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ECONOMICS OF RESOURCE USE ON SAMPLE FARMS OF CENTRAL GUJARAT

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Economics of Resource Use on Sample Farms of Central Gujarat

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I.

Objectives

This paper considers whether or not the returns on the resource use for a sample farms located in two distinct parts of central Gujarat, given their respective production functions, are maximized and if not, why not.

Two different methodologies for studying this question are based on linear programming and production functions. We have selected the latter. The second objective is therefore to analyze the economic and statistical implications of selection of (a) functional forms, and (b) variables for estimating production functions for a cross-section of farms.

II.

Sample Design and Sample Characteristics

Sample Design: The paper is based on the data collected by the Indian Institute of Management, Ahmedabad for its study on "Potentialities of Mobilizing Investible Funds in Developing Agriculture". For this study, Baroda district was selected because of its high level of agricultural development (2).

For selecting talukas, Baroda district was classified into four agricultural zones on the basis of proportion of area under different crops to the total cropped area in 1967/68. From each zone, a taluka was selected at random. The selected talukas were Sinor, Waghodia,

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Baroda and Chhota Udepur. Baroda and Sinor talukas are considered as belonging to more developed region (MDR), whereas Waghodia and Chhota Udepur are considered as belonging to less developed region (LDR). The justification for this is explained in the section on sample characteristics.

From each taluka, two villages, representing "rapid changing" agriculture and "slow changing" agriculture, were selected at random. The villages were classified into these two categories according to their irrigated area and fertilizer use.

The farmers in each selected village were classified into three groups, having equal land, after arranging them in ascending order of farm size (in acres). From each group, four farmers were selected at random. This design for farmer selection was adopted because it gave better representation of big farmers who may have larger investible funds (3). The data pertained to the agricultural year, July, 1968 - June, 1969.

Sample Characteristics: Implicit in the question under study is the assumption that the production functions of the sample farms of the two regions are different. This assumption can be justified mainly by the differences in irrigation resource, a crucial determinant of farm-level production decisions, in the two regions. There are three differences: (i) MDR farms have more rainfall than LDR farms, (ii) this rainfall is also more evenly distributed over the monsoon season in MDR than in LDR, and (iii) even the artificial source of irrigation viz., underground wells in MDR is more reliable than in LDR. This is because in MDR the water table being high the recharge of water in wells is better. In LDR, the water table is not only low but the digging of wells is hampered by rocky soil and uneven topography. The differences in production functions of sample farms of the two regions will also be tested statistically.

Finally, an examination of such characteristics as extent of uncultivable land, soil types, rainfall, extent of irrigated land, nature of sources of irrigation, and the existence of infrastructure facilities in the selected talukas, villages and farms also confirmed that Baroda and Sinor are more developed than Waghodia and Chhota Udepur (2,3). Data on some of these characteristics are given in Appendicies 1 and 2.

III.

Model Specification

Two important aspects of model specification for analyzing cross-sectional production functions are the selection of (a) a functional form and (b) relevant variables. The statistical test viz., F for testing the differences in slope and intercept coefficients of two (production) functions assumes of course, that the specified model is correct.

(a) Selection of a Functional Form:

Because of the nature of the problem under study three functional forms were selected.[1]

These are: 1. Transcendental -- TRAN

$$Y = \alpha X^{\beta} e^{\delta X}$$

or

$$\ln Y = \ln\alpha + \beta \ln X + \delta X$$

2. Log - log - inverse -- LLI

$$Y = \varepsilon e^{\theta / X} X^{\lambda}$$

or

$$\ln Y = \ln\varepsilon + \theta \frac{1}{X} + \lambda \ln X$$

3. Cobb-Douglas - - C-D

$$Y = \pi X^{\sigma}$$

or

$$\ln Y = \ln\pi + \sigma \ln X$$

The important properties of these three functions from the viewpoint of production theory are briefly discussed below.

