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Vol XXI
No. 3

ISSN 0019-5014

JULY-
SEPTEMBER
1966

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

NOTES

ANALYSIS OF GROWTH COMPONENTS AND METHOD OF CONSTRUCTING THE INDEX NUMBER OF AGRICULTURAL PRODUCTION UNDER CONSTANT CROPPING PATTERN*

The Ministry of Food and Agriculture, Government of India has constructed the index numbers of area, production and productivity in the memorandum entitled Growth Rates in Agriculture (1964). Production and area index have been constructed from the raw data (after making relevant adjustments) of area and agricultural production over the period 1952-53 to 1961-62. The purpose of constructing these indices is to provide comparability[1] of series of production and area over time. In this paper it is proposed to construct index number of agricultural production under constant cropping pattern from the data provided in the Growth Rates in Agriculture. If the raw data are provided for each crop in tons, bales, etc., the aggregate agricultural production is to be obtained by the use of index number taking some year as the base year. The Ministry has constructed the index number of agricultural production by taking 1956-57 as the base year. All production and area figures are deflated by those of 1956-57. The prices of crops prevailing in 1956-57 are used in obtaining the contribution of value product of each crop to total value product. These weights are applied to the index number of production under each crop and weighted average is known as the index number of agricultural production with 1956-57 as the base year. We recognize this index number of agricultural production as the agricultural production under prevailing cropping pattern, composite of changes in productivity acreage and changes in cropping pattern. Similarly, area under each crop is given in acres from which the index number of area under crop is obtained by deflating by area statistics of 1956-57. From the raw data of area and production under each crop, the production for each crop in tons or bales can be obtained under constant cropping pattern. The term constant cropping pattern implies that if proportions of area under each crop to total cropped area are held constant, what will be the production under each crop under changes in productivity per acre from time to time ? In order to have an aggregate measure of production, once again, we could take the help of index number device and the construction of index number of agricultural production under constant cropping pattern could be carried out. It is shown here that it is not necessary to refer to the basic data for the construction of index number of agricultural production under constant cropping pattern once the index numbers of area and agricultural production are constructed from the adjusted data. In this paper, it is indicated how the Ministry's index number of agricultural production (cropwise and aggregate) and area (cropwise and total) could be used in constructing the aggregate index number of agricultural production under constant cropping pattern. We do not go back to the original adjusted data but operate with the index numbers. It is also proposed to isolate two components, namely, the contribution of changes in productivity and acreage in the absence of changes in cropping pattern and the

* The author wishes to thank Prof. V. M. Dandekar for his helpful suggestions.

1. The non-comparability of raw data over time is the outcome of the improvement effected in the quality and content of agricultural statistics in different States and for different crops over the last decade. These improvements broadly relate to substitution of traditional eye-estimation method by the objective random sample crop-cutting method and to general extension of reporting areas.

contribution of changes in cropping pattern in the absence of changes in productivity and acreage from the composite index of agricultural production under prevailing crop pattern. This isolation constitutes the analysis of growth components. In section I, the method of constructing index number of agricultural production under constant cropping pattern is provided while in section II, the analysis of growth components for Maharashtra State on the basis of data for the decade is undertaken.

I

Let the index of area under a particular crop be denoted as A_{it} at time t and index of total area be denoted as A_t. A_{it}/A_t will be known as index of proportion of area under crop i at time t. Let the total area index at time $t+1$ be A_{t+1}. Under the constant cropping pattern, the index of proportion of area under a particular crop is to be held constant. The allocation of A_{t+1} should be made exactly in the same proportions. This means that A_{it}/A_t should be multiplied by the index of area under all crops at time $t+1$, *i.e.*, $A_{it}/A_t \times A_{t+1}$. This will be the index of area under crop i at time $t+1$ under constant cropping pattern. It can be shown that operations on index numbers in this case is the same as the operations on the basic data. Illustrating by way of a numerical example, we take two years' raw data and total area figures for three years.

AREA IN ACRES AND INDEX NUMBERS

Year/Crop	Area in acres			Area in index numbers		
	Rice	Wheat	Total	Rice	Wheat	Total
1956-57	60	40	100	100	100	100
1953-54	80	40	120	133	100	120
1954-55			130			130

Note: These figures are illustrative.

For the year 1953-54, total area in acres are available and index number is obtained on the basis of 1956-57 as the base year. Applying the total area index of 1954-55, area index for each crop under 1953-54 cropping pattern is obtained as 144 and 108. Using these index numbers, the area in acres under constant cropping pattern (1953-54) are obtained as 87 and 43 for rice and wheat respectively. This is identical with the area under each crop computed from the raw data

$$\left(\frac{80}{120} \times 130\right) \text{ and } \left(\frac{40}{120} \times 130\right).$$

Let the index of agricultural production be P_t which is a weighted average of indices of production under different crops (P_{it}). Using new index of area under each crop of year $t+1$ $A_{it}/A_t \times A_{t+1}$ we can compute the index of production under each crop on the basis of constant cropping pattern for year $t+1$. The formula will be

$$\frac{\frac{A_{it}}{A_t} \times A_{t+1}}{A_{it+1}} \times P_{it+1}.$$

The index of production under each crop on the basis of constant cropping pattern will be obtained by the above formula. In order to obtain the index of agricultural production, weights are to be applied to the index of various crops. These weights are available in the Growth Rates in Agriculture.

$$\sum_{i=1}^{n} W_i \left[\frac{\frac{A_{it}}{A_t} \times A_{t+1}}{A_{it+1}} \times P_{it+1} \right]$$

will be known as the index of agricultural production under constant cropping pattern at time $t+1$. Generalizing the expression for any time-period, we can write

$$\sum_{i=1}^{n} W_i \left[\frac{\frac{A_{it}}{A_t} \times A_{t+j}}{A_{it+j}} \times P_{it+j} \right]$$

where $j = 1, 2, \ldots\ldots 9$.

In the above method, two assumptions are made : (i) the new unit of land is treated as homogeneous or as good as the old one, and (ii) the same proportionality relationship between output and area is assumed to hold true as is prevailing between the index of area and production of the Ministry of Food and Agriculture.

The general method and its assumptions are given above. Now, we illustrate the method by taking a small example. Let the index of area under rice and wheat be 120 and 80 and the index of total area under all crops be 100. If the total area index changes from 100 to 120, the area index for rice and wheat under constant cropping pattern will be 144 and 96 respectively. Suppose that actual area index for rice and wheat be 160 and 80 respectively (Table I).

TABLE I

Crop	Area index under the prevailing crop pattern		Area under constant cropping pattern
	t	t + 1	t + 1
Rice	120	160	144
Wheat	80	80	96
Total	100	120	120

The index of agricultural production in year $t+1$ under the prevailing crop pattern is given in Table II. Weights are assumed to be the same for both the crops. The index of production for rice and wheat under constant cropping pattern is constructed and shown in column 3 of Table II.

TABLE II

Crop	Index of production corresponding to prevailing crop pattern at time t+1	Index of production corresponding to constant cropping pattern at time t+1
Rice ..	180	162
Wheat ..	120	144
Total ..	150	153

When the area index for rice is 160, the output index for rice is 180; then what will be the output index if area index is 144 under constant cropping pattern ? The output index will be 162 for rice.

II

In the earlier section, the method of constructing the agricultural production under constant cropping pattern is discussed. In this section, the study on the analysis of growth component is undertaken. The use of the method presented earlier is made in isolating different components of growth.

In a mimeographed paper of the Indian Statistical Institute,[2] the analysis of growth (componentwise) is carried out. Three-yearly average agricultural production for the years 1958-61 is compared with the corresponding average of the 1951-54 and growth rate in agricultural production is computed.[3] This growth rate is explained by growth in area, the effect of changes in crop pattern in the absence of any changes in productivity per acre and effect of changes in yield for a constant crop pattern and the residual element which was explained as the interaction between per acre yield changes and changes in crop pattern. In order to use a slightly different decomposition scheme, it is necessary to construct the index number of agricultural production under changes in cropping pattern with constant productivity and acreage. If the index number of agricultural production under prevailing crop pattern is deflated by the index number of agricultural production under constant cropping pattern, the index number of contribution of changes in cropping pattern to the production is obtained.[4] This implies that

2. B. S. Minhas and A. Vaidyanathan: Analysis of Crop-Output Growth by Component Elements: India 1951-54 to 1958-61 (mimeo.).

