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period of nine years though slightly high is however compensated by more than 40 years of productive life. The study also shows that the plants are worth retaining as long as they give an income of Rs. 108 over maintenance cost which is quite low. Regarding the method of economic appraisal, the annual amortization method seems to be preferable to the present value summation method because of its simplicity, equal efficiency and close to real situation results.

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RELATIVE EFFICIENCY, FARM SIZE AND PEASANT PROPRIETORSHIP—A CASE STUDY OF RANCHI DISTRICT (BIHAR)†

In recent years relative economic efficiency of small versus large farms and peasant versus capitalist farms has been a subject of lively debate particularly in Indian agriculture. While some of the findings of the early fifties would point to the higher relative efficiency of small farms and farms based on peasant proprietorship,[1] those relating to the late sixties and early seventies would focus on the equal relative efficiency of small and large farms.[2] The explanations of the early batch of researchers were that the small sized farms, by and large, were characterized by the predominance of family labour whose contribution to the raising of crops was significant. The managerial ability of small farms and the greater care and attention paid by the peasant family labour would enable them to raise greater per acre yield of crops and thus put them in a better position vis-a-vis the large farms. The findings of the late sixties have their major explanations in terms of technological changes, which might have, to a large extent, brought about economies of large scale production, thus reducing the relative gains of small sized farms.

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† The present paper is based on the author's Ph.D. thesis, Resource Use Efficiency and the Size of Farms—A Case Study of Ranchi District, Ranchi University, Bihar, 1980.

1. A. K. Sen, "An Aspect of Indian Agriculture", *The Economic Weekly*, Vol. XIV, Nos. 4, 5 and 6, Annual Number, February 1962, "Size of Holdings and Productivity", *The Economic Weekly*, Vol. XVI, Nos. 5, 6 and 7, Annual Number, February 1964, and "Peasants and Dualism With or Without Surplus Labour", *Journal of Political Economy*, Vol. LXXIV, No. 5, October 1966; D. Mazumdar, "On the Economics of Relative Efficiency of Small Farmers", *The Economic Weekly*, Vol. XV, Nos. 28, 29 and 30, Special Number, July 1963; L. J. Lau and P. A. Yotopoulos, "A Test for Relative Efficiency and Application to Indian Agriculture", *The American Economic Review*, Vol. LXI, No. 1, March 1971, and "Profit, Supply and Factor Demand Functions", *American Journal of Agricultural Economics*, Vol. 54, No. 1, February 1972; and P. A. Yotopoulos and L. J. Lau, "A Test for Relative Economic Efficiency: Some Further Results", *The American Economic Review*, Vol. LXIII, No. 1, March 1973.

2. S. S. Sidhu, "Relative Efficiency in Wheat Production in Indian Punjab", *The American Economic Review*, Vol. LXIV, No. 4, September 1974 and M. H. Khan and D. R. Maki, "Effects of Farm Size on Economic Efficiency: A Case Study of Pakistan", *American Journal of Agricultural Economics*, Vol. 61, No. 1, February 1979. The study by Khan and Maki relates to Punjab and Sind Provinces of Pakistan, during 1974.

Technological change in agriculture can, however, be grouped into two categories: technological change through biological inputs [high-yielding variety (HYV) seeds, chemical fertilizer, irrigation water] and technological change through mechanical inputs (tractors, pumpsets, combine harvesters and other machine powers). The former being neutral to farm size, equal application of seed-fertilizer based technology, other things being equal, would probably leave the relative efficiency of small and large farms at the same level unless the net gain of the mechanical inputs is larger than those of the biological inputs. However, given the differential rate of application of biological chemical inputs among the different size-groups of farms due largely to the differences in motivation, knowledge, entrepreneurship and accessibility to the credit institutions, the relative efficiency among the different categories of farms would remain a debatable question. The contribution of peasant family labour in terms of greater care and attention is, however, expected to remain significant even in the changing structure of agriculture.

The concept of economic efficiency is often decomposed into 'technical efficiency' and 'price/allocative efficiency'. While the former refers to the highest amount of output with given amounts of factor inputs, the latter is the concept of efficiency with which the resources are allocated in the profit maximizing sense so that the marginal value products (of resources) are equal to the resource prices. Although these components of efficiency are, at least, conceptually independent of each other, an overall economic efficiency could be defined as the combination of 'technical' and 'price' efficiencies. Thus, economic efficiency = technical efficiency × price efficiency.[3] An operational model of measuring and testing the relative economic efficiency has been developed by Lau and Yotopoulos[4] in terms of unit-output-price profit function. The basic feature of such a profit function is that the actual normalized restricted profit would be a decreasing function of the normalized wage rate; while it would be an increasing function of the quantities of fixed inputs (like land and capital) and price of output. Thus, as is implied by the model, actual normalized profit function for two groups of farms would differ to the extent that one or the other group would have higher technical and/or price efficiency.

