Vol XXIV
No. 2

APRIL-
JUNE
1969

ISSN 0019-5014

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

RESOURCE-USE EFFICIENCY IN AGRICULTURE

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INTRODUCTION

One of the main objectives of a production unit is to co-ordinate and utilize resources or factors of production in such a manner that together they yield the highest net returns. The purpose of the present study is to evaluate the efficiency with which farmers in the States of Uttar Pradesh and Punjab use their resources to achieve this objective in crop production. An attempt is also made to study resource-use efficiency in different categories of farms, and to estimate the returns to scale underlying agricultural production in the region. The analysis is based on disaggregated[1] farm management data of a sample of farms each in Uttar Pradesh (Meerut and Muzaffarnagar districts) and Punjab (Amritsar and Ferozepore districts) for the years 1955-56 and 1956-57.[2] As is well-known, these farms were selected by the method of multi-stage stratified random sampling. The data used in our study were collected through the cost accounting method.

II

THE PRODUCTION FUNCTIONS

The postulated production relationship in agriculture is reflected in the algebraic form of the function. "Functions estimated from farm samples ordinarily have been of power form because of the smaller number of degrees of freedom involved in estimating the parameters, and partly because a multiplicative model has seemed logically appropriate."[3] We, therefore, choose the function stated in the following equation :

$$Q = C \quad A^{b_1} \quad L^{b_2} \quad B^{b_3} \quad F^{b_4} \quad I^{b_5}$$

In our analysis, we shall use the log-linear transformation of this production function and state it as :

$$\log Q = \log C + b_1 \log A + b_2 \log L + b_3 \log B + b_4 \log F + b_5 \log I$$

* I am deeply indebted to Professor A. M. Khusro for his constant encouragement, comments and helpful suggestions. I have also benefited from discussions with Dr. Amit Bhaduri, Dr. K. L. Krishna, Dr. C. H. Hanumantha Rao and Dr. D. P. Chaudhari. The errors in this paper, if any, are mine.

The analysis presented in this paper is based on a research study undertaken at the University of Delhi with financial support from the Indian Society of Agricultural Economics. I wish to express my gratitude to the Society for the generous grant of a Fellowship which enabled me to undertake the study.

Numbers in brackets in the footnotes refer to the bibliography given at the end of the paper.

1. Several previous analyses of farm management data have been based on published data in aggregated farm-sizes. Such analyses have often been found to suffer from aggregation bias. Our endeavour here is to go to the original source and use farmwise data of inputs and output obtained from the basic tables to avoid aggregation bias.
2. Source of data : Government of India (1, 2), Basic Tables.
3. Heady and Dillon (3), pp. 97-98.

where

Q = Gross value of output of crops (Rs.)
A = Land (acres)
L = Human labour (adult man-days)
B = Bullock labour (pair-days)
F = Farm manures and fertilizers (Rs.)
I = Irrigation expenditure (Rs.)

We estimate the equation by the method of ordinary least squares for Uttar Pradesh and Punjab farms for each of the two years. The estimated parameters are shown in Table I.

The value of R^2 in all cases turns out to be quite high. The included variables explain between 78 to 83 per cent of the variations in the logarithm of the gross value of crop output.

The coefficients of land and labour are statistically significant at 1 per cent level in all the estimated equations. The coefficient of bullock labour is significant in all the equations except equation 1. The coefficient for manures and fertilizers is statistically significant in equation 2 only. The coefficients of expenditure on irrigation are positive in all cases, but statistically significant only in the equations for the year 1955-56.

In production function analysis based on cross-sectional data, there often exists high correlation between some of the explanatory variables leading to problems of multicollinearity. Simple correlation coefficients between the variables included in our function reflect the presence of this problem (see Appendix Table A-I). There exists high[4] correlation between land and human labour in regression equation 1 and between land and bullock labour in equation 2. It has been suggested that inter-correlation or multicollinearity is not necessarily a problem unless it is high relative to the overall degree of multiple correlation among all variables simultaneously.[5] Since the equations and most of the regression coefficients are well estimated and the coefficient of multiple correlation, R, is high in relation to simple correlation coefficients between explanatory variables, the two estimates of the function can be accepted as efficient ones. Regression equation 4 is found to be free from the influence of high correlation between the explanatory variables. Equation 3, however, needs to be modified as the simple correlation coefficient between human and bullock labour in this case is rather high not only absolutely but also in relation to the coefficient of multiple correlation. Thus, a choice has to be made between the two variables. Keeping in view the relative importance of human labour, we decide to estimate the equation by dropping bullock labour as a variable. The new set of equations, exclusive of bullock labour, is shown in Table II. For the purposes of our analyses, we shall use equation 1, 2, 3a and 4.

4. Correlation coefficient is considered as high if it is $\geq .8$. See Heady and Dillon (3), p. 136.
5. Lawrence R. Klein (5), p. 101.