3. In two-point comparison, one good or bad year affects the base and computations considerably.

4. To demonstrate the expression algebraically in case of deflation,

$$I_A^M = \sum_{i=1}^{n} W_i \; P_{it+j}$$

and

$$I_A^P = \sum_{i=1}^{n} W_i \left[\frac{\frac{A_{it}}{A_t} \times A_{t+j}}{A_{it+j}} \times P_{it+j} \right] \quad j=1....9$$

and

$$I_A^C = \frac{\sum_{i=1}^{n} W_i \; P_{it+j}}{\sum_{i=1}^{n} W_i \left[\frac{A_{it}}{A_t} \times A_{t+j} \times \frac{P_{it+j}}{A_{it+j}} \right]} \quad j=1....9$$

the Ministry's index is equivalent to the product of index number under constant crop pattern and contribution of changes in crop pattern. In other words, we have a multiplicative model, *i.e.*,

$$I_A^M = I_A^P \times I_A^C \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where I_A^M = Index number of agricultural production under prevailing crop pattern,

I_A^P = Index number of agricultural production under constant cropping pattern (composite index of productivity and area changes),

and I_A^C = Index number of contribution of changes in cropping pattern.

The Ministry's index is composed of area changes, productivity changes and cropping pattern changes. Hence, the deflation of index number of agricultural production under prevailing crop pattern by the index number of agricultural production under constant crop pattern yields the contribution of changes in crop pattern in the absence of productivity and area changes. Both these index numbers $\left(I_A^M \text{ and } I_A^P\right)$ have the element of productivity and area changes and the deflation will eliminate this common factor.

Taking the logarithms of (1), we obtain

$$\log I_A^M = \log I_A^P + \log I_A^C \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

For the growth rate analysis, the time derivatives of (2) will yield the following expression

$$\frac{d \log I_A^M}{d_t} = \frac{d \log I_A^P}{d_t} + \frac{d \log I_A^C}{d_t} \quad \ldots \quad \ldots \quad (3)$$

In order to use (3), the growth rates are computed for each of the three series by fitting a function of the type $V_{it} = A_e^{kit}$ where $k_i \times 100$ is the growth rate for the respective index number series.

Using k_i's in (3), we obtain[5]

$$k_1^o = k_2^o + k_3^o \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

---

5. Let $I_A^M = A_e^{k_1 t}$ and taking logs will yield

$$\log I_A^M = \log A + k_{1t} \log 10^e$$
$$= \log A + k_1 T \text{ where } T = .4343\ t.$$

The time-derivative of the above expression gives $\frac{d \log I_A^M}{dt} = k_1 \times 2.3$ and multiplying by 100 will yield the percentage growth rate $\left(k_1^o\right)$.

where k_1^o is the percentage growth rate of the Ministry's composite index number,

k_2^o is the percentage growth rate of the composite index of productivity and area changes, and

k_3^o is the percentage growth rate of the index of contribution of changes in crop pattern.

As an illustration, data for Maharashtra from growth rates in agriculture over the last 10 years (1952-53 to 1961-62) are used. On the basis of procedure outlined before, the index number of agricultural production under constant cropping pattern having the elements of area and productivity changes and the index number of contribution of changes in cropping pattern in the absence of productivity and area changes are obtained. We get the overall growth rate as 3.727 per cent out of which a composite index of productivity and area changes have a growth rate of 1.057 and crop pattern contributes 2.680 to the overall growth. The composite index of productivity and area changes is to be further decomposed into two parts: (1) the contribution of area to the agricultural production and (ii) the contribution of changes in productivity to the growth in production. This may be done under the assumption of 1:1 correspondence between area and production, *i.e.*, to say that 1 per cent increase in area will lead to 1 per cent increase in production. If this approach is adopted, the growth in area is .650 per cent and hence its contribution to the growth of production must be .650 per cent.

Deducting .650 per cent growth of area from productivity changes and area changes, we will be left out with .407 per cent growth in productivity net of area. In this approach,

$$I_A^P = I_A^a \times I_A^{P_r} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

is assumed. I_A^P is the composite index having area and productivity changes or it is the index number of agricultural production under constant crop pattern. I_A^a is the index of area and $I_A^{P_r}$ is the index of productivity changes net of area. The growth rates of I_A^P could be split in the manner as done before.

$$G_A^P = G_A^a + G_A^{P_r} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

However, this approach is subject to one important limitation that with the passage of time, more and more marginal land will come under cultivation. In case of marginal land, 1:1 correspondence will not hold true because 1 per cent increase in area will lead to less than 1 per cent increase in output. Hence, weight obtained by way of some *a priori* information may have to be applied. We can obtain the weights by carrying out a regression of I_A^P on I_A^a and the residuals may be deno-

ted as the index number of changes in productivity net of area. In other words, instead of (5), the following scheme is adopted.

$$I_A^P = C\left(I_A^a\right)^{W_i} \times I_A^{P_r} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Taking the logs, (7) reduces to

$$\log I_A^P = \log C + W_i \log I_A^a + \log I_A^{P_r} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

If (8) is used for the growth rate analysis, we get

$$G_A^P = W_i G_A^a + G_A^{P_r} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

The residuals $\left(\log I_A^P - \log C - W_i \log I_A^a\right)$ is known as the changes in productivity index net of area changes. In all the decomposition schemes, the multiplicative hypothesis is applied and isolation of different components is carried out, one by one.

For Maharashtra, W_i turns out to be .6532 which implies that marginal land has come under cultivation during the decade. Using it for the growth analysis, the contribution of area turns out to be .425 per cent while that of productivity changes .633 per cent and the changes in cropping pattern contribute 2.680 per cent to the total growth rate of 3.730 per cent per annum. In terms of percentage, changes in cropping pattern alone contribute 72 per cent of the growth in output, area changes contribute 11 per cent and productivity changes contribute 17 per cent to the total growth in agricultural output.

DATA TABLE

Year	Index number of agricultural production (Ministry's Series 1956-57 = 100)	Index number of area	Index number of agricultural production under 1952-53 cropping pattern	Index number of contribution of changes in cropping pattern
1952-53 ..	72.5	93.1	72.5	100.0
1953-54 ..	91.7	97.3	93.9	97.6
1954-55 ..	99.7	99.0	100.5	99.2
1955-56 ..	86.8	99.3	87.5	99.6
1956-57 ..	100.0	100.0	98.7	101.3
1957-58 ..	100.6	98.9	98.0	102.6
1958-59 ..	105.8	100.1	102.4	103.3
1959-60 ..	97.5	100.1	92.8	105.1
1960-61 ..	125.1	100.4	118.4	105.6
1961-62 ..	107.1	101.8	100.5	106.6

Note : At relevant places, multiplication by 100 is done.

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AN APPLICATION OF MAHALANOBIS-D^2 IN DISCRIMINATING CONSUMER'S BEHAVIOUR

The behaviour of consumers (cultivators) falling under different income groups[1] has been studied in this paper. This study mainly concentrates itself on visualizing as to how consumers of two distinct income groups behave so far as the consumption of different items is concerned, *i.e.*, whether the pattern of consumption of cultivators falling in these groups is similar or they behave in a different way from each other. The study is essentially a methodological one and is illustrated by analysis of data from family budget survey of Punjab cultivators.[2]

The consumption pattern of cultivators falling under two income groups can be studied by simply plotting the per capita expenditure on X-axis and the percentage of expenditure on different items of consumption on Y-axis and then studying the pattern from graph thus plotted for these two groups simultaneously. The second method basically lies in using distance concept visualized by Mahalanobis.[3] The assumption involved is that the samples should come from a normal population, which holds true in our case also since individuals are supposed to behave in a normal way so far as their consumption of these items is concerned.

Discriminatory Analysis

Let n_1 and n_2 be the number of households in two income groups classified as low and high, each characterized by k variates $x_1, x_2 \ldots\ldots x_k$. Let $\bar{x}_{i_1}$ and $\bar{x}_{i_2}$ $(i = 1, 2, \ldots\ldots k)$ be the mean characters of low and high income groups. Then the Mahalanobis distance between the two groups on the bases of these k characters is given by

$$D_k^2 = \sum_i \sum_j w_{ij} \left(\bar{x}_{i_1} - \bar{x}_{i_2} \right) \left(\bar{x}_{j_1} - \bar{x}_{j_2} \right)$$

where

w_{ij} is the (i, j)th element in the inverse of the matrix (w_{ij}) where

$$w_{ij} = \frac{1}{n_1 + n_2 - 2} \left[\left(\bar{x}_{i_1 t} - x_{i_1} \right) \left(x_{j_1 t} - \bar{x}_{j_1} \right) + \left(x_{i_2 t} - \bar{x}_{i_2} \right) \left(x_{j_2 t} - \bar{x}_{j_2} \right) \right]$$

This concept of distance can safely be utilized in studying the behaviour of consumers falling in different income groups so far as their percentage expenditure on different items is concerned. In other words, if distance is statistically significant then the two groups are said to behave in a distinct manner from each other.