From the viewpoint of production theory one may select transcendental or log-log-inverse function. This is because both these functions incorporate all the three stages of neoclassical function (5). However, theory also says that the (economic) optimum decisions lie only in the second

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1 An estimate of the quadratic function was also attempted. However, this function could not be estimated because the matrix of independent variables could not be inverted. This implies a serious problem of multicollinearity for the data under study, and very high values of simple correlations between pairs of variables including quadratic terms suggest multicollinearity could be serious. Johnston suggests a more reliable guide to detect multicollinearity. For this, each independent variable in the model is regressed on the remaining independent variables, and then the F statistic is computed for the multiple determination of each regressor (R^2i). That regressor whose R^2 has the highest F statistic is considered as causing the maximum problem of multicollinearity (7). We did not follow this method.

stage of production function. This is, of course, true only under perfect competition. Of the various assumptions of perfect competition, the assumption that is most unlikely to hold in our data is that of certainty regarding output expectations. This is particularly the case in LDR sample. One may, therefore, like to impose certain restrictions in estimating the TRAN and LLI, provided one has a prior sound knowledge needed to develop the restrictions. We have, however, not imposed any restrictions on the estimation of this functional form.

The Cobb-Douglas function provides a direct test on the existence of rational production behavior. This is because it accounts for only the so-called second stage of neoclassical production function. Furthermore, the C-D function completely disregards the existence of the third stage of production which is characterized by zero and negative marginal productivity. Disregarding zero and negative marginal productivity implies that as input use increases production increases though at a decreasing rate ad infinitum! (6,8). Thus, the use of the three functional forms mentioned above implies examining two basic hypotheses. These are (1) that the marginal productivity of resources are increasing, decreasing and negative (TRAN and LLI) or it is just decreasing (C-D); and (2) that the production elasticities are constant (C-D) or varying (TRAN and LLI). Therefore, C-D function can be considered as a special case of both TRAN and LLI. This can also be seen from the fact that if δ in TRAN and θ in LLI are both zero, then both these functions result into C-D function.

(b) Selection of Variables:

In our context, the discussion of this aspect of the model specification involves raising questions (4) like:

(i) Are the variables selected relevant?

(ii) Have we selected all the relevant variables?

(iii) What is the degree of multicollinearity among the variables?

(iv) What is the degree of aggregation?

These questions must be raised because of their bearing on both economic and statistical analysis. Thus, omission of a relevant variable would bias the estimate of the regression coefficients associated with the variables included in the model. Against this, although the inclusion of an irrelevant variable does not bias the estimate of regression coefficients, it is unsatisfactory for two reasons. One, it does not satisfy a criterion of logic behind selecting a variable. Two, it reduces the degrees of freedom and also increases the possibility of multicollinearity besides possibly inducing autocorrelated residuals. A high degree of multicollinearity leads to imprecise estimates of the parameters. After considering these implications, we selected the following variables:

$$Y = f(H, A, F, I, L, N, M)$$

Y is defined as the gross value of production of all crops grown on a farm. The physical production of each crop is evaluated at its prevailing farm harvest price.

The use of Y as the dependent variable in estimation of cross-sectional production functions implicitly assumes that the crop composition of total production is the same for various farms. This assumption may not be tenable particularly if some farm sizes tend to grow more high-valued crops than others. In such a condition, a crop composition effect may be confused as a size effect in production (1). To overcome this problem we include the variable H.

H is defined as the ratio of acreage under high-value crops to total crops acreage. In MDR, such crops are cotton and tobacco whereas in LDR, such a crop is cotton.

A is defined to include net sown area. This variable instead of operational holding, which includes net sown area and fallow land, is selected because the effective farm size is the area used for production.

F includes expenditure on fertilizers and organic manures including farm yard manure and oil cakes. This implies an assumption that the average prices for fertilizers and manures are similar for all the farms. Such an assumption is tenable for cross-sectional data of farms in a district. Further, under the prevailing government controlled distribution arrangements for fertilizers the prices of fertilizers in a district are uniform.

I is defined as expenditure on irrigation water purchased or supplied from a farmer's own source of irrigation. To impute the expenditure on irrigation from owned source of irrigation the items of diesel oil/electricity units consumed, and repairs and maintenance charges are considered.

Although irrigation and fertilizers are likely to have a high degree of correlation, both variables are considered because of their obvious importance in increasing production. The importance of irrigation in Indian agriculture arises because it reduces production uncertainty and also augments effective supply of land by facilitating multiple cropping and other improved methods and inputs (including new seeds) of production.

L includes expenditure on hired human labor. Since data to impute the value of family labor are not available this variable is used as a separate variable called N. It is defined as the number of family members working on own farm.