TABLE I—COEFFICIENTS OF FARM PRODUCTION FUNCTIONS FOR UTTAR PRADESH AND PUNJAB : 1955-56, 1956-57

Equation No.	State	Year	N‡	Constant log C	Regression coefficients A	L	B	F	I	R^2
1.	Uttar Pradesh	1955-56	147	1·2032	·2410*	·6504*	·0155	—·0174	·0789*	·83†
					(·059)	(·072)	(·035)	(·019)	(·021)	
2.		1956-57	196	1·5018	·3340*	·3108*	·2502*	·0521*	·0198	·78†
					(·067)	(·064)	(·067)	(·020)	(·020)	
3.	Punjab	1955-56	200	1·3375	·4468*	·8242*	—·3548*	·0108	·1082*	·82†
					(·053)	(·113)	(·098)	(·015)	(·030)	
4.		1956-57	200	1·4994	·4322*	·4149*	·1093**	·0151	·0390	·79†
					(·055)	(·072)	(·054)	(·013)	(·030)	

Figures in parenthesis indicate the standard errors of the estimates.

‡ Due to non-availability of data from the official records, not all of the sampled farms in Uttar Pradesh could be included for 1955-56.

*Significant at 1 per cent level.

** Significant at 5 per cent level.

† Indicates that in the F-test, the statistic for the respective regression turned out to be significant at 1 per cent level.

TABLE II—COEFFICIENTS OF FARM PRODUCTION FUNCTIONS FOR UTTAR PRADESH AND PUNJAB : 1955-56, 1956-57

Equation No.	State	Year	N	Constant log C	Regression coefficients					R^2
					A	L	B	F	I	
1a	Uttar Pradesh	1955-56	147	1·2035	·2475*	·6601*	—	—·0166	·0778*	·83†
					(·057)	(·068)		(·019)	(·021)	
2a		1956-57	196	1·6459	·4735*	·4082*	—	·0598*	·0156	·76†
					(·057)	(·061)		(·020)	(·021)	
3a	Punjab	1955-56	200	1·3138	·4322*	·4846*	—	·0158	·1306*	·81†
					(·055)	(·063)		(·016)	(·030)	
4a		1956-57	200	1·5524	·4609*	·4871*	—	·0129	·0379	·79†
					(·053)	(·063)		(·013)	(·030)	

Figures in parenthesis indicate the standard errors of the estimates.

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Figures in parenthesis indicate the standard errors of the estimates.

* Significant at 1 per cent level.

† Indicates that in the F-test, the statistic for the respective regression turned out to be significant at 1 per cent level.

Regression coefficients in respect of various input factors indicate that land and human labour were the important inputs to which output was highly responsive in the agriculture of this region.[6] That the elasticity of output with respect to human labour input turned out to be not only positive but also fairly high and statistically significant, is, as we shall presently observe, a matter of some importance in view of the common assumption in economic literature about a very low (or near zero) marginal product of labour in less developed agriculture. A noteworthy feature of agriculture in the mid-'fifties is the negligible contribution of manures and chemical fertilizers, but this is easily explained by the fact that in areas under investigation agriculture in the 1950's was still practised on traditional lines with a near absence of modern inputs like chemical fertilizers.

III

RETURNS TO SCALE

We have estimated the unrestricted form of the Cobb-Douglas production function. The regression coefficients in this function are the production elasticities, and their sum indicates the returns to scale. The returns to scale are increasing, constant or decreasing according as the sum of the regression coefficients is greater than, equal to or less than unity. Table III gives the sums of regression coefficients derived from regression equations 1, 2, 3a and 4.

TABLE III—RETURNS TO SCALE

State	Year	Regression No.	Sum of the regression coefficients	Returns to scale indicated by 't'-test
Uttar Pradesh	1955-56	1	·97	Constant
	1956-57	2	·97	Constant
Punjab	1955-56	3a	1·06	Constant
	1956-57	4	1·01	Constant

The sums of the regression coefficients were tested for their deviation from unity. The t-test indicated constant returns to scale in all the cases. This finding confirms the results of some recent investigations[7] indicating constant returns to scale in Indian agriculture. The emergence of constant returns to scale is also of particular interest in the context of the much-discussed 'inverse relationship between farm-size and productivity'[8] (suggested by Farm Management Studies) which clearly is a matter of relationship between output (output per acre) and only a single input (acreage) without holding other inputs constant. With returns to scale being constant, the 'inverse relationship' can be easily explained away in terms of the operation of the law of variable proportions.

6. In regression equation 3a, it is assumed that the inputs are accompanied by the requisite complement of bullock labour.

7. A. M. Khusro (4); Raj Krishna (9).

8. See for example Amartya K. Sen (16, 17); Morton Paglin (8); Dipak Mazumdar (6, 7); A. M. Khusro (4); C. H. Hanumantha Rao (11, 12); A. P. Rao (10); and Ashok Rudra (14, 15).