1. Income here refers to disposable income which has been equated to total expenditure. This is a close approximation to the disposable income.
2. Board of Economic Inquiry, Punjab : Family Budgets of Cultivators in the Punjab for the years 1959-60, 1960-61 and 1961-62, Publication Numbers 86, 91 and 93 (Annual Series).
3. P. C. Mahalanobis, "On the Generalized Distance in Statistics," *Proc. National Inst. Sciences* (India), Vol. 12, 1936, p. 49. Refer also C. R. Rao, "Tests with Discriminant Functions in Multivariate Analysis," *Sankhya*, Vol. 7, 1946, p. 407 ; and R. A. Fisher, "The Use of Multiple Measurement in Taxonomic Problems," *Ann. Eugen*, London, Vol. 7, 1936, p. 197.

This distance can be further utilized to make a judicious selection of the characters (consumer items) which play a significant role in drawing a line of distinction between the two groups. Finally, the problem concentrates on finding a function of $x_1, x_2 \ldots\ldots\ldots\ldots\ldots x_k$ characters used to distinguish between two groups such that the probability of error in assigning a particular individual to one or the other of these two groups is the smallest.

To test the hypothesis that the distance between the two groups on the basis of the k-characters measured is significant or not we shall have to test D_k^2 for significance by using the statistic

$$\frac{n_1 n_2 (n_1 + n_2 - k - 1)}{k (n_1 + n_2) (n_1 + n_2 - 2)} D_k^2$$ as variance ratio with k and $n_1 + n_2 - k - 1$ degrees of freedom.

We can safely eliminate certain characters after finding the significance of their role in creating a gap between two groups. This can be done by testing whether the distance based on (k — s) characters is same as that based on k-characters. This difference can be tested by the statistic

$$F = \frac{n_1 + n_2 - k - s - 1}{S} R$$ with S and $n_1 + n_2 - k - s - 1$ degrees of freedom

where $$R = \frac{1 + \frac{n_1 n_2}{(n_1 + n_2)(n_1 + n_2 - 2)} D_{k+s}^2}{1 + \frac{n_1 n_2}{(n_1 + n_2)(n_1 + n_2 - 2)} D_k^2}$$

If F is not significant then the distance on the basis of k—s and k-characters is same. We conclude that the characters eliminated do not play a significant role in discriminating between two groups and hence exclude it from analysis.

Illustration

The Board of Economic Inquiry, Punjab conducts Family Budget Surveys of certain number of cultivators spread all over Punjab annually. The data for the present analysis has been taken from the reports published for the years 1959-60, 1960-61 and 1961-62. The period is spread over three consecutive years. In all, 75 households are taken and arranged in order of their income (per adult unit) and classified into two groups, namely, low income group having a range of total annual income from Rs. 800 to Rs. 2,400 and high income group with income ranging from Rs. 2,900 to Rs. 5,000. This left out middle 14 households. The low income group (P_1) and high income group (P_2) had n_1 (31) and n_2 (30) number of sample households.

Since the classification of low and high income groups is based on the income per adult unit the effect of household-size is thus removed from our analysis. The results presented in this paper would have been confounded with the effects of varying sizes of the households had this classification been done on the basis of income classes on expenditure classes. It is because the variation among household-sizes is great within each class.

The consumer items, each of which is used is distinguished between two groups the P_1 and P_2, are as follows :

x_1 (food), x_2 (clothing), x_3 (fuel), x_4 (housing), (x_5 (social), x_6 (religion).

The analysis has been carried on with the percentage expenditure on these items of consumption. Before proceeding with the analysis it is necessary to give the definition of these heads of the household expenditure.

Expenditure on :

Food: This includes the costs of cereals, pulses and all other articles which form a part of daily diet of the cultivator.

Fuel : This consists of cattle dung cakes, firewood, dry cotton sticks and other products of the farm which can be used for burning purposes.

Clothing : This includes the expenditure on clothes of everyday wear, those kept for special occasions, presented to relatives and other beddings. The expenditure incurred on hair oil, washing requisites and shoes is also included under this head.

Housing : The expenditure under this head included interest, depreciation charges on the values of the dwelling and the cost of new furniture. It also includes the cost of alterations and repairs to the residential house and furniture. Depreciation has been charged at the following rates: (1) *Pucca* house 2.5 per cent, and (2) *kacha* house 5.0 per cent.

Religion : This includes offerings made at places of worship and the alms given on religious ceremonies.

Social occasions: This head includes expenses incurred on social occasions such as births, deaths and marriage celebrations.

Analysis

Table I gives the mean per cent expenditure on these items of consumption for two populations and their difference.

TABLE I—OBSERVED MEAN VALUES OF THE PER CENT EXPENDITURE ON DIFFERENT ITEMS BASED ON 30 AND 31 OBSERVATIONS EACH FOR TWO POPULATIONS

Characters (Items) 1	Income Groups		$P_1 - P_2$
	Low (P_1) 2	High (P_2) 3	Difference 4
Food (x_1)	60.1613	57.0700	+ 3.0913
Clothing (x_2)	12.5677	13.8000	— 1.2323
Fuel (x_3)	7.4839	5.1666	+ 2.3173
Housing (x_4)	7.4322	7.1166	+ 0.3156
Social (x_5)	3.0000	1.9500	+ 1.0500
Religion (x_6)	0.8226	0.9900	— 0.1674

Table II gives the corrected sum of squares and sum of products matrix, *i.e.*, $(n_1+n_2-2)\ w_{ij}$.

TABLE II—MATRIX $(w_{ij})\ (n_1 + n_2 - 2)$

	x_1	x_2	x_3	x_4	x_5	x_6
x_1 ..	6071.4565	—306.8587	—920.3293	—2119.9262	—349.8350	—86.9519
x_2 ..		1232.5477	— 3.7761	—201.8977	— 43.1400	50.2426
x_3 ..			1054.2786	—184.2072	—242.3000	—41.0787
x_4 ..				2243.4093	257.7850	—9.5476
x_5 ..					601.9950	24.6650
x_6 ..						43.1412

The distance D_k^2 thus calculated has been shown in Table III.

TABLE III—VALUES OF D_k^2 AND THEIR F-VALUES

Characters included	K	D_k^2	F-Values
1	2	3	4
$x_1\ x_2\ x_3\ x_4\ x_5\ x_6$	6	1.66557	3.87**
$x_1\ x_2\ x_3\ x_4\ x_5$	5	1.59536	4.53**
$x_1\ x_2\ x_3\ x_4$	4	1.00890	3.65*
$x_1\ x_2\ x_3$	3	0.68425	3.11*
$x_1\ x_2$	2	0.14927	1.12

** Significant at 1 per cent. * Significant at 5 per cent.

The significance of D_6^2 at 1 per cent shows that the pattern of consumption of these two groups is distinct. This distance is significant even when five characters are taken and sixth, *i.e.*, religion is eliminated from study. The level of significance reduces from 1 per cent to 5 per cent when characters x_6 and x_5, *i.e.*, expenditure on religion and social are eliminated, thus giving an indication that the pattern of consumption is not markedly different in the two income groups so far as food, fuel, clothing and housing is concerned. The percentage expenses on food and clothing do not make any distinctive mark between the two groups. This is even otherwise true for those items from the necessities of life.

Now the point of interest is to see which character plays an important role in discriminating between the two populations. This can be seen by testing for significance the gap between the two distances. Table IV gives these differences and their F-values.

TABLE IV

$D_k^2 - D_k^2 - 1$	Gaps	Values of F
1	2	3
$D_6^2 - D_5^2$	0.07021	0.6936
$D_6^2 - D_4^2$	0.65767	3.6332*
$D_6^2 - D_3^2$	1.03132	4.1215*
$D_6^2 - D_2^2$	1.51630	5.0931**
$D_5^2 - D_4^2$	0.58646	6.6110*

* Significant at 5 per cent. ** Significant at 1 per cent.