There are three unsatisfactory points about L and N. One, neither for L nor for N are quality differences taken into account. This is because of nonavailability of data to define such a variable. Griliches has shown how omission of (such) variable also causes a bias in the analysis (4). This is likely to be more true in the case of MDR sample which uses relatively more capital-intensive techniques than the LDR sample. Two, N includes both the managerial and nonmanagerial labor. Third, N is a stock instead of a flow variable. Nevertheless, inclusion of an unsatisfactorily defined variable, i.e. N, is better than to exclude altogether a relevant variable.

M is defined as expenditure on other inputs. These inputs are seeds, insecticides and pesticides, bullock labor, repairs and maintenance of implements, land revenue, rent on leased land and interest on borrowed working capital for production. Aggregation over inputs implies causing a bias in the estimate. However, two reasons guided us to aggregate these inputs and consider them as only one variable in the model. These are: one, each of these items individually may have a small association with production, and two, inclusion of all these items as separate variables would greatly reduce degrees of freedom.

Furthermore, Griliches says, "if the underlying production function is of the form of the Cobb-Douglas function, we should, in order to minimize bias, use geometric sums (i.e. products) rather than arithmetic sums in aggregating our inputs. This is not strictly true. Using arithmetic aggregates could induce a bias in the opposite direction of the 'aggregation' bias and hence reduce the total bias. However, there is no reason to expect it to do so," (4, p.17). We have, therefore, used arithmetic instead of geometric sums in our estimation.

Finally, the definition of expenditure on bullock labor excludes the expenses on home produced feed and depreciation of bullocks. Similarly, the definition of interest on working capital also excludes interest on owned funds used to finance purchase of current inputs. Such an inconsistent definition of these items is used because of difficulties of obtaining satisfactory data. However, we must recognize the statistical bias that may be caused due to the omission of other relevant items for these two inputs.

IV.

Selection from Estimated Models

Using ordinary least squares, C-D, LLI, and TRAN were estimated separately for MDR and LDR and also for MDR and LDR pooled. The estimated models are given in Table 1. The table shows that the C-D model appears to be the best fit for both the MDR and LDR. This is because most of the θ's in TRAN and δ's in LLI are statistically insignificant. These results can be interpreted to mean that the

Table 1. Estimates of Production Functions

(1) Cobb-Douglas Function

Regions	MDR (i)	MDR (ii)	LDR	MDR & LDR Pooled
$\ln\hat{\beta}_0$	4.945* (.336)	4.943* (.324)	3.5[illegible]* (.335)	4.231* (.241)
$\hat{\beta}_1 \ln H$	-.001 (.052)		.045** (.020)	.053* (.020)
$\hat{\beta}_2 \ln A$	.282* (.071)	.282* (.070)	.093 (.080)	.209* (.052)
$\hat{\beta}_3 \ln F$	.178* (.060)	.178* (.059)	.466* (.051)	.348* (.037)
$\hat{\beta}_4 \ln I$	.084* (.024)	.084* (.024)	.023*** (.017)	.058* (.014)
$\hat{\beta}_5 \ln L$	.165* (.060)	.164* (.047)	.050** (.025)	.042** (.025)
$\hat{\beta}_6 \ln N$	.066 (.113)	.066 (.110)	.208* (.084)	.046 (.065)
$\hat{\beta}_7 \ln M$	.092 (.102)	.093 (.081)	.241* (.082)	.201* (.062)
degrees of freedom	40	41	40	88
SSE	3.8555	3.8555	2.8575	8.8490
R^2	.941	.941	.953	.938

Figures in parentheses are standard errors.

