus, one cannot conclude, that the two groups of observations came from a population of equal productivity. More specifically, the two groups of farm sizes appear to be using different production techniques. Consider the results of estimation for small farms; coefficient of capital (X_3) is non-significant whereas the coefficients of all other variables are significant at 99% level. On the other hand, the empirical result for large farms indicated that the coefficient of labor (X_2) is non-significant whereas the coefficients of all other variables are significant at 99% level. Thus, we may conclude that the small farms are using relatively more labor intensive techniques in farming while the large farms are relatively more capital intensive.[6]

The level of input used, under the assumption of equal price efficiency, in order to demonstrate that the two classes of farm sizes are using comparatively different input intensities is shown in Table 2. We see that the optimum input combination is quite different with respect to the farm sizes. The overall conclusion, for the moment, is that, in maximizing profit, the small farms employed more labor but less capital inputs whereas the larger farms, on the other hand, employed less labor but more capital inputs per unit (rai) of land.

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[6]The t-test of equality of an individual parameter on the same variable between the two separated regressions is not given here. However, one could easily prove that the hypothesis of equality between the relative share of capital for the separated equations is rejected at $\alpha = 0.05$.

The hypothesis that large farms are relatively more technically efficient in farming is rejected in the light of the empirical finding of equation (4) in Table 1. We concluded from there that the small farm is relatively more technically efficient since the coefficient of dummy variable (D_s) is statistically different from zero at the 5% level.[7,8] It can be observed that intercept term for the production function of small farms is higher than that of large farms by about 5.6%. This means that small farms had production functions which were shifted upward above the expected values for large farms with similar capital and labor intensity and managerial experience. Contrary to the hypothesized result, the empirical analysis shows that small farms are more technically efficient than larger farms. The reason might be that the average input combination on the small farms was more effectively matched to the size of the farm land base than was true of the large farm.

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[7]Empirical result of equation (4) is obtained by assuming only an intercept shifter, not slope shifters. In fact, one might argue that both intercept and slope shifters should be included since it has already been proven earlier that the separated regression equations for small and large farms are not the same, implying not only intercept but also the slopes are different. However, the constant term (A) of the Cobb-Douglas production function measures the existing technical efficiency, and our objective is to show the relative difference in technical efficiency. The estimating equation in the form of equation (5) is thus sufficient for the purpose. However, a fitted regression equation which is not shown here has both intercept and slope shifters. The empirical finding from this much more complex model also indicated a positive relation between the output level (Y) and the intercept shifter. The intercept shifter was significant at $\alpha = 0.16$.

[8]The predicted output levels (Y) for small and large farm sizes evaluated at the mean values of the independent variables are not given here. Nevertheless, the reader could verify the fact that small farms do attain higher output relative to input intensity by substituting the numerical values of actual input intensities given in Table 2 into the relevant regression results (1) and (2) in Table 1.

Since the outputs were measured in monetary terms in these empirical analyses, the results obtained in Table 1, for equation (4), may imply that the small farms are relatively more economically efficient as well. This is so because they obtain higher total value products per unit of each input than the larger farms. Nevertheless, there is no a priori way to judge this statement. The economic relationship such as the one given in the model (3) is thus formulated and subsequently translated into a statistical linear model for estimation in order to test the hypothesis that economic efficiency of large farms was greater than small farms. The OLS regression analysis for the pooled observations gives the following result;

$$\text{(6)} \qquad R = \underset{(0.055)}{0.562} - \underset{(0.0002)}{0.0006}\, Z_1 + \underset{(0.0011)}{0.0045}\, Z_2 + \underset{(0.0018)}{0.0011}\, Z_3 - \underset{(0.0451)}{0.1193}\, Z_4 + e.$$

Except for the coefficient of Z_3, all the coefficients have expected signs and are different from zero at a 1% significance level. The empirical result obtained helps to confirm, first of all, the inverse of the original hypothesis namely that the small farms, in addition to having more technical efficiency, are also more economically efficient. This conclusion comes from the actual negative relationship between the average cost of production (R) and the dummy variable for farm sizes, Z_4. It can be observed that the intercept term for the small farms is lower by about 0.1193 (21.23%). This means that the average cost of producing 1 baht worth of output is 21.23% lower for the small farms than the cost would be on the large farms.