The additional distance created by including expenditure on religion as one of the items is not significant. Hence we can exclude that item of expenditure for further analysis. But if at the same time expenditure on social customs is excluded the gap is significantly widened. This implies that only five characters, *i.e.*, food (x_1), clothing (x_2), fuel (x_3), housing (x_4) and social (x_5) are sufficient to build up a discriminant function. The function is

$$Z = .15231\ x_1 + .01444\ x_2 + .35061\ x_3 + .15145\ x_4 + .26845\ x_5$$

This function can be put to many uses provided (1) the classification of income groups is sound and (2) the estimates are based on a large number of observations. We can expect a family to behave in a particular fashion by virtue of its being a member of a particular income group. If there is a shift in economy, the consumer pattern of households will change accordingly and the Z values will tell us whether there is upgrading of households from lower income group to higher one at a point of time, may be 2 years, three years or after each of the plan periods. This technique can further be used to study the consumption pattern of rural population versus urban population within the same income groups or to study the adoption pattern of innovators and laggards on the basis of characters like, size of holding, age, education, social participation, extension contacts, tenurial status, liquid assets and other relevant characters.

JAWAHAR L. KAUL*

A NOTE ON CHANGES IN CROP PATTERN IN THE NORTH DECCAN REGION (INDIA) DURING 1949-58†

It is often assumed in India, at the level of policy-makers and sometimes even at the level of professional economists, that farmers show scant response to market incentives. Raj Krishna's findings on cotton in Punjab and other recent studies

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† This note was presented to the Asian Workshop in the Department of Economics, University of Chicago, Chicago (U.S.A.), in February, 1965. The author is grateful to the participants in the workshop for helpful comments.

have been helpful in removing some of these misconceptions about traditional agriculture. In this note, we propose to give some findings for the North Deccan region in India which lead to interesting, though very tentative, inferences on the issue of market-responsiveness of farmers.

Region and Data

The North Deccan region, consisting of nine districts, is situated in the rain-shadow area of the Western Ghats in Bombay State. Rainfall in the region, except in the western parts near the Ghats, is meagre and uncertain. Irrigation and multiple cropping play a very limited role in the farm economy of the region. Millets (jowar and bajra), cereals (rice and wheat) are the main foodgrains grown in the region. Cotton, sugarcane, tobacco and oilseeds are the cash-earning crops.

The data used for this note consist of figures of area under different crops and figures of physical production of these crops in each district of the region during the period of ten years—1949-50 to 1958-59. They were collected from the annual compilations on crop statistics brought out by the Bureau of Economics and Statistics of the State Government.

Test

A feature of the observed change over time in the proportions of total cropped area devoted to different crops which strikes us as significant is that in relation to some of the crops some districts show fairly continuous rise in the proportion of cropped area devoted to these crops while other districts in the region show a fairly continuous fall in the corresponding proportions. Weather fluctuations and rotational practices, which are important sources of changes in the composition of cropped area from year to year, would not normally give rise to such steady patterns of rise or fall in the proportion of total cropped area devoted to any single crop. Since movements in relative prices are presumably uniform over the region, it does not look to be promising to try to interpret the observed changes in cropped areas in terms of movements in relative prices. In explaining these changes one should look to factors which are relevant in the decision-making of the farmers *and* which vary sufficiently from district to district over the region to give rise to dissimilar responses on the part of farmers. Profitability of a crop is an important factor in this category and we have sought an explanation of observed differences in changes in crop pattern as among the districts in terms of varying profitability of a crop over the region.

The data available to us suggest physical production per acre (gross) as an index of profitability of a crop. It is realized that this is a crude measure and, hence, open to criticism. We, however, feel that, for the crops considered in this note, the grade and quality of a given crop and techniques of its production (and, hence, level and composition of inputs used in producing it) are sufficiently homogeneous over the region and that weather fluctuations and suitability of soil for the crop are the only major factors which could give rise to inter-district variations in production per acre. In relation to weather fluctuations, it may be mentioned here that the configuration of the region is such that each district has a fair

share of high and meagre rainfall areas. This is so because while the districts in the region are situated in the north-south direction, the rainfall conditions vary from west to east. It can, therefore, be assumed that very dissimilar weather conditions in a given year as among the districts is a comparatively rare occurrence. In view of these considerations, relatively higher physical production per acre over a period of years in a district as compared to that in other districts can be regarded with some confidence as reflecting stable differences among the districts in relation to physical production per acre. Owing to the homogeneity of quality of crop and of techniques and costs of production, it would then be permissible to infer differences in the profitability of a crop from these differences in the physical production per acre.

The procedure of the test is now briefly described. As our main interest was in seeking an explanation for continuous rise or fall in the proportion of total cropped area devoted to a given crop, the first step in the procedure was to locate, for each crop, districts having such continuous changes. Out of these districts, we selected for each crop two districts, one having relatively marked rise in area and the other having relatively marked fall. In the second step, the levels of production per acre of crop in these districts were compared with the level in the region as a whole to find out whether the changes in the proportion of area on one hand and the differences in production per acre on the other showed any consistent relationship.

Owing to the large variations in physical production from year to year and owing to the limited number of years of observation, it was felt that it would be quite unsatisfactory to use any average of figures of production over the years in judging the differences among the districts in relation to production per acre. Therefore, a simple index was devised in terms of number of years in which production per acre in a district was higher and the number of years in which it was lower than the regional production per acre. If the level of production per acre in a district is of the same order as the regional level, one would expect these two numbers to be quite close. If, on the other hand, the level in a district is either higher or lower than the regional level, the numbers would diverge and, thus, show up this fact. No attempt was made to measure quantitatively the margins of difference owing to the limitations of such procedure mentioned above.

The results of comparison are presented in the following table.

Crop*	District having rise in the proportion of cropped area			District having fall in the proportion of cropped area		
	District	Number of years of higher production	Number of years of lower production	District	Number of years of higher production	Number of years of lower production
Rice	Kolhapur	10	—	East Khandesh	1	9
Wheat	Nasik	5	5	West Khandesh	6	4
Jowar	South Satara	10	—	Poona	—	10
Bajra	Nasik	8	2	East Khandesh	8	2
Gram	North Satara	7	3	East Khandesh	3	7
Groundnut†	West Khandesh	4	5	East Khandesh	2	7

* These crops account for about 75 per cent of total cropped area in the region.
† Data available only for nine years.

Inference

It would appear from the table that districts experiencing rise in the percentage of area devoted to certain crops do have relatively higher production per acre of these crops than in the region as a whole and, conversely, for the districts experiencing fall in percentage. An important crop not included in the table is cotton. Soils suitable for cotton are heavily concentrated in the Khandesh districts and the percentage of cropped area devoted to this crop increased markedly in these districts. In view of the concentration of these soils in the Khandesh districts, it is hardly appropriate to interpret this change in terms of inter-district variations in the production per acre of cotton and, hence, it has not been included in the table. The presence of cotton in the Khandesh districts probably explains fall in the percentage of area devoted to wheat and bajra in these districts even though the production per acre of these crops in the districts compares quite favourably with the regional production per acre. This points to an important limitation of the test made in this note, *viz.*, the test is based on inter-district variations in the profitability of a given crop while a more satisfactory procedure for explaining changes in crop pattern would be to examine profitability of different crops within each district and changes in them over the years. In terms of requirements of data, this procedure would be far more difficult to accomplish with the available data. Also, the test made in this note appears to be quite adequate for the limited purpose at hand, *viz.*, to suggest that farmers in the region do respond to incentives of profitability.

In concluding this note, we would like to make some observations which are speculative rather than inferential. On first sight, the results of the test appeared rather puzzling. In relation to established crops like those considered in this note with stable and routinized techniques and practices of cultivation, one would expect that adjustments such as those observed in the data of this note should have worked themselves out long time back in the past. For explaining the observed adjustments, it is, therefore, necessary to bring in a factor which could have given rise to new inter-district differentials in the production per acre of different crops or a factor which could have made the existing differentials more relevant in the decision-making of farmers than in the past. A possible factor in the former category is the unequal impact among the districts of the community development programmes for improving agricultural production. However, we would not believe that the actual impact of these programmes has been sufficiently large and unequal to give rise to the observed adjustments. A factor in the second category, which appears to be more promising in explaining the puzzle, is the decline in subsistence farming and growth in production for market and in exchange. Under such conditions, it is conceivable that farmers find growing opportunities for specialization without any change in the existing production per acre of different crops. Utilization by the farmers of such opportunities is, therefore, a possible explanation for the observed adjustments. Unfortunately, no data are available to quantify for the region the growth in production for market and in exchange. During the period 1949-58, the region as a whole and also the districts, with a single exception, show increase in the proportion of cropped area devoted to cash-earning crops and this increase was quite marked for some of the districts. But, this is a poor index of growth in production for market and in exchange

since such growth can and, presumably, is taking place in the region through increase in the proportion of marketed crop to produced crop in relation to all crops including food crops.