The statistical test of relative economic efficiency as devised by the authors lies in the estimation of profit function and utilizing a dummy variable distinguishing two different groups of farms in order to test the significance of the value of its coefficient.

The purpose of the present paper is to judge the relative efficiency of

3. M. J. Farrell, "Measurement of Productive Efficiency", *Journal of the Royal Statistical Society*, Series A (General), Vol. 120, No. 3, 1957, and Lau and Yotopoulos, *op. cit.*, *The American Economic Review*, March 1971.

4. Lau and Yotopoulos, *op. cit.* and Yotopoulos and Lau, *op. cit.* Please also refer to the following studies: A. M. Khusro: Economics of Land Reform and Farm Size in India, Macmillan Company of India Ltd., Delhi, 1973; P. A. Yotopoulos, "From Stock to Flow Capital Inputs for Agricultural Production Functions: A Microanalytic Approach", *Journal of Farm Economics*, Vol. 49, No. 2, May 1967; P. A. Yotopoulos, L. J. Lau and K. Somel, "Labour Intensity and Relative Efficiency in Indian Agriculture", *Food Research Institute Studies in Agricultural Economics, Trade and Development*, Vol. IX, No. 1, 1970 and P. A. Yotopoulos and J. B. Nugent: Economics of Development: Empirical Investigations, Harper and Row Publishers, New York, 1976.

small versus large farms, on the one hand, and peasant versus capitalist farms, on the other. The small farms are defined as those having a net cultivated area of 4 hectares (10 acres) or less, while large farms are those above 4 hectares.[5] The peasant farms are defined as those which are predominantly family based—the proportion of family labour to total labour days being more than 50 per cent, while in the capitalist farms this proportion is less than 50 per cent.[6]

The Analytical Framework

We have utilized the Lau-Yotopoulos profit function model in the following form:

$$\ln \pi_i = \ln\lambda_i + \delta_{Li} D_{Li} + \alpha_i \ln W_i + \beta_i \ln K_i + e_i \ldots (1)$$

and $$\ln \pi_i = \ln\lambda_i + \delta_{Pi} D_{Pi} + \alpha_i \ln W_i + \beta_i \ln K_i + e_i \ldots (2)$$

where π is profit per hectare, *i.e.*, total value of output minus the total wage bill per hectare, W is the money wage rate, K is the capital input (in terms of service flows in rupees), D_L and D_P are the dummy variables,

α, β and λ are the coefficients to be estimated and e is the error term.

We have not included land input as the other variables are expressed on per hectare basis.

Description of Variables

Profit (π):— Profit is defined as the total value of output minus the total wage bill. Profit thus includes interest on fixed capital and land rent. We have calculated the actual profit per hectare for each crop studied.

Wage rate (W):— It refers to the wage rate per day of an adult farm labourer. We have obtained this variable by dividing the total wage bill by the total number of days worked on the crop production. We have calculated the total wage bill for each farm by adding together the wages paid to the hired labour and the imputed value of family and exchange labour.[7]

Capital (K):—Capital input is expressed in terms of service flows in rupees per hectare of the crop production. Two broad categories of capital have been distinguished: fixed capital and working capital. Fixed capital includes all the fixed resources of the farm (including the live capital in the form of bullocks) while working capital refers to the sum total of the costs of seeds, manures, fertilizers, pesticides, etc., applied in the cultivation of crops. Fixed capital service flows have been calculated as the product of the maintenance cost of each fixed capital item per day and the actual number of days of the capital item used in the cultivation of each crop. The sum of fixed capital service flows and seed-fertilizer costs gives the total service flows of capital per crop production.

5. These criteria are based upon the usual criteria for distinguishing between small and large farms for different regions of our country.

6. This distinction is, however, arbitrary.

7. Family and exchange labour have been imputed according to the value of wages paid to annual farm labour. The wage rate per day of the annual farm labour has been worked out by dividing the total value of cash and kind wages paid annually to the farm labour by the total number of working days in a year.

Dummy variables:— Two types of dummy variables have been used in the profit functions in order to capture the impact of the types of farms. In equation (1), D_L, the dummy variable for large farms, takes the value of unity in the case of the cultivated area of the farm being 4 hectares and above and zero otherwise. In equation (2), D_P the dummy variable for peasant farms, takes the value of unity if the farm category is of family-based peasant variety (*i.e.*, farms using 50 per cent or more as family labour) and zero otherwise.