* Significant at 1%

** Significant at 5%

*** Significant at 10%

Table 1. Estimates of Production Functions

(2) Log-log-inverse Function

Regions	MDR	LDR	MDR & LDR Pooled
$\hat{\delta}_0$	3.386** (1.421)	5.323* (.763)	3.953* (.620)
$\hat{\alpha}_1 \ln H$	.010 (.123)	.019 (.050)	.038 (.039)
$\hat{\alpha}_2 \ln A$	.262** (.111)	.046 (.181)	.244* (.086)
$\hat{\alpha}_3 \ln F$	.333* (.097)	.508* (.080)	.364* (.059)
$\hat{\alpha}_4 \ln I$	.052 (.060)	-.050 (.076)	.057 (.042)
$\hat{\alpha}_5 \ln L$	.272* (.074)	-.009 (.059)	.164* (.048)
$\hat{\alpha}_6 \ln N$	.586 (.777)	.066 (.327)	.407 (.315)
$\hat{\alpha}_7 \ln M$	-.012 (.015)	.029 (.017)	-.001 (.011)
$\hat{\delta}_1 \frac{1}{H}$	.002 (.004)	-.0001 (.0002)	-.0001 (.0002)
$\hat{\delta}_2 \frac{1}{A}$	.056 (.286)	-.158 (.609)	-.025 (.259)
$\hat{\delta}_3 \frac{1}{F}$	1.332 (1.218)	-.125 (.982)	.497 (.688)
$\hat{\delta}_4 \frac{1}{I}$	-.211 (.421)	-.368 (.386)	.016 (.240)
$\hat{\delta}_5 \frac{1}{L}$	.168 (.837)	-.295 (.355)	.694* (.267)
$\hat{\delta}_6 \frac{1}{N}$	.795 (1.226)	-.155 (.627)	.561 (.544)
$\hat{\delta}_7 \frac{1}{M}$	6.425 (15.362)	-30.471 (20.740)	-4.459 (4.8752)
degrees of freedom	33	33	81
SSE	3.0635	2.4381	8.6768
R^2	.953	.957	.939

See notes on page 7.

Table 1. Estimates of Production Function

(3) Transcendental Function

Regions	MDR	LDR	MDR & LDR Pooled
$\ln\hat{\alpha}_0$	5.779* (.791)	2.906* (.557)	3.908* (.455)
$\hat{\alpha}_1 \ln H$	.011 (.093)	.007 (.035)	.035 (.313)
$\hat{\alpha}_2 \ln A$	.322* (.126)	.186 (.141)	.241 (.085)
$\hat{\alpha}_3 \ln F$	.123*** (.065)	.421* (.075)	.285* (.046)
$\hat{\alpha}_4 \ln I$	.065** (.028)	.034 (.026)	.042* (.015)
$\hat{\alpha}_5 \ln L$	.161** (.076)	.033 (.034)	.017 (.027)
$\hat{\alpha}_6 \ln N$	.154 (.559)	.402 (.302)	-.092 (.218)
$\hat{\alpha}_7 \ln M$	-.009 (.161)	.339** (.161)	.294* (.100)
$\hat{\theta}_1$ H	-.081 (.412)	.445 (.358)	.282 (.235)
$\hat{\theta}_2$ A	-.009 (.014)	-.006 (.014)	-.007 (.008)
$\hat{\theta}_3$ F	.0001 (.00009)	.101 (.001)	.0001** (.0001)
$\hat{\theta}_4$ I	.00002 (.00005)	-.0003 (.0004)	.00002 (.00004)
$\hat{\theta}_5$ L	.00003 (.00009)	.0001 (.0001)	.0001 (.0001)
$\hat{\theta}_6$ N	-.040 (.299)	-.067 (.112)	.074 (.097)
$\hat{\theta}_7$ M	.0002 (.0002)	-.0001 (.0003)	-.0001 (.0001)
degrees of freedom	33	33	81
SSE	2.6174	2.5107	7.5902
R^2	.960	.959	.947

See notes on page 7.

relatively simple Cobb-Douglas specification is to be preferred to the LLI or TRAN functional forms.

It is also true, however, that the "statistical insignificance" associated with the estimated LLI and TRAN production functions may be due to high multicollinearity. The large values of simple correlations between the observed and transformed values of variables under study in both these functions suggest that multicollinearity could be serious.2/ For the MDR sample, the simple correlations between the transformed and own values of different variables in the TRAN model ranged from .726 to .978, whereas those in the LLI varied between -.726 to -.988. The corresponding values for the LDR sample were, respectively, .660 to .959 and -.719 to -.969.