V. M. RAO*

ESTIMATION OF SUPPLY FUNCTIONS FOR TRANSPLANTED PADDY IN MANDYA DISTRICT, MYSORE STATE

Introduction

Supply response of agricultural commodities to their respective price changes is an area where not much work has been done in India.[1] As a result, this is acting as an impediment in the formulation of realistic agricultural policies especially of price policies. Economists and policy-makers have been advocating the provision of price incentives to farmers to increase their production. In this respect the discussions so far have been confined mainly more to the theoretical aspects of the measures rather than to their practical implications. Empirical studies of supply responses to price changes provide the basic material for the consideration of price incentives to boost agricultural production. The measures devised should take into account the present economic and technological relationships and the farmers' reactions in terms of supplies to the price fluctuations or the changes in price policies. Estimation of supply responses also play a significant role in providing the basis for the long run price relationships needed in all agricultural planning.[2] When supply response estimates are available for a number of commodities, estimates of cross elasticities of supplies can also be obtained. Farmers would be interested in developing guidelines to help them in deciding about their total production of a particular commodity within the framework of their physical and economic limitations. Specifically, they may desire to know the quantities they should produce at certain projected prices if they have to maximize profits. Here the dearth of useful information is more pronounced. Hence a suitable supply function establishing the relationship between the relevant variables would appreciably reduce their imperfect knowledge.

Estimation of supply responses will help farmers to know the maximum factor prices they can afford to pay at a particular level of production still maintaining profit maximization as their objective. With such information, the farmers

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1. Most of the work done pertains to the time series analysis of acreage response of commodities to price changes.

e.g. (*i*) Raj Krishna, "Farm Supply Response in India-Pakistan : A Case Study of the Punjab Region," *The Economic Journal*, Vol. LXXIII, No. 291, September, 1963, pp. 477-487. (*ii*) Dharm Narain, "Impact of Price Movements on Areas under Crops in India," *The Indian Economic Review*, Vol. 5, No. 2, August, 1960, pp. 116-141. (*iii*) Some of the papers published under the subject "Structure of Relative Prices of Farm Products in Relation to Their Production and Supply" in the *Indian Journal of Agricultural Economics*, Conference Number, Vol. XX, No. 1, January-March, 1965, pertain to this subject.

This paper is based on a cross-sectional study of data collected from farmers.

2. R. L. Mighell and R. H. Allen, "Supply Schedules 'Long Time' and 'Short Time'," *Journal of Farm Economics*, Vol. 22, No. 3, August, 1940, p. 557.

can estimate the additional quantities of commodities they can supply and thereby the increased returns they can obtain by getting control of additional resources. This in turn will help the farmers in the optimum allocation of scarce resources and provides them guidelines to make better short and long run decisions on investment and planning. Firms producing inputs used in agriculture can also make use of this type of information for investment planning.

Objectives:—The specific objectives of this study are :

(i) to determine the functional relationship between the fixed cost, variable cost and output;

(ii) to estimate the supply response to varying product and factor prices;

(iii) to estimate factor demand at varying factor prices; and

(iv) to estimate the price elasticity of supply.

Characteristics of the Region

Mandya district is located in the southern part of the dry belt in Mysore State. The average annual rainfall in the district is 611.65 millimetres. The rainy season extends from May to November. The climate is moderate with the temperature varying between 15.5°C and 36.5°C. The soils are mainly lateritic and range from red sandy loams to red clay loams.

The district has 26 per cent of the total cultivated area under irrigation which is the highest in Mysore State, where the average area under irrigation is about 11 per cent. Paddy, sugarcane, irrigated *ragi* and tobacco are the important irrigated crops. *Ragi*, jowar, oilseeds and pulses are the major crops grown under rain-fed conditions.

Source of data

The data collected for the year 1962-63 by the Farm Management Research Centre, Bangalore, in the Mandya district, have been utilized. A multi-stage stratified sample was selected in the Mandya district. The district was divided into two broad zones, namely, canal area and non-canal area, consisting of 5 and 2 talukas respectively. From each zone ten clusters of two villages each were selected at random. In each selected village four farmers were chosen from each size-group of operational holdings, *viz.*, less than 2 acres, 2 to 4.99 acres, 5 acres and above. The sample thus consists of 240 farmers.

Transplanted paddy is grown both in canal and non-canal areas. Among the selected farmers 118 have grown transplanted paddy of whom 105 have grown it in the canal area and the remaining in the non-canal area. With a purpose of having a homogeneous group only the farmers in the canal area are included in the study.

Time Series and Cross-Sectional Analysis

Supply function can be derived either by using time series or cross-sectional data depending upon the objectives in view. Time series data are generally used to

project into the future total agricultural output or output of individual commodities. Cross-sectional data are used to derive supply responses which would help to use the resources optimally. Since the object of this paper is to derive optimum supply responses at different product and input prices cross-sectional data are considered to be more suitable and hence used in the analysis.

Technique of Analysis

Various techniques can be used in estimating supply responses, *viz.*, budgeting, linear programming and production functions. Budgeting with all its limitations has proved to be a useful tool in deriving supply responses. It should be used by experienced workers. It has been commonly used to estimate what would be most profitable. The gap between the estimate and the actual is quite often wide and depends on the judgment of the research worker and the information on the past responses furnished by other analysis.

Linear programming is another tool used to derive normative supply functions. When resources are to be allocated among a number of competing enterprises on a farm, the estimation of normative supply functions assumes importance.[3] Estimates of the normative supply function for a particular product of a farm at different product prices can be obtained by variable price programming. The quantities produced at different prices can be obtained from the successive iterations which can be used in constructing the supply schedule.

Production function approach is also used in deriving positive supply responses using cross-sectional as well as time series data. This provides a picture of what is likely to happen when the price of the commodity in question changes, with those of the factors remaining constant or when the price of the commodity changes relative to the prices of the factors. In the present study, the production function approach is used.

Selection of a Production Function

Estimation of supply response through production function using cross-sectional data can be done in two ways. First, the underlying physical relationship can be estimated by a production function and then using input prices the cost and supply functions can be derived. Second, the cost and supply relationships can be estimated directly by using the cost data of the individual farm units.[4] The latter approach has been followed in the present study.

Several production functions can be used for determining the relationships between the inputs and output depending upon the agronomic and economic logic underlying such relationships and the availability of computational facilities. Some of the more commonly used functions are quadratic, quadratic with square-

3. D. E. Mckee and L. D. Loftsgard, "Programming Intra-Farm Normative Supply Functions," in Agricultural Supply Functions—Estimating Techniques and Interpretation, Edited by E. O. Heady and Others, Iowa State University Press, Ames, Iowa, U.S.A., 1961, p. 152.

4. E. W. Kehrberg, "Determination of Supply Functions from Cost and Production Functions," in Agricultural Supply Functions—Estimating Techniques and Interpretation, *Op. cit.*, p. 142.

root transformation and Cobb-Douglas.[5] These functions have their own merits and demerits. Some of them may be more suited to this type of analysis than others. However, the following Cobb-Douglas production function of logarithmic form has been fitted to the data as it would provide a reasonably adequate fit.

$$\log Y = \log b_0 + b_1 \log X_1 + b_2 \log X_2$$

where, Y is output, X_1 and X_2 are the inputs, b_o is the constant, b_1 and b_2 are the regression coefficients.

The merits that weighed in favour of selection of this function are: (1) The computational work involved in fitting this function is relatively less as compared to that of other functions. Since there are as many as 105 observations, fitting of other functions like quadratic would involve, considerably more computational work especially in the absence of electronic computers. (2) Derivation of supply function is easier. (3) The function permits diminishing marginal productivity while still using linear regression analysis. (4) Returns to scale are obtained directly by summing the regression coefficients.

It should, however be recognized that this function has the following demerits: (1) It assumes constant rate of substitution between inputs when they are increased proportionately. (2) It assumes constant elasticity of production.

Selection of Variables

Supply function gives the quantity of commodity supplied at different prices. This assumes that factors like the production technology, cost of the inputs, and the prices of the competing products remain constant.[6] Under assumptions of perfect knowledge and profit maximization, a firm's static supply function can be derived from its cost function. The marginal cost function above its average variable cost is the firm's supply function. Aggregating firm's supply functions, the industry supply function can be obtained.

Supply of transplanted paddy is a function of inputs which can be broadly classified as fixed and variable. The fixed cost remains fixed with respect to an individual firm. In a cross-sectional analysis fixed cost becomes variable since the level of investment from firm to firm varies. Further, when supply is estimated as a function of variable cost holding fixed cost constant at its geometric mean, the fixed cost is assumed to be representative of an average firm.