All the variables except the dummy variables are in natural logarithms. The estimates of the regression coefficients have been made by the statistical method of ordinary least squares.

Region and the Data

A relatively backward region of our country, *viz.*, Ranchi district (Bihar) has been chosen for obtaining empirical data and testing our model for relative efficiency. The district enjoys certain distinctive features with regard to socio-economic as well as climatic factors. Being a plateau region, having an elevation of 305 to 1,610 metres above the sea level, it not only gets more rainfall but is also cooler than its latitudinal position would otherwise warrant.[8] The normal annual rainfall of the district is 1,482.6 millimetres.[9] It is predominantly inhabited by tribal population which forms 58.08 per cent of the total population.[10] However, it is primarily a food-growing district —the percentage of area under total food crops being 96.5 per cent. Paddy alone occupies as much as 65 per cent of the total cropped area.[11] For obtaining primary data with regard to the details of inputs and outputs, we have conducted a sample survey of 150 agricultural households, randomly selected and stratified for different size classes of holdings during the agricultural year 1977-78. Table I gives the characteristic features of the sample farms. Tables II and III present data regarding the value of output, wage bill, profit per hectare, wage rate and capital services per hectare of the individual crops of paddy and wheat by size-distribution of farms.

We have utilized the above data at individual farm level to estimate the profit functions for the two crops of paddy and wheat. Thus we have tested the following hypotheses:

(1) Equal Relative Efficiency of Small and Large Farms

As it would be evident from the profit function model, the two profit functions of the two groups of small and large farms would be identical if both are equally technically and/or allocatively efficient. This would be reflected in the coefficient of dummy variable, the expected value of which would be zero. Our null hypothesis for testing the equal relative efficiency of small and large farms has thus been set up as follows:

$$Ho : \delta L = 0$$

8. Report on Agricultural Census, 1970-71, Revenue Department, Government of Bihar, 1974.
9. Annual Season and Crop Report, 1969-70, Government of Bihar.
10. District Census Handbook, Ranchi District, Government of Bihar, 1971.
11. Report on Agricultural Census, 1970-71, *op. cit.*

TABLE I—CHARACTERISTICS OF SAMPLE FARMS, RANCHI DISTRICT: 1977-78

Size classes (hectares)	Number of households	Cultivated area (hectares)	Number of peasant farms
0-1	26	16·38	21 (80·7)*
1-2	23	38·75	17 (73·9)
2-3	21	54·64	15 (71·4)
3-4	17	63·58	13 (76·5)
4-5	14	66·20	6 (42·9)
5-10	19	136·92	8 (42·1)
10-15	12	132·36	5 (41·7)
15-20	10	160·22	3 (30·0)
20 and above	8	181·43	2 (25·0)
Total	150	850·48	90 (60·0)

Source:—Own survey.
* Figures in brackets are percentages.

TABLE II—PROFIT FUNCTION DATA OF PADDY OF THE SAMPLE FARMS, RANCHI DISTRICT: 1977-78

(*Rs.*)

Size classes (hectares)	Value of output per hectare	Wage bill	Profit per hectare	Wage rate	Capital
(1)	(2)	(3)	(4) = (2)—(3)	(5)	(6)
0-1	2,264·19	230·98	2,033·21	2·91	424·54
1-2	2,313·13	220·98	2,092·23	2·64	421·31
2-3	2,275·02	227·25	2,047·77	2·95	432·39
3-4	2,325·04	247·65	2,077·39	2·96	451·95
4-5	2,061·36	297·54	1,763·82	4·31	448·68
5-10	1,835·06	270·79	1,564·27	4·39	434·41
10-15	1,746·51	338·50	1,408·01	5·81	464·32
15-20	1,648·50	346·21	1,302·29	6·20	441·00
20 and above ..	1,653·05	341·36	1,311·69	6·28	420·13

Source:—Own survey.

TABLE III—PROFIT FUNCTION DATA OF WHEAT OF THE SAMPLE FARMS, RANCHI DISTRICT: 1977-78

(*Rs.*)

Size classes (hectares)	Value of output per hectare	Wage bill	Profit per hectare	Wage rate	Capital
(1)	(2)	(3)	(4) = (2) — (3)	(5)	(6)
0-1	2,097·35	249·92	1,923·69	2·80	483·74
1-2	2,292·41	252·13	2,003·81	2·72	516·42
2-3	2,152·68	250·78	2,016·68	3·00	488·49
3-4	2,987·54	260·67	1,873·41	2·53	663·38
4-5	3,492·01	193·78	2,783·70	2·59	686·41
5-10	3,444·09	198·18	3,449·19	2·77	667·17
10-15	3,661·78	210·63	3,175·74	3·38	724·97
15-20	3,520·15	207·19	3,413·83	3·32	701·45
20 and above ..	3,366·97	232·04	2,715·50	3·58	671·68

Source:—Own survey.