IV

MARGINAL VALUE PRODUCTS, FACTOR COSTS AND ECONOMIC EFFICIENCY

The estimated production functions underlying crop production enable us to proceed to an evaluation of the efficiency of prevalent factor proportions in the still traditional agriculture of the region.

A resource or input factor is considered to be used most efficiently if its marginal value product is just sufficient to offset its cost. Equality of marginal value product to factor cost is, therefore, the basic condition that must be satisfied to obtain efficient resource-use. Marginal productivity of x_i, the i-th input is given by the following equation:

$$\frac{\delta \hat{Y}}{\delta X_i} = b_i . \quad \hat{Y}/X_i$$

"The most reliable, and perhaps the most useful, estimate of marginal productivity is obtained by taking X_i at its geometric mean, *i.e.*, at the value where log X_i assumes its arithmetic mean. Also, $\hat{Y}$ should be the estimated level of output when each input is held at its geometric mean."[9] Marginal value products of input factors so obtained from the estimated regression equations are shown in Table V.

Marginal value products of land in Uttar Pradesh and Punjab turn out to be very close to each other in both the years. Marginal value products of human labour (except for Uttar Pradesh in 1955-56) appear to be moving in line with the level of market wage for casual labour in the respective regions. Marginal value products of other inputs are positive in all the cases with the only exception of manures and fertilizers in Uttar Pradesh in 1955-56. The negative figure in this case appears to be due to the excessive rainfall received in the region in 1955-56, with much of the downpour having been received during a short period of 24 to 48 hours.[10]

TABLE IV—GEOMETRIC MEANS OF INPUTS

State	Year	Geometric means				
		A	L	B	F	I
Uttar Pradesh	1955-56	7·98	401·8	98·9	30·41	44·26
	1956-57	7·64	444·6	132·4	41·88	46·24
Punjab	1955-56	13·49	385·6	144·6	23·71	51·05
	1956-57	13·71	362·2	134·6	16·98	69·02

9. Heady and Dillon (3), p. 231.
10. Government of India (1), p. 3.

TABLE V—MARGINAL VALUE PRODUCTS OF INPUT FACTORS AT THE GEOMETRIC MEAN LEVEL

Regression No.	State	Year	Marginal value products of resources				
			A	L	B	F	I
1	Uttar Pradesh ..	1955-56	63·67	2·87	0·23	—1·02	3·17
2		1956-57	81·12	1·29	3·50	2·31	0·80
3a	Punjab	1955-56	63·99	2·51	—	1·33	5·11
4		1956-57	80·77	2·93	2·08	2·28	1·44

In order to evaluate the economic efficiency of farmers as users of resources, we compare the marginal value products of input factors with their respective acquisition costs. Table VI gives the ratios of marginal value products to the respective cost of the input factor.

TABLE VI—RATIOS OF MARGINAL VALUE PRODUCTS TO FACTOR COSTS

Regression No.	State	Year	Ratio of marginal returns to factor cost				
			A	L	B	F	I
1	Uttar Pradesh ..	1955-56	1·03	2·79*	·05*	—1·02†	3·17*
2		1956-57	1·56†	1·25	·80	2·31	0·80
3a	Punjab	1955-56	1·14	1·68*	—	1·33	5·11*
4		1956-67	1·24	1·45†	·35*	2·28	1·44

* Indicates that the ratio is significantly different from unity at the 1 per cent level.
† Indicates that the ratio is significantly different from unity at the 10 per cent level.
N.B. : Sources, data and method of estimation of acquisition costs are given in Appendix Table A-VI.

Irrigation in 1955-56 gave the highest returns per unit of cost. Farmers' response to this economic opportunity is reflected in higher expenditure on irrigation in the following year (see Table IV). The ratio of marginal returns to acquisition cost continued to be greater than unity in Punjab in 1956-57. The rise in the marginal productivity of land in Uttar Pradesh can be explained by a slight reduction in acreage being accompanied by a more intensive application of other inputs. The explanation in Punjab can also be sought in a somewhat better co-ordination of farm resources.

In the first year of our study, the ratio of marginal returns to acquisition costs in respect of human labour was greater than unity in both the States. Farmers in both the States responded rationally to the economic opportunities; Uttar Pradesh farmers by increasing this input and Punjab farmers by decreasing it (see Table IV). The economic rationality of Punjab farmers in reducing labour input in 1956-57 particularly when the marginal value product of labour in the preceding year was much greater than unity, is explained amongst other things, by the rise

in the cost of labour from Rs. 1.49 per day in 1955-56 to Rs. 2.02 in 1956-57. A rational use of labour also appears to have contributed to bringing the marginal value product of labour nearer its cost per day.