The Cobb-Douglas fit which is a special case of both TRAN and LLI shows that most variables are significant in explaining the variations in gross output in both regions. There are, however, two unsatisfactory points about C-D fit. First, in the case of MDR sample alone, the sign of β_1 i.e. the coefficient associated with H -- the ratio of high-value crops acreage to total cropped area, is negative. Second, for the MDR sample two coefficients viz., β_6 and β_7 associated, respectively, with family labor (N) and other inputs (M) are insignificant. Similarly for the LDR sample the coefficient β_2, of net sown area (A) turned out insignificant. Both these points are examined below.

Since the variable H has the smallest partial r^2 (.00001), the C-D model for MDR was reestimated (see (ii) under C-D in Table 1) excluding this variable.3/ R^2 of the reestimated model remained the same. More important, the regression coefficients of the retained variables remained practically unchanged and the standard errors of some coefficients declined. It may thus be concluded that the variable H is not a relevant variable to explain the variation in output in MDR. A detailed probe into the data on cropping pattern and irrigation also support this conclusion. A large majority of sample farmers of MDR had an access to irrigation which is necessary to grow high value crops, particularly tobacco.

2/ Johnston's additional guide beyond the simple correlations to detect multicollinearity is discussed earlier in footnote one, p. 3. The use of Johnston's method would involve estimation of at least 14 equations for each of the two functional forms for each of the two regions. We have not used this method for examining multicollinearity in LLI and TRAN models, although this method is used to probe into a similar problem that may exist in C-D model.

3/ Other variables that are statistically insignificant were not excluded because their corresponding r^2 values are not as low.

The nonsignificance of $\hat{\beta}_6$ and $\hat{\beta}_7$ for MDR and $\hat{\beta}_2$ for LDR could be due to little variation in the associated variables and/or due to a high multicollinearity of these variables with the others in the model. To examine the latter, each independent variable was regressed on the remaining independent variables. Appendix 3 gives the estimated regressions.

. Considering the size of F statistic, the variable M appears to be collinear with a linear combination of A, F, and L in the LDR sample. Likewise, in the MDR sample, L is collinear with a linear combination of A, F, and M. However, the R^2 of the none of these subsidiary regressions is greater than .822. This suggests that the sample data of both the regions might not have exhibited, from the viewpoint of conventional standards, a serious problem of multicollinearity. In order to further confirm this judgement the following two modifications were made to reestimate the C-D model:

(a) Omission of nonsignificant variables in the original model and

(b) Omission of those two variables (L and F for MDR and M and F for LDR) that appear to create the greatest multicollinearity based on the regressions of independent variables.

The reestimated models are presented in Table 2. Their comparison with the original model as given in Table 1 reveals the following:

One, the equations reestimated after excluding the nonsignificant variables (see (i) in Table 2) have most coefficients slightly larger in size, although their standard errors have not increased. Also, the standard error of the estimated equations increased very little. This finding implies that whatever little explanation the omitted variables gave before is now captured by the retained variables in the new equations. Two, the exclusion of the two variables that may have caused the multicollinearity (see (iv) in Table 2) has lowered the R^2 considerably for both the samples. This is also true of the model (see (iii) for LDR in Table 2) that excluded only one of the two variables viz., F for the LDR sample. Three, although the exclusion of other variable (see (ii) for LDR and (ii) and (iii) for MDR in Table 2) has not lowered the R^2 the fit is less satisfactory. This is because some regression coefficients seem to have captured the explanation provided by the omitted variable. Against this, for some other coefficients the standard errors increased without a sizeable increase in the coefficients themselves. It is therefore concluded that the original model (Table 1) is superior to the alternate models, which exclude some variables. This is because omitting variables may cause a bias in estimating the coefficients of the remaining variables. Also exclusion of nonsignificant variables would imply loss of, although imprecise, information. The ideal solution for overcoming imprecise estimates is to have data that have the less collinearity and also the sufficient variation in them.(7)