Fixed inputs included in the analysis are : (1) rent or rental value, (2) interest on investment on buildings, implements and machinery, (3) depreciation charges on buildings, implements and machinery, and (4) revenue and taxes.

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5. Examples of these functions are :
   Quadratic : $Y = b_o + b_1 X_1 + b_{11} X_1^2 + b_2 X_2 + b_{22} X_2^2 + b_{12} X_1 X_2$.
   Quadratic : (Square-root) $Y = b_o + b_1 X_1^{.5} + b_{11} X_1 + b_2 X_2^{.5} + b_{22} X_2 + b_{12} X_1^{.5} X_2^{.5}$
   Cobb-Douglas : $Y = b_o X_1^{b1} X_2^{b2}$
   where Y is output, X_1 and X_2 are variables, b_o is a constant and b's are coefficients.

6. J. E. Kadlec, *et al.*: Estimation of Supply Functions for Milk in Louisville Milkshed with Farm Cost Data, Research Bulletin No. 720, Purdue University, Lafayette, Indiana, U. S. A., 1961, p. 3.

Variable inputs included are expenses on: (1) seed, (2) labour, (3) manures and fertilizers, (4) water, (5) repair charges and miscellaneous charges, and (6) disease and pest control measures.

The quantity of a commodity produced by a farmer is influenced among other things by its price. In the short run, varying his production necessitates changes in the variable costs. Also the level of production is determined by the level of fixed costs.[7] Hence supply is regarded as a function of fixed and variable costs.

Assumptions

The assumptions involved in the study are : (1) Farmers supply whatever they produce, *i.e.*, they do not speculate or hoard.[8] (2) The variation in the production of transplanted paddy does not result in external economies or diseconomies. (3) There will be no change in the number of farmers producing the crop. (4) The objective of the farmers is profit maximization. And (5) the prices of the competing products remain the same.

Estimated Production Function

The function fitted to the data by following the least squares regression technique is

$$\log \quad Y = 1.1130 + 0.7631 \log X_1 + 0.1867 \log X_2$$

where, Y is output in pounds, X_1 is the fixed cost in rupees, and X_2 is the variable cost in rupees. The multiple correlation coefficient R is 0.92, the coefficient of multiple determination (R^2) is 84.64 per cent and when adjusted $\bar{R}^2$ is 84.34 per cent. This means that as much as 84.34 per cent of the total variation in the yield is explained by the independent variables. Both the regression coefficients are significant at 1 per cent level. The results are presented in Table I.

TABLE I—RESULTS OF MULTIPLE REGRESSION ANALYSIS, TRANSPLANTED PADDY, MANDYA DISTRICT : 1962-63

Input category	Geometric mean* (Rs.)	Regression coefficient	Standard error	't'	Significance†
Fixed Cost	619	0.7631	0.0605	12.6135	Significant at 1 per cent level
Variable Cost	375	0.1867	0.0690	2.7036	Significant at 1 per cent level

* The geometric mean of Y is 5294.
† 't' at 1 per cent for 102 d.f. is 2.58.

7. Fixed costs also reflect the level of technology and quantities of physical inputs like land, machinery and implements.
8. J. E. Kadlec, *et. al.: Op. cit.*

Interpretation of the Results

The regression coefficients in a Cobb-Douglas function are the elasticities of production which represent the change in output due to one per cent change in the corresponding input. That is, the regression coefficient of fixed cost (0.7631) represents the per cent change in output due to one per cent change in fixed cost. Similarly, the regression coefficient of variable cost (0.1867) represents the per cent change in output due to one per cent change in variable cost.

The sum of the regression coefficients indicates increasing, constant or decreasing returns to scale according as their sum is greater than, equal to or less than one, respectively. The sum of the regression coefficients is 0.9497, which indicates decreasing returns to scale. However, the 't' test[9] showed that it is not significantly different from unity. In other words, the function gives constant returns to scale.

The standard errors of the regression coefficients reflect the relative reliability of the corresponding coefficients. Thus, one per cent change in the fixed cost will, on an average, result in 0.7026 to 0.8236 per cent change in output holding all other factors constant. Likewise one per cent increase in the variable cost holding fixed cost constant at its geometric mean will, on an average, result in an increase of 0.1177 to 0.2557 per cent in output. Both the regression coefficients are less than unity indicating diminishing marginal returns to each input holding the other input constant.

Supply Function

In a Cobb-Douglas function of the type, $Y = a\ X_1^{b1}\ X_2^{b2}$ the supply function is given by the following formula

$$\log Y = \frac{b_2}{1 - b_2} \log b_2 + \frac{1}{1 - b_2} \log a + \frac{b_1}{1 - b_2} \log X_1 + \frac{b_2}{1 - b_2} \log P_y - \frac{b_2}{1 - b_2} \log P_2$$ [10]

where, Y is the supply of the product in pounds,

X_1 is the fixed cost in rupees,

X_2 is the variable cost in rupees,

a is a constant,

b_1 and b_2 are the regression coefficients of X_1 and X_2 respectively.

P_2 and P_y[11] are the prices of input X_2 and the product Y respectively.

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9. The following statistic was used to test whether the sum of regression coefficients is significantly different from unity.

$$| t | = \frac{| b_1 + b_2 - 1 |}{| \sqrt{V(b_1) + V(b_2)} |}$$

10. E. O. Heady, "Uses and Concepts in Supply Analysis" in Agricultural Supply Functions—Estimating Techniques and Interpretation, *Op. cit.*, pp. 11-12.

11. In this case P_2 is the price of a unit of variable cost, which is equivalent to the unit of variable cost plus its interest rate. Since the unit of variable cost is a rupee and its prevailing rate of interest (for short term loans) is 0.09, the price will be Re. 1.09, P_y is Re. 0.17 per pound of paddy which is the prevailing market rate in the area of study.

Thus, output becomes a function of b_1 and b_2 with X_1 constant at a specified level given the prices P_y and P_2. By varying the price of the product (P_y) the quantities of the product produced at the respective prices can be estimated. Using this procedure the supply function of transplanted paddy at its different prices has been determined. The price (P_2) of variable cost is held constant at Re. 1.09 and the fixed cost (X_1) is held constant at its geometric mean[12] (Table II).

TABLE II—SUPPLY OF TRANSPLANTED PADDY AT VARYING PRODUCT PRICES, MANDYA DISTRICT : 1962-63

Product price P_y (Rs.)	Output per farm (lbs.)	Added output (lbs.)	Supply of the sample farmers (lbs.)
0.12	3,989		4,18,845
0.14	4,131	142	4,33,755
0.16	4,261	130	4,47,405
0.18	4,377	116	4,59,585
0.20	4,484	107	4,70,820

The supply function indicates that with increase in the price of output the supply increases at a decreasing rate.

The supply as obtained by the above formula is for the average (representative) farm of the sample. Using this information, the supply of the commodity for the sample farmers is estimated by multiplying the farm supplies by the number of farms in the sample growing transplanted paddy (*i.e.*, 105). Similarly, if the number of farmers in the population as a whole is known, the total supply of transplanted paddy in the Mandya district can be estimated. It has not been done in this case as the information is not available.

Changes in Supply with Varying Factor Price

Changes in factor prices also affect the supply of paddy. From the above equation, the supplies of paddy that would be forthcoming at different prices of the inputs holding the product price constant can also be worked out. The extent of variation in paddy supplies has been studied by varying the price of variable cost from Re. 1.04 to 1.14 holding constant the product price at Re. 0.17 per pound of paddy and the fixed cost at its geometric mean (Table III).

12. Series of similar supply functions can be generated by varying the interest rate of variable capital and holding the fixed cost constant at different levels and vice versa.

TABLE III—SUPPLY OF TRANSPLANTED PADDY WITH VARYING FACTOR PRICES, MANDYA DISTRICT : 1962-63

Interest rate per rupee (Rs.)	Price of a unit of variable cost (Rs.)	Supply of paddy per farm (lbs.)	Supply for the sample (lbs.)
0.04	1.04	4,367	4,58,535
0.06	1.06	4,348	4,56,540
0.08	1.08	4,329	4,54,545
0.10	1.10	4,311	4,52,655
0.12	1.12	4,293	4,50,765
0.14	1.14	4,276	4,48,980

It can be seen that as the interest rate increases the supply goes down at a negligible rate and vice versa. In other words, changing interest rate does not affect supply appreciably.

As discussed above, the supply for the population can also be estimated by following the same procedure.