It would be quite in order to make some observations on the marginal productivity of labour (actually used) and the wage rate. We have noticed that, on an average, the marginal value product of labour in the two States tends to be higher than the wage rate during the two years under study. This finding is not in line with the widely held belief that the marginal product of labour in Indian agriculture is much lower than the wage rate, if not actually zero. The results here are that the marginal product of labour is not only positive but also corresponds to the market wage rate. Appropriateness of the use of wage rate for valuation of family labour and as a guideline to labour use has often been questioned.[11] Our finding suggests that the market wage rate is, in fact, a real phenomenon and guides the decisions of farmers who appear to be making adjustments in labour use depending upon the ratio between labour productivity and wage rate. Since our analysis is based on the entire sample of farms, the results may tend to iron out some of the differences which may obtain between different strata of farms. We shall, therefore, examine this question again when we analyse resource-use for farms in different size-groups.

Our estimates also indicate the uneconomic nature of bullock power used on the farms. The situation is aggravated by the excess capacity of bullock labour, an input factor characterized by specificity and indivisibility, maintained on the farms. Absence of any reliable estimate of the cost of power from an alternative source makes it difficult to form any opinion about the economic rationality of maintaining bullocks on the farms.

Our analysis shows that farmers are quite rational in terms of their response to economic opportunities and make adjustments in resource-use. This rationality however does not imply that farmers always succeed in operating their farm businesses at economically optimum levels. The unexploited economic margins (indicated by the existence of an excess of marginal value products over factor costs) in the two States suggest that farmers are not always efficient as allocators of resources in exploiting fully the economic opportunities available to them. However, we note that while farmers make *ex-ante* decisions about farming, our evaluation of their efficiency is based on an *ex-post* examination of their decisions. Actually realised results need not reflect fully upon results expected at the time of decision-making.

V

FARM-SIZE, RESOURCE PRODUCTIVITY AND RESOURCE-USE EFFICIENCY

The foregoing analysis was based on the entire sample of farms. Our estimates, though valid on an average, might tend to iron out and thereby conceal some of the differences which may obtain between farms belonging to different strata of the sample. For instance, one can expect the marginal value product of labour, which, on an average, turned out to be higher than the wage rate, to be

11. See, for example, Amartya K. Sen (16, 17).

much below the wage rate on small farms where the bulk of labour is supplied by the farm family itself and where the efforts of the farmers are directed primarily at maximizing the returns per acre rather than at equating the value of the marginal product with an (imputed) wage rate. It has been suggested that in a situation of surplus labour, farmers with abundant family labour may go on applying additional units of family labour till the marginal value product of labour equals its 'real cost' rather than the wage rate.[12] On the other hand, large farms using mostly hired or purchased inputs may present quite a different picture. It, therefore, becomes important to study separately the resource-use for farms of different sizes. For this purpose, we divide the sample of farms into three groups, the first group consists of farms below 7.5 acres, the second of farms between 7.5 acres and 15 acres, and the third of farms with 15 acres or more. We shall call these small, medium and large farms respectively.

Regression coefficients for the three groups of farms estimated from farm level observations are given in Appendix Table A-II. The estimated equations were tested for the equality of the corresponding coefficients through a test of the equality of regression equations.[13] The results of this test are presented in the form of an analysis of variance in Appendix Table A-III. It was found that the coefficients of separate equations in respect of small, medium and large farms were not statistically different from the corresponding coefficients of regression equations presented earlier.[14] In our analysis, we shall, therefore, use the coefficients of pooled regressions only. Marginal value products of input factors in respect of small, medium and large farms, thus obtained, are given in Table VII along with their ratios to the factor costs.

The marginal value product of land is highest on small farms and tends to decrease with an increase in the farm-size. Land, thus, appears to be utilized more intensively on smaller farms. Over the year, the marginal value productivity of land has gone up generally. Higher ratios of marginal value productivity of land to its rent (and relatively greater divergence of this ratio from unity) in 1956-57 could be due to the reluctance of farmers to change rents in response to short period rise in economic productivity of land which may not be sustained over a longer period. The fact that the bulk of land resources on selected farms are owned by the farm families themselves, may also contribute to the explanation of this phenomenon.

The ratios of marginal value product of labour to wage rate in the two years indicate that farmers made adjustments and moved in the direction of optimum use of this resource. It is noteworthy that the marginal value product of labour is invariably higher[15] than the wage rate. This supports our earlier observations about the relevance of the market wage rate which now also emerges as a real economic factor even in cases where the bulk of labour comes from the farm family itself. Accordingly, the valuation of family labour at the ruling wage rate seems to be quite justified. It is possible that in the region under study, the

12. For detailed discussion and definition of 'real cost' of labour, see Amartya K. Sen (17).

13. C. R. Rao (13), pp. 112-114.

14. An exception was, however, noted in the case of Punjab farms in 1956-57. The Punjab farms also fell in line with the other sets when significance was tested at 1 per cent level.