Table 2. Reestimated C-D Production Functions

	MDR				LDR			
	(i) Excluding non-significant variables M and N	(ii) Excluding Variable L	(iii) Excluding Variable F	(iv) Excluding Variables L and F together	(i) Excluding non-significant variable A	(ii) Excluding Variable M	(iii) Excluding Variable F	(iv) Excluding Variables M and F together
$\ln\hat{\beta}_0$	5.222* (.195)	4.552* (.344)	5.165* (.345)	4.607* (.454)	3.365* (.315)	4.288* (.222)	3.407* (.584)	
$\hat{\beta}_1 \ln H$	-	-	-	-	.042** (.020)	.047** (.022)	.086* (.034)	.110* (.040)
$\hat{\beta}_2 \ln A$	.310* (.066)	.344* (.077)	.292* (.076)	.457* (.098)	-	.182** (.081)	.338* (.132)	.715* (.125)
$\hat{\beta}_3 \ln F$	.198* (.057)	.304* (.053)	-	-	.486* (.048)	.534* (.049)	-	-
$\hat{\beta}_4 \ln I$	.090* (.023)	.076* (.027)	.097* (.026)	.101* (.035)	.021 (.017)	.023 (.019)	.056** (.029)	.071** (.035)
$\hat{\beta}_5 \ln L$	.179* (.044)	-	.249* (.040)	-	.056** (.025)	.071* (.026)	.041 (.044)	.102** (.051)
$\hat{\beta}_6 \ln N$	-	.046 (.124)	.107 (.119)	.130 (.162)	.219* (.084)	.181*** (.091)	.192*** (.146)	.106 (.176)
$\hat{\beta}_7 \ln M$	-	.177** (.088)	.144** (.087)	.430* (.100)	.276* (.076)	-	.581* (.127)	-
Degrees of Freedom	43	42	42	43	41	41	41	42
SSE	4.0302	5.0324	4.7081	8.9742	2.9533	3.4783	8.8828	13.4118
R^2	.938	.923	.928	.862	.952	.943	.855	.781

Figures in paratheses are standard errors

* Significant at 1%

** Significant at 5%

*** Significant at 10%

V.

Analysis of the Selected Model

Having selected the original C-D model we shall now examine the differences in production functions of two regions and then whether or not the resource use is optimum.

The hypothesis of equal production functions for the two regions was tested. For this purpose, the model that included the H variable was used. The test suggests that differences exist in production functions of the two regions. This difference may primarily be ascribed to the differences in irrigation and also in methods of production used on the sample farms of the two regions. Thus, the elasticity of production with respect to irrigation in MDR is .08, whereas in LDR it is .02. Further, the elasticity of production with respect to land (A) and hired human labor (L) are also higher in MDR than LDR. The higher production elasticity of both these inputs may in part be due to quality differentials in land and (hired) labor. The soils of sample farms of MDR is more fertile than that of LDR sample farms. However, the production elasticities with respect to fertilizer and manures (F), family labor (N), other expenses (M) and ratio of high-value crops (H) are higher in LDR than in MDR. Except for fertilizers all other inputs can be termed as traditional sources of increasing production.

From the viewpoint of production economics, there are two very interesting properties of the C-D function. These are: one, the sum of coefficients of the C-D function represents returns to scale parameter. Second, the marginal and average products are proportional and therefore, the associated coefficient of a particular factor shows the share of this factor in production (8). This property holds provided there exists perfect competition. This is because under perfect competition all factors of production are paid according to their marginal value product. This in turn implies that the returns to scale are constant, and also that the net returns on use of inputs are maximized.

Thus, to determine whether the estimated production functions exhibited constant returns to scale the sum of regression coefficients are tested by "t" test.[4] The test strongly indicates that the returns to scale are constant for the sample farms of both MDR (.8674) and LDR (1.1256). This result then directly facilitates the use of estimated regression coefficients to test whether maximum returns on the use of inputs are achieved or not.

For this test we hypothesize that the <u>observed</u> ratios of average expenditure to gross value of production for F, I, L and M are equal to their respective estimated regression coefficients, i.e.

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[4] Hereon for MDR that model which excludes variable H was used.

$\hat{\beta}_3$, $\hat{\beta}_4$, $\hat{\beta}_5$, and $\hat{\beta}_7$ in the model. Appendix 4 discusses the derivation of an optimum condition for an input use under the C-D function.

The results of "t" statistic examining the above hypothesis shows the following: For MDR sample farms, the hypothesis that the observed ratios and their respective estimated coefficients are equal is accepted in all cases. This means that the net returns on the use of fertilizers and manures, irrigation, hired human labor and other expenses are maximized on the sample farms of MDR. A similar conclusion emerges for the LDR sample for two inputs viz., irrigation and other expenses. But the net returns on the use of fertilizers and manures and hired human labor in the (LDR) sample are not maximized.