A further conclusion from this empirical result is that, regardless of size class, capital intensive techniques (Z_1) reduce average production costs whereas labor intensive techniques (Z_2) increase them. The findings indicated that separate effects of capital and labor intensive techniques on the average cost of production have followed what was usually believed, in the sense that the more advanced production methods are productivity increasing, regardless of size, hence having lower average costs of production. The opposite interpretation would be true for the labor intensive methods, i.e., average cost of production tends to be increased as more and more labor is employed by the farm. Nevertheless, we found here that the small farm, despite its relative labor intensity, was relatively more technically as well as economically efficient than the larger farms. This leads to the conclusion that the small-farm sizes were more nearly optimal in terms of the existing available input combination, i.e., the combinations were more effectively matched to the size of the farm.

There is a non-significant relationship between the variables R and Z_3 indicating that variations in an average cost of production among the farm samples were not associated with differences of experience in farming of various farm managers.

Conclusion

The conclusion of the test of both relative technical and economic efficiency is in favor of the small farms i.e., farms of less than 25 rais (10 acres). It is observed that under the maintained hypothesis of equal prices i.e., of no-pecuniary economies of scale, the results obtained indicated that the small farms employ more labor inputs relative to capital inputs and have lower actual unit cost. In the context of this analysis, this finding means that the small farms attain higher levels of both technical and economic efficiency. The question arises as to why, if scale inefficiencies do exist in the large farms, i.e., if unit costs are higher, the larger farms still survive? A possible answer would follow from the findings of Berry (168-169) that economies of buying fertilizer inputs do exist in northeast Thailand. We have assumed equal prices in computing costs and returns. If similar pecuniary economies of scale exist with respect to other inputs and to product prices, they might have offset the relatively inferior pure technical returns to scale of the larger farms. Furthermore, with respect to their relative economic efficiency, these findings are similar to those found in India by Yotopoulos and Lou, and by Mukhoti, but different from those proposed by Sindhu, Khan and Maki etc. The direct implications of this study appear to be that land reform and other policies designed to limit the size of farm are not inconsistent with efficiency in these particular types of farms in the northeast region of Thailand. Indeed, equity and growth as goals of agricultural development policy are mutually reinforcing.

TABLE 1 Estimates of Production Function for Rice-Peanut, 1973/74, Northeast Region, Thailand.[a]

Regression Number	Farm Sizes	No. Obs.	Constant	D_s	Coefficient of $\log X_1$	$\log X_2$	$\log X_3$	R^2	Return To Scale
1	small	48	2.266		0.548	0.423	0.032	0.822	1.003
			(0.157)		(0.071)	(0.081)	(0.043)		
2	large	35	1.924		0.582	0.179	0.277	0.786	1.038
			(0.291)		(0.208)	(0.229)	(0.100)		
3	pooled	83	2.188		0.421	0.331	0.121	0.848	0.933
			(0.139)		(0.063)	(0.087)	(0.045)		
4	pooled	83	1.981	0.111	0.520	0.415	0.106	0.856	1.041
			(0.168)	(0.052)	(0.078)	(0.086)	(0.044)		

[a]Regressions which are linear in common logs are estimated by least squares. The dependent variable is the value of gross output of a farm (bahts/farm). D_s is a dummy with a value of one for small farms and zero otherwise. X_1, X_2 and X_3 are land(rais), labor(man-days), and capital flows(cash cost on fertilizer, insecticide, machinery, hired labor etc., bahts/farm) respectively. Standard errors of coefficients are in parenthesis.

TABLE 2 Optimum and Actual Input Intensities for the Small and Large Farms.[b]

Input Intensity	Small Farm Optimal	Small Farm Actual	Large Farm Optimal	Large Farm Actual
Labor intensity	6.43	23.	2.56	15.28
Capital intensity	73.00	129.	595.00	158.21
Capital-labor ratio	11.35	6.	232.12	10.35

[b]The optimum input combinations for each group of farm sizes are calculated from the first order condition of profit maximization with respect to each production function. The inputed prices of land (X_1), labor (X_2) and capital (X_3) are 100 bahts/rai, 12 bahts/man-day and 8 bahts/100 bahts of capital, respectively.

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