15. We do not entirely rule out the possibility of some under-estimation or over-estimation of marginal productivity of input factors at levels other than the geometric mean level for the entire sample of farms.

"real opportunity cost" of family labour may indeed be somewhat higher than the market wage rate, the wage rate serving only as its lower limit.

TABLE VII—RATIOS OF MARGINAL VALUE PRODUCTS OF INPUT FACTORS TO THE FACTOR COSTS FOR SMALL, MEDIUM AND LARGE FARMS AT THE GEOMETRIC MEAN LEVEL OF INPUTS

State	Year	N	Category	Marginal value products				
				A	L	B	F	I
Uttar Pradesh								
	1955-56	60	S	1·24 (64·42)	2·73* (2·81)	·05* (0·27)	—1·18† (1·18)	2·86** (2·86)
		55	M	·97 (50·64)	2·78** (2·87)	·05** (0·28)	—·88** (—0·88)	3·46* (3·46)
		32	L	·81 (42·11)	2·92* (3·01)	·05* (0·29)	—1·00† (—1·00)	3·31* (3·31)
	1956-57	89	S	1·78** (92·31)	1·16 (1·20)	·81 (3·55)	2·20 (2·20)	·75 (0·75)
		71	M	1·46 (75·90)	1·32 (1·36)	·77 (3·38)	2·78† (2.78)	·82 (0·82)
		36	L	1·29 (67·14)	1·40 (1·44)	·84 (3·68)	1·84 (1·84)	·89 (0·89)
Punjab								
	1955-56	42	S	1·23 (68·83)	1·46** (2·18)	—	2·04 (2·04)	4·29* (4·29)
		69	M	1·18 (66·08)	1·59* (2·36)	—	1·51 (1·51)	5·15* (5·15)
		89	L	1·10 (60·29)	1·89* (2·82)	—	·99 (0·99)	5·52* (5·52)
	1956-57	43	S	1·46** (94·88)	1·25 (2·53)	·15* (0·90)	2·44 (2·44)	1·42 (1·42)
		61	M	1·28† (83·44)	1·40† (2·83)	·16* (0·96)	3·57 (3·57)	1·47 (1·47)
		96	L	1·13 (73·63)	1·59** (3·22)	·20* (1·17)	1·68 (1·68)	1·44 (1·44)

Figures in parenthesis show the marginal value products of input factors.
S = Small farms.
M = Medium-sized farms.
L = Large farms.
* Significantly different from unity at 1 per cent level.
** Significantly different from unity at 5 per cent level.
† Significantly different from unity at 10 per cent level.

The ratios of marginal value products of input factors to the factor costs given in Table VII broadly confirm our earlier observation that farmers tend to make adjustments and move towards the optimum. The divergence of the ratios from unity, however, persists, to show that there appears to be little indication of the farmers operating their business at the optimum level. Nevertheless, the existence in Indian agriculture during the 1950's of trend increases in farm output as well as in wage rates (perhaps the former rising, at any rate in Punjab, at a faster pace than the latter) may partly explain the disparity.

VI

DEPENDENCE ON FAMILY LABOUR, RESOURCE PRODUCTIVITY AND RESOURCE-USE EFFICIENCY

Our analysis in the preceding section was based on a classification of farms according to their size. Since farms differ from each other in the extent of their dependence on family or hired labour, it would also be of interest to approach the problem of resource-use efficiency and factor productivity (particularly that of human labour) from the point of view of the extent of dependence of farms on family

TABLE VIII—RATIOS OF MARGINAL VALUE PRODUCTS OF INPUT FACTORS (AT THE GEOMETRIC MEAN LEVEL OF INPUTS) TO THE FACTOR COSTS, FOR FARMS CLASSIFIED ACCORDING TO DEPENDENCE ON HIRED LABOUR

State	Year	N	Farm class	Marginal value products				
				A	L	B	F	I
Uttar Pradesh								
	1955-56	89	I	1·11 (57·83)	2·71* (2·79)	·05* (0·28)	— ·92† (—0·92)	3·39* (3·39)
		31	II	·96 (50·05)	2·85* (2·94)	·05* (0·25)	—1·16† (—1·16)	3·11** (3·11)
		27	III	·87 (45·46)	2·99* (3·08)	·05* (0·30)	—1·23† (—1·23)	2·60** (2·60)
	1956-57	138	I	1·64† (85·11)	1·23 (1·26)	·79 (3·46)	2·31 (2·31)	·76 (0·76)
		40	II	1·45 (75·23)	1·30 (1·34)	·86 (3·73)	1·86 (1·86)	·84 (0·84)
		18	III	1·27 (66·23)	1·44 (1·48)	·78 (3·40)	3·81† (3·81)	1·02 (1·02)
Punjab								
	1955-56	116	I	1·15 (64·34)	1·60* (2·39)	—	1·72 (1·72)	5·16* (5·16)
		54	II	1·12 (62·84)	1·77* (2·64)	—	·76 (0·76)	5·48* (5·48)
		30	III	1·16 (64·75)	1·88* (2·80)	—	1·37 (1·37)	4·36* (4·36)
	1956-57	130	I	1·28† (83·29)	1·41† (2·85)	·17 (0·99)	2·55 (2·55)	1·46 (1·46)
		43	II	1·22 (79·30)	1·46† (2·94)	·18* (1·07)	2·20 (2·20)	1·69 (1·69)
		27	III	1·10 (71·78)	1·66** (3·36)	·21* (1·25)	1·46 (1·46)	1·09 (1·09)