(2) *Equal Relative Efficiency of Peasant and Capitalist Farms*

In a similar vein, we have set up our null hypothesis for testing the relative efficiency between peasant and capitalist farms as follows:

$$Ho : \delta P = 0$$

The results of the regression exercises and other related statistics are given in Tables IV and V respectively.

TABLE IV—REGRESSION RESULTS OF PROFIT FUNCTION

(Ho : $\delta L = 0$)

Crops	Number of observations	Regression coefficients				R^2	F	Fc 0·10
		λ	δL	α	β			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Paddy	150	6·15779	—0·47519 (0·20174)	0·05101 (0·00604)	0·18236 (0·04821)	0·685	103·77	6·81 (1, 146)
Wheat	135	7·16682	0·12053 (0·00426)	—0·03049 (0·00117)	0·67582 (0·23104)	0·773	151·59	6·84 (1, 131)

TABLE V—REGRESSION RESULTS OF PROFIT FUNCTION

(Ho : $\delta P = 0$)

Crops	Number of observations	Regression coefficients				R^2	F	Fc 0·01
		λ	δP	α	β			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Paddy	150	6·58871	0·14730 (0·00372)	0·03520 (0·00094)	0·17108 (0·01064)	0·616	209·23	6·81 (1, 146)
Wheat	135	7·03514	0·10302 (0·00633)	—0·02716 (0·00054)	0·15364 (0·10304)	0·703	101·87	6·84 (1, 131)

Note:— Figures in brackets indicate standard errors of estimates while those under Fc 0·01 indicate the degrees of freedom for the numerator and denominator respectively.

The above analysis of the relative efficiency tests shows that while the small farms are relatively more efficient with regard to the production of paddy, large farms are more efficient with regard to wheat. The coefficient of the dummy variable for large farms (δL) in the profit function for paddy turns out negative and is statistically significant at one per cent level as indicated by the F-test. This implies that the profit function for large farms has a lower intercept term, suggesting lower level of economic efficiency. However, with regard to wheat, the coefficient of the dummy variable for large farms in the profit function is significantly positive, thus suggesting higher economic efficiency for large farms.

Similarly, the statistical tests with regard to the difference in the two profit functions for peasant and capitalist groups of farms indicate that in

both the crop productions the peasant farms are relatively more efficient than the capitalist farms. However, the size of the coefficient of the dummy variable for paddy is higher than that of wheat. Both the coefficients are statistically significant as revealed by the F-test. The calculated F-values are much higher than the critical F-values at the respective levels of significance. These results suggest that the role of peasant proprietorship is significant in the cultivation of crops. Family labour contributes greater care and attention as compared to the hired labour in the raising of crops.

However, a close analysis of wheat farms would suggest that since the percentage of peasant family-based farms, by and large, decreases with the size of farms (Table I), the positive impact of family labour would also be diminishing. On the other hand, the technological innovations applied by the large farms particularly in the production of wheat might have produced a neutralising effect. It may be mentioned in this connection that while paddy happens to be a traditional and chief subsistence crop of this region, wheat cultivation is of comparatively recent origin. The new variety of wheat giving higher yield has been adopted mostly by the larger farms. Table VI

TABLE VI—PERCENTAGE DISTRIBUTION OF FARMS USING NEW TECHNOLOGY: PADDY AND WHEAT

Size classes (hectares)	Percentage of farms using HYV paddy	Percentage of farms using HYV Wheat	Percentage of farms using recommended doses of fertilizer	
			Paddy	Wheat
(1)	(2)	(3)	(4)	(5)
0-1	0·0	3·7	0·0	0·0
1-2	0·0	4·8	0·0	0·0
2-3	0·0	11·0	0·0	2·3
3-4	0·0	10·6	0·0	5·4
4-5	0·0	26·8	0·0	18·0
5-10	0·0	59·7	0·0	48·3
10-15	3·6	71·5	2·4	68·7
15-20	8·4	86·9	6·6	81·2
20 and above	10·1	85·4	9·5	81·9

Source:—Own survey.

gives the percentage distribution of farms using new technology in both the crop productions of paddy and wheat. Thus the seed-fertilizer technology might have put the larger farms on a better position with regard to wheat cultivation and hence they have proved to be economically more efficient.

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