Factor Demand at Varying Factor Prices

The demand for factors depends on the factor-product price ratios. Holding constant the product price at Rc. 0.17 per pound of paddy and the fixed cost at its geometric mean, the factor demand is estimated at various factor prices (Table IV). This can be derived in case of X_2 (variable cost) by using the following formula:

$$\log X_2 = -\frac{1}{b_2 - 1}(\log b_2 + \log a + b_1 \log X_1 + \log P_y - \log P_2)$$

where, X_1 and X_2 are fixed and variable costs,

a is a constant,

b_1, b_2 are regression coefficients of X_1 and X_2,

P_y and P_2 are the prices of the product and the variable costs.

TABLE IV—DEMAND FOR VARIABLE CAPITAL FOR GROWING TRANSPLANTED PADDY AT DIFFERENT INTEREST RATES, MANDYA DISTRICT : 1962-63

Interest rate per rupee (Rs.)	Price of a unit of variable cost (Rs.)	Demand for variable capital (Rs.)	Demand for variable capital for the sample as a whole (Rs.)
0.04	1.04	133.2	13,986
0.06	1.06	130.2	13,671
0.08	1.08	127.2	13,356
0.10	1.10	124.4	13,062
0.12	1.12	121.6	12,768
0.14	1.14	119.1	12,506

With the increase in the interest rate the demand for the variable capital decreases at a negligible rate. The demand for variable capital at the prevailing interest rate would be about Rs. 126 which is much less than the average (geometric) variable capital of Rs. 375 used at present. This indicates that the present productivity of variable capital is not sufficient to meet its cost. Hence to meet the cost the farmer should increase the productivity of variable capital.

Elasticity of Supply

Supply or production responds to changes in the prices of product and input factors. From the macro aspect a policy-maker would like to know the changes in production or supply (assuming that whatever is produced is supplied) which would result from a certain change in the price of the product. This can be known by working out the elasticity of supply at different product prices, holding constant the factor price at Re. 1.09 and fixed capital at its geometric mean. Elasticity of supply represents the percentage change in supply due to one per cent change in the product price.

TABLE V—PRICE ELASTICITY OF SUPPLY OF TRANSPLANTED PADDY AT SELECTED PRODUCT PRICES, MANDYA DISTRICT : 1962-63

Price of transplanted paddy (P_y)		Elasticity of supply (E_s)
0.12	..	0.2331
0.14	..	0.3042
0.16	..	0.3134
0.18	..	0.3221
0.20	..	0.3299

The elasticity of supply at a particular point is known as the point elasticity. The average elasticity prevailing in an interval is known as arc elasticity. In this case, point elasticity has been worked out by using the formula

$$E_s = \frac{dy}{dp_y} \cdot \frac{P_y}{y} = b_2 \frac{b_2}{1-b_2} \cdot a \frac{1}{1-b_2} X_1 \frac{b_1}{1-b_2} P_2 \frac{1}{b_2-1} -1 P_y \frac{1}{1-b_2} \cdot$$

The results indicate that the elasticity of supply increases with the increase in the price of paddy.

Summary and Conclusions

Study of supply response is helpful for formulating realistic farm policies. It also helps farmers to decide about their level of production keeping in view the physical and economic relationships. A power function of Cobb-Douglas type has been fitted to the data on transplanted paddy obtained from 105 farms of Mandya district. Output is considered as a function of inputs represented by fixed and variable costs. The regression coefficients for both fixed and variable

capital turned out to be significant at one per cent level. Each indicates decreasing marginal returns holding the other constant. The sum of the regression coefficients indicate constant returns to scale as it is not significantly different from unity. The analysis indicates that supplies can be increased by either increasing the product price or reducing the prices of the input factors.

It is shown that the farmers are using more variable capital at the current interest rate than what they can afford depending on the present productivity. The results indicate that with one per cent change in the price of the product, it would be possible to increase the supply of transplanted paddy by about 0.30 per cent.

Suggestions for Further Study

As seen from the analysis (Table IV), the productivity of the variable capital is very low. This may be due to the fact that some of the important items which constitute the variable capital may have very low productivity which in turn pulls down the aggregate productivity of the variable capital. This can be examined by a separate study where the constituent factors appear as separate variables.

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AND
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A SURVEY OF SHEEP AND WOOL PRODUCTION IN THE PLAINS OF PUNJAB STATE

Introduction

A correct assessment of the position of any commercial commodity forms an essential requirement for development plans and increased production of any country. Sheep and wool are important commercial products to provide clothings and meat. Development of both these products have attracted greater attention in recent years in the country due to the chronic food shortage and increased requirement of warm clothings for civil population and defence forces. With a view to studying the position of sheep and wool in the plains of the Punjab State, a survey was planned during the year 1963-64. A survey of this type has already been completed by the Institute of Agricultural Research Statistics in the hill region of some parts of the State. The objects of this survey were (1) to get a reliable estimate of total sheep, their breed composition and wool production in the State, and (2) to collect reliable data on wool trade, marketing facilities and turn over of wool business in the various wool markets of the State.

Plan of Survey

The survey covered the entire Punjab State excluding the districts of Hoshiarpur, Kapurthala, Jullundur, Kangra, Kulu, Lahaul and Spiti and Simla. This area included approximately 77 per cent of the sheep population of the whole

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State. For the purpose of survey, the whole region was divided into 13 strata and the names of the tehsils included in each stratum with the tehsils selected in each for sampling, were as follows:

Stratum No.	Tehsils included in each stratum	Tehsils selected from each stratum
1	Rupar, Sirhind, Samrala, Gurdaspur, Batala, Kharar, Nabha, Gohana, Nalagarh	2
2.	Rohtak, Amritsar, Sonepat, Ballabgarh Zira, Naraingarh, Ajanala, Jhajjar, Ferozepur,—Jhirka and Ludhiana	2
3.	Gurgaon, Jagadhri, Patti, Tarn Taran, and Thanesar ..	2
4.	Ambala, Dadri, Nuh, Jagraon, Palwal, Mohindergarh, Pathankot and Rajpura	3
5.	Patiala, Rewari, Panipat, Karnal, Jind and Malerkotla ..	3
6.	Fatehabad, Bhiwani, Ferozepur Nurnaul, Barnala, Sangrur, Narwana, Moga, Kaithal and Faridkot	6
7.	Hansi	1
8.	Hissar	1
9.	Muktsar	1
10.	Mansa	1
11.	Fazilka	1
12.	Sirsa	1
13.	Bhatinda	1
Total	55	25

Thus a sample of 25 tehsils was selected from the entire region and distributed to the strata in proportion to the sheep population of each stratum according to the Livestock Census 1961. Within each tehsil, three clusters of three villages were selected. Towns were also included in the sample. Selection at every stage was with equal probability without replacement. For the estimation of wool yield and body-weight one more stage of sampling was introduced. From every flock in each of the villages/towns selected, two rams, two ewes and two lambs were selected at random.

Procedure Followed for Collection of Data

The collection of data which included migratory and stationary flocks covered a period of four months from the last week of July to the last week of October, 1963. It consisted of recording the number of sheep in each flock in the selected villages, their breedwise and age-groupwise distribution, wool yield and its mode of disposal and acquisition of sheep. Additional information was collected in respect of migratory flocks, with regard to the place of migration, distance covered during migration and the months of leaving and return.

In each selected village general information such as marketing facilities, etc., was also collected.

The field staff consisted of one field officer, six supervisors and 23 enumerators (Stock Assistant). The analysis of the data was carried out by the Statistical Cell of the Animal Husbandry Department.

Results: Estimate of Sheep Numbers

All sheep in each selected village were counted and were categorized into breed types and age-groups. While categorizing the sheep into breed types, they were classified into five different types, *viz.*, Nali, Bikaneri or Bagri, Lohi, *Desi* and Munjal (probably a cross between Nali and Lohi). Except for Lohi which has its home in Pakistan, other types are indigenous to this region. The presence of Lohi sheep as such is for the few flocks of sheep brought by refugees at the time of partition from West Pakistan. Firstly, an estimate of sheep population for each selected tehsil was obtained by simple estimate and thereafter for each stratum by ratio method. Adding up the estimates for the 13 strata the total sheep population for the plains of the Punjab State was obtained.

The estimate of sheep numbers of the stationary flocks was obtained from the actual count of all sheep whereas in the case of migratory flocks only such sheep were counted which could be contacted at the time of the visit of the enumerators. In the entire region, there were 789 flocks out of which 82 per cent were stationary and 18 per cent migratory; 35 per cent of migratory flocks could not be contacted.