Figures in parenthesis show the marginal value products of input factors.
I = Farms hiring less than 25 per cent of the total labour used on the farm.
II = Farms hiring 25 to 50 per cent of the total labour used on the farm.
III = Farms hiring 50 per cent or more of the total labour used on the farm.
* Significantly different from unity at 1 per cent level.
** Significantly different from unity at 5 per cent level.
† Significantly different from unity at 10 per cent level.

or hired labour. For this purpose, we divide the sampled farms into three groups. Group I includes all farms which depend primarily on family labour and where the dependence on hired labour does not exceed 25 per cent of the total labour used during the year. Group II includes farms where 25 to 50 per cent of labour used for farm operations is hired one. The last group of farms hires 50 per cent or more of the total labour used on the farm. Coefficients of regression equations in respect of the three classes of farms are given in Appendix Table A-IV. The estimated equations were tested for the equality of the corresponding coefficients in the three equations. As in the previous case, the results of the test of equality of regression equations are presented in the form of an analysis of variance in Appendix Table A-V. Coefficients in the three regression equations were not found to be significantly different from those in the pooled equations. We, therefore, proceed to estimate the marginal value products of input factors for the three classes of farms at the geometric mean level of their inputs on the basis of pooled regression equations. The estimated marginal value products along with their ratios to the factor costs are given in Table VIII.

Statistics given in Table VIII show that the pattern and magnitude of marginal value products remain almost the same as was obtained for the three size-groups of farm (see Table VIII). It is noteworthy that the marginal value product of human labour continues to be greater than the wage rate for all classes of farms. This strongly suggests that the farmers do expect a return to their labour which is not only equal to what a hired hand would earn but is actually somewhat above it.

The ratios of marginal returns to factor costs given in Table VIII lend support to our earlier observations about the economic rationality of farmers in so far as they try to make adjustments and move towards the economic optima. Farmers in the region are generally seen to be responsive to economic stimulus, though possibilities of increasing farm incomes through adjustment in resource-use still seem to exist.

APPENDIX

TABLE A-I

SIMPLE CORRELATION COEFFICIENTS BETWEEN SELECTED VARIABLES

State	Year		A	L	B	F	I	Q
Uttar Pradesh	1955-56	A	1·000	·818	·663	·423	·405	·822
		L		1·000	·693	·551	·421	·886
		B			1·000	·407	·258	·644
		F				1·000	·523	·498
		I					1·000	·502
		Q						1·000
Uttar Pradesh	1956-57	A	1·000	·766	·826	·405	·389	·814
		L		1·000	·796	·521	·414	·815
		B			1·000	·459	·352	·815
		F				1·000	·369	·521
		I					1·000	·412
		Q						1·000
Punjab	1955-56	A	1·000	·775	·724	·531	·558	·833
		L		1·000	·927	·565	·597	·844
		B			1·000	·504	·496	·735
		F				1·000	·308	·535
		I					1·000	·650
		Q						1·000
Punjab	1956-57	A	1·000	·765	·690	·454	·588	·832
		L		1·000	·764	·527	·607	·831
		B			1·000	·372	·485	·724
		F				1·000	·362	·490
		I					1·000	·596
		Q						1·000