In LDR, the observed ratio (.0996) of expenditure to gross output for fertilizers and manures is lower than the estimated regression coefficient (.4665). This indicates that the farmers' expected average returns on fertilizers and manure use are lower than those estimated by the production function analysis. The farmers' lower expectations may be explained by the fact that irrigation--the input complementary to fertilizers--in this region is characterized by high degree of uncertainty. This in turn may cause a conservative use of fertilizers.

For hired human labor, the situation is exactly the reverse i.e. that the observed ratio (.1608) is greater than the estimated coefficient (.0499). This may, however, be due to the reason that in technologically stagnant and uncertain agriculture like the one in LDR, labor is the only certain and relatively inexpensive source of increasing production (9). Hence, farmers may have a tendency to use this input excessively.

VI.

Conclusions

The production functions on the sample farms in two regions of Baroda district are different. This is primarily ascribed to the differences in the underlying uncertainty with respect to the irrigation resource in the two regions. This very factor pervades so deeply that it seems to have also caused an uneconomic use of labor (hired) and suboptimum use of fertilizers and manures in LDR. In MDR, where irrigation resource is more reliable and adequate, the sample farmers maximized the net returns over all inputs (that are measured in money units).

Appendix 1

Regressions of Independent Variables Used in C-D Production Function

MDR Sample

Independent Variables as Dependent Variables	Constant	Regression Coefficients Associated with A	F	I	L	N	M	R^2	'F' Statistic
A	-1.839*	-	.039	.034	.165***	.014	.373**	.651	15.656
	(.655)	-	(.130)	(.052)	(.099)	(.241)	(.170)		
F	1.247	.055	-	.074	.476*	.234	.286	.807	35.099
	(.826)	(.183)	-	(.061)	(.097)	(.284)	(.208)		
I	-.899	.298	.455	-	-.176	-.091	.700***	.357	4.657
	(2.092)	(.451)	(.375)	-	(.299)	(.709)	(.515)		
L	-2.379**	.377***	.769*	-.046	-	-.121	.508***	.822	38.819
	(1.013)	(.225)	(.156)	(.079)	-	(.364)	(.259)		
N	-.490	.006	.068	-.004	-.022	-	.087	.133	1.295
	(.450)	(.098)	(.082)	(.033)	(.065)	-	(.114)		
M	3.173*	.277**	.151	.060	.165***	.158	-	.761	26.757
	(.372)	(.126)	(.109)	(.044)	(.084)	(.206)	-		

Figures in parentheses are standard errors

* Significant at 1%
** Significant at 5%
*** Significant at 10%

Appendix 2 (continued)

LDR Sample

Independent Variables as Dependent Variables	Constant	Regression Coefficients Associated with H	A	F	I	L	N	M	R^2	'F' Statistic
H	-4.269***	-	-.455	.570	-.002	.074	-1.172***	.156	.292	2.815
	-	-	(.624)	(.387)	(.135)	(.197)	(.632)	(.639)		
A	-1.490**	-.028	-	.211**	-.014	.069	.126	.382**	.699	15.856
	(.610)	(.038)	-	(.093)	(.033)	(.048)	(.162)	(.147)		
F	- .205	.088	.526**	-	.070	-.018	-.032	.728*	.744	19.870
	(1.030)	(.060)	(.232)	-	(.052)	(.078)	(.258)	(.244)		
I	-2.589	-.003	-.298	.609	-	.349	.416	.026	.260	2.407
	(3.004)	(.180)	(.723)	(.449)	-	(.222)	(.757)	(.739)		
L	-1.100	.046	.696	-.073	.163	-	-.879***	.920***	.602	10.330
	(2.064)	(.123)	(.483)	(.313)	(.104)	-	(.501)	(.484)		
N	1.496**	-.066***	.115	-.012	.017	-.079***	-	-.103	.302	2.953
	(.578)	(.036)	(.148)	(.094)	(.032)	(.045)	-	(.151)		
M	3.256*	.009	.368**	.281*	.001	.088***	-.109	-	.783	24.719
	(.390)	(.038)	(.142)	(.086)	(.033)	(.046)	(.160)	-		

Figures in parentheses are standard errors

* Significant at 1%
** Significant at 5%
*** Significant at 10%

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