TABLE A-II

COEFFICIENTS OF FARM PRODUCTION FUNCTIONS FOR DIFFERENT GROUPS OF FARMS ACCORDING TO SIZE

State/Year	Farm category	N	Constant log C	Regression coefficients					R^2
				A	L	B	F	I	
Uttar Pradesh									
1955-56	S	60	1.1769	.1263 (.092)	.6499* (.084)	.0864 (.066)	—.0037 (.021)	.0565† (.032)	.87
	M	55	1.4472	.1865 (.310)	.5585* (.163)	.0130 (.067)	—.0206 (.041)	.1012** (.046)	.40
	L	32	.6262	.9098* (.248)	.5969* (.222)	—.0472 (.065)	—.0118 (.051)	.0735 (.045)	.66
1956-57	S	89	1.5376	.1125 (.124)	.3425* (.102)	.2688* (.093)	.0344 (.033)	.0188 (.038)	.68
	M	71	1.2096	—.0568 (.283)	.4021* (.144)	.4565* (.164)	.0430 (.029)	.0083 (.034)	.40
	L	36	1.6143	.6502* (·226)	.2222** (.100)	.1531 (.132)	.0261 (.059)	.0557† (.032)	.60
Punjab									
1955-56	S	42	1.6500	.3798 (.245)	.6579* (.220)	—.2925 (.209)	.0534 (.039)	.0568 (.107)	.45
	M	69	1.6539	(.4617** (.212)	.9793* (.216)	—.5860* (.210)	—.0044 (.027)	.0856 (.058)	.42
	L	89	1.1828	(·4657* (.094)	.8317* (.181)	—.3198** (.149)	.0067 (.021)	.1161* (.037)	.76
1956-57	S	43	1.9800	.8048* (.225)	.1039 (.221)	.1666 (.234)	—.0371 (.035)	—.0343 (.080)	.49
	M	61	.7038	.7070* (.209)	.5109* (.142)	.1851 (.158)	.0029 (.020)	.1013* (.037)	.70
	L	96	1.4791	.4232* (.110)	.4549* (.095)	.0894 (.059)	.0394** (.019)	.0036 (.048)	.67

Figures in parenthesis are the standard errors of the estimates.

S = Small farms
M = Medium-sized farms.
L = Large-sized farms.

* Significant at 1 per cent level.
** Significant at 5 per cent level.
† Significant at 10 per cent level.

TABLE A-III

ANALYSIS OF VARIANCE TESTS OF THE EQUALITY OF SIZE CLASS REGRESSIONS

	Source	D.F.	S.S.	M.S.	F-value
I.	Uttar Pradesh : 1955-56				
	Deviation from HO	12	·3186	·026556	1·3571
	Residual (H)	129	2·5242	·019568	
	Residual (HO)	141	2·8429		
II.	Uttar Pradesh : 1956-57				
	Deviation from HO	12	·4655	·038973	1·4144
	Residual (H)	178	4·8819	·027426	
	Residual (HO)	190	5·3474		
III.	Punjab : 1955-56				
	Deviation from HO	12	·1558	·012985	·6953
	Residual (H)	182	3·3986	·018674	
	Residual (HO)	194	3·5545		
IV.	Punjab : 1956-57				
	Deviation from HO	12	·4825	·040209	2·0985**
	Residual (H)	182	3·4872	·019160	
	Residual (HO)	194	3·9697		

** Significant at 5 per cent level, but not significant at 1 per cent level.

TABLE A-IV

COEFFICIENTS OF FARM PRODUCTION FUNCTIONS FOR DIFFERENT CLASSES OF FARM ACCORDING TO EMPLOYMENT OF HIRED LABOUR

State/Year	Farm class	N	Constant log C	Regression coefficients					R^2
				A	L	B	F	I	
Uttar Pradesh									
1955-56	I	89	1.1255	.1504**	.6875*	.0491	.0102	.0450	.83
				(.071)	(.089)	(.043)	(.028)	(.031)	
	II	31	1.7879	.4505**	.1992	.2081	—.0581	.0932**	.76
				(.184)	(.440)	(.310)	(.055)	(.045)	
	III	27	1.4569	.4589*	.5606*	—.0786	.0732	.0336	.90
				(.170)	(.172)	(.061)	(.040)	(.045)	
1956-57	I	138	1.5241	.3298*	.2984*	.2665*	.0473**	.0160	.75
				(.081)	(.073)	(.083)	(.022)	(.027)	
	II	40	1.7994	.5716*	.2799**	—.0025	.0883	.0369	.85
				(.147)	(.146)	(.120)	(.052)	(.035)	
	III	18	—.1920	—.2985	.6762**	.9710*	—.1129	.0193	.89
				(.379)	(.339)	(.285)	(.088)	(.056)	
Punjab									
1955-56	I	116	1.3013	.4307*	.8566*	—.3709*	—.0014	.1154*	.74
				(.082)	(.152)	(.142)	(.022)	(.043)	
	II	54	1.5049	.3933*	.6330*	—.2154	.0566	.1019**	.78
				(.089)	(.242)	(.191)	(.032)	(.053)	
	III	30	1.6027	.4983*	.6046**	—.1861	—.0010	.0519	.87
				(.134)	(.262)	(.232)	(.032)	(.073)	
1956-57	I	130	1.3482	.3572*	.5172*	.0862	.0034	.0566	.74
				(.069)	(.090)	(.071)	(.016)	(.036)	
	II	43	2.0308	.5006*	.1222	.1526	.0643**	.0435	.83
				(.116)	(.158)	(.103)	(.030)	(.058)	
	III	27	2.0520	.5831*	.2414	.2099	.0293	—.2151	.73
				(.220)	(.218)	(.150)	(.038)	(.158)	

Figures in parenthesis indicate the standard errors of the estimates.
I = Farms hiring less than 25 per cent of the total labour used on the farm.
II = Farms hiring between 25 to 50 per cent of the total labour used on the farm.
III = Farms hiring 50 per cent or more of the total labour used on the farm.
* Significant at 1 per cent level.
** Significant at 5 per cent level.

TABLE A-V

ANALYSIS OF VARIANCE TEST OF THE EQUALITY OF REGRESSIONS

	Source	D.F.	S.S.	M.S.	F-value
I.	Uttar Pradesh : 1955-56				
	Deviation from HO	12	·3528	·029403	1·5232
	Residual (H)	129	2·4901	·019303	
	Residual (HO)	141	2·8429		
II.	Uttar Pradesh : 1956-57				
	Deviation from HO	12	·4881	·040681	1·4901
	Residual (H)	178	4·8593	·027299	
	Residual (HO)	190	5·3474		
III.	Punjab : 1955-56				
	Deviation from HO	12	·1454	·012121	·6471
	Residual (H)	182	3·4090	·018731	
	Residual (HO)	194	3·5545		
IV	Punjab : 1956-57				
	Deviation from HO	12	·2950	·024586	1·2177
	Residual (H)	182	3·6746	·020190	
	Residual (HO)	194	3·9697		

TABLE A-VI

ACQUISITION COST OF INPUT FACTORS

State	Year	Land (Rs./acre)	Human labour (Rs./man-day)	Bullock labour (Rs./bullock pair-day)
Uttar Pradesh	1955-56	52·0	1·03	5·58
	1956-57	52·0	1·03	4·36
Punjab	1955-56	56·0	1·49	4·46
	1956-57	65·19	2·02	5·92

Sources of cost data :

Land : Rent of land per acre for Uttar Pradesh has been obtained by charging interest on the average price of land at 6 per cent. The rate of interest is the same as used in the "Studies in the Economics of Farm Management in Uttar Pradesh." Figures for Punjab have been taken from Raj Krishna (9), p. 91.

Human labour and bullock labour : Average cost of labour has been obtained by dividing the total wage bill (cost) by the number of days worked.

N.B. : No interest has been charged on expenditure on fertilizers and irrigation as payment for these items are generally made at the end of the crop season and is taken to be inclusive of interest charges, if any.

REFERENCES

(1) Government of India : Studies in the Economics of Farm Management in Uttar Pradesh, Combined Report 1954-55 to 1956-57, New Delhi, 1963.

(2) Government of India : Studies in the Economics of Farm Management in the Punjab, Combined Report 1954-55 to 1956-57, New Delhi, 1963.

(3) E. O. Heady and J.L. Dillon: Agricultural Production Functions, Ames, Iowa, U.S.A., 1964.

(4) A. M. Khusro, "Returns to Scale in Indian Agriculture," *Indian Journal of Agricultural Economics*, Vol. XIX, Nos. 3 & 4, July-December, 1964.

(5) Lawrence R. Klein : An Introduction to Econometrics, Prentice-Hall, New Delhi, 1965.

(6) Dipak Mazumdar, "On the Economics of Relative Efficiency of Small Farmers," *The Economic Weekly*, Special Number, July, 1963.

(7) Dipak Mazumdar, "Size of Farm and Productivity: A Problem of Indian Peasant Agriculture," *Economica*, New Series, Vol. XXXII, No. 126, May, 1965.

(8) Morton Paglin, "Surplus Agricultural Labour and Development : Facts and Figures," *American Economic Review*, Vol. LV, No. 4, September, 1965.

(9) Raj Krishna, "Some Production Functions for the Punjab," *Indian Journal of Agricultural Economics*, Vol. XIX, Nos. 3 & 4, July-December, 1964.

(10) A. P. Rao, "Size of Holding and Productivity," *Economic and Political Weekly*, November 11, 1967.

(11) C. H. Hanumantha Rao, "Farm Size and the Economies of Scale," *The Economic Weekly*, December 14, 1963.

(12) C. H. Hanumantha Rao, "Alternative Explanations of the Inverse Relationship between Farm Size and Output per Acre in India," *Indian Economic Review*, Vol. 1 (New Series), No. 2, October, 1966.

(13) C. R. Rao : Advanced Statistical Methods in Biometric Research, John Wiley, New York, U.S.A., 1952.

(14) Ashok Rudra, "Farm Size and Yield per acre," *Economic and Political Weekly*, Special Number, July, 1968.

(15) Ashok Rudra, "More on Returns to Scale in Indian Agriculture," *The Economic and Political Weekly*, October, 1968.

(16) Amartya K. Sen, "An Aspect of Indian Agriculture," *The Economic Weekly*, Annual Number, February, 1962.

(17) Amartya K. Sen, "Peasants and Dualism with or without Surplus Labour," *Journal of Political Economy*, Vol. LXXIV, No. 5, October, 1966.