It was estimated that during the period of survey there were about 7.87 lakhs of sheep in the plains of the Punjab State. This figure was estimated with a percentage standard error of 7.7. Table I shows the estimated sheep population with their standard errors, in each stratum.

TABLE I—ESTIMATES OF SHEEP POPULATION IN DIFFERENT STRATA

Stratum No.	Sheep population	Standard error	Percentage of standard error
1.	6,564	2865	43.65
2.	24,660	4919	19.95
3.	27,270	12776	46.85
4.	89,611	30566	34.11
5.	95,068	20685	21.76
6.	2,46,549	36012	14.61
7.	30,498	10068	33.01
8.	36,322	11076	33.04
9.	29,275	7380	25.21
10.	50,350	10707	21.27
11.	35,436	8770	24.75
12.	61,495	12123	19.71
13.	53,904	11838	21.96
Total	7,87,002		7.70

The percentage distribution of sheep according to breeds and classes, namely, rams, ewes and wethers (above one year of age) and lambs (below one year of age) is presented in Table II;

TABLE II—PERCENTAGE DISTRIBUTION OF SHEEP ACCORDING TO BREEDS AND CLASSES

Breeds	Classes				
	Rams	Wethers	Ewes	Lambs	Overall
Munjal	0.59	—	16.94	4.59	22.12
Nali	2.30	0.02	45.10	10.04	57.46
Desi	0.75	—	10.18	3.43	14.36
Bikaneri	0.08	0.07	1.13	0.56	1.84
Lohi	0.09	—	2.99	1.13	4.21
	3.81	0.09	76.34	19.75	99.99

From the table, it is evident that 57.46 per cent of the sheep were of Nali breed, 22.12 per cent of Munjal, 14.36 per cent of *Desi*, 4.21 per cent of Lohi and the rest are of Bikaneri breed. It is further noted that 76.34 per cent of sheep were ewes above one year of age, 3.81 per cent were rams and 0.09 per cent were wethers. The lambs under one year of age of both sexes considered together were 19.75 per cent.

It would be interesting to compare the estimate of sheep population as obtained in this survey with the sheep numbers as reported in the 1961 Livestock Census. According to the Census, there were about 6.84 lakhs of sheep in the plains of Punjab State. The increase as such in the sheep population since the Livestock Census 1961, was 15 per cent.

Distribution of Flock Size and Number of Rams per Breeding Flock

It was found that about 57 per cent of the stationary flocks were having 40 sheep or less. Only 6 per cent of the flocks constituted more than 100 sheep. On the other hand, about 46 per cent of the migratory flocks were of the size of 40 sheep or less and 10 per cent of the flocks were having 100 or more sheep. The average size of the flock in stationary and migratory type of sheep were 38 and 49 respectively.

In about 26 per cent of the stationary flocks and about 17 per cent of the migratory flocks no rams were kept. However, in such cases the average flock sizes were 9 and 22. In about 71 per cent of the stationary and 79 per cent of the migratory flocks the number of ram was between 1 to 3, which showed that the common practice was to keep less than 4 rams in a flock. Even though there was a tendency to have more rams in bigger flocks, the average number of ewes per ram showed a decreasing trend as the number of rams in a flock increased.

Presence of Other Livestock in the Sheep Flocks

The flock owners were also noticed to have other types of livestock with their sheep. About 62 per cent of the flock owners of stationary type of sheep and 77 per cent of the flock owners of migratory type of sheep had kept goats in their flocks. About 79 per cent of the former type and 58 per cent of the latter type had bovines.

Average Clip Yield of Sheep

For estimating the average wool yield per sheep, two rams, two ewes and two lambs were selected at the time of shearing (August-September clip) from every flock in the selected villages. The grease fleece weights of the selected sheep were recorded in kilogram. The wool yield in Ferozepur tehsil could not be recorded as the shearing had already been carried out before the commencement of the survey. The general practice in the plains of the Punjab State is to allow the growth of wool on the body of the sheep for a period of 4 to 6 months in accordance with the practice of obtaining 2 to 3 clips in a year. The average wool yield with their standard error in different strata is given in Table III.

TABLE III—AVERAGE WOOL YIELD AND STANDARD ERROR

Stratum No.	Average wool yield in kg.		
	Rams	Ewes	Lambs
1.	0.72 (0.14)	0.77 (0.03)	0.65 (0.08)
2.	1.47 (0.02)	0.98 (0.04)	0.93 (0.06)
3.	1.11 (0.08)	0.78 (0.12)	0.67 (0.20)
4.	0.53 (0.04)	0.38 (0.01)	0.48 (0.04)
5.	1.07 (0.13)	0.71 (0.10)	0.45 (0.10)
6.	1.74 (0.28)	1.10 (0.20)	0.66 (0.06)
7.	1.59 (0.01)	1.08 (0.01)	1.01 (0.01)
8.	1.29 (0.05)	1.03 (0.04)	0.56 (0.04)
9.	1.02 (0.04)	0.87 (0.02)	0.05 (0.05)
10.	1.70 (0.07)	1.28 (0.06)	0.98 (0.03)
11.	1.47 (0.21)	0.89 (0.07)	— (—)
12.	2.32 (0.11)	1.75 (0.08)	0.11 (0.07)
13.	1.51 (0.01)	1.03 (0.01)	0.50 (0.01)
Overall	1.35 (0.15)	0.97 (0.08)	0.65 (0.08)

Note : Figures in brackets are standard errors.

It was estimated that on an average a ram yielded 1.35 kg. of wool per September clip, an ewe 0.97 kg. and a lamb 0.65 kg. The standard error of these estimates were 0.15, 0.08 and 0.08 respectively. The average wool yield for ram and ewes was the highest (2.32 for rams and 1.75 for ewes) in stratum No. 12 (Sirsa tehsil) and was the lowest (0.53 for rams and 0.38 for ewes) in stratum No. 4 (Palwal, Pathankot and Rajpura tehsils). For lambs, the average wool yield (1.01) was the highest in stratum No. 7 (Hansi tehsil) and was the lowest (0.45) in stratum No. 5 (Patiala, Rewari and Jind tehsils).

The average wool yield for rams, ewes and lambs was also estimated for each breed separately and are presented in Table IV.

TABLE IV—AVERAGE WOOL YIELD PER CLIP OF DIFFERENT BREEDS

Breed	Rams	Ewes	Lambs
Munjal	2.05	1.73	0.99
Nali	1.73	1.24	0.73
Bikaneri	1.25	1.00	0.79
Desi	0.89	0.74	0.55
Lohi	0.87	0.73	0.55
Overall	1.35 (0.15)	0.97 (0.08)	0.65 (0.08)

From the table it is evident that the average wool yield in kilogram for rams, ewes and lambs was the highest in Munjal breed followed by Nali and Bikaneri breeds. It was the lowest in the case of Lohi breed. The average wool yield of *Desi* was approximately of the same order as that of Lohi breed.

In any sheep development programme, to step up wool production, ewes play an important role by virtue of their numbers constituting about 76 per cent of the sheep population. Rams of high transmitting ability would be needed to give forth progeny of better wool yielding capacity. Thus in order to upgrade the *Desi* and Lohi breed the rams of Munjal and Nali breeds may be used respectively.

From the survey, it was found that the Nali and Munjal breeds were mostly located in the arid and semi-arid zones adjoining Rajasthan whereas the *Desi* breed was found in the central zone comprising of Patiala, Rajpura, Sirhind Nalagarh, Pathankot and Amritsar tehsils. The poor type of sheep in this area is probably due to the fact that it comes under intensive cultivation with comparatively heavy rainfall for which the pastures are minimized and the environments are not very suitable for wool type sheep. Mutton type sheep might prove more useful for this area where introduction of a new programme is suggested. The Lohi sheep were found to be only confined to the Ferozepur district which appear to have been brought by the refugees from West Punjab at the time of partition.

Estimation of Total Wool Production

The wool production in the August-September shearing season was estimated at 5.11 lakh kgs. with a percentage of standard error 10.17. Ewes contributed about 86 per cent to the total wool production followed by lambs and rams, each category contributing about 8 and 6 per cent respectively.

Disposal of Wool

Information on modes of disposal of wool from the households in the sample was also obtained. It was revealed that 75 per cent of wool was sold against cash payment, 17 per cent was lying at home undisposed and about 5 per cent was utilized for home consumption. The remaining 3 per cent was sold either against money advanced or against deferred payments.

The majority of the wool was sold to wool merchants by previous contract. Under the contract system, the price is fixed in advance and 20 per cent of the total estimated value of wool is given as advance. The rest of the balance is paid after the sheep are shorn. Further, the shearing is to be completed within a stipulated period.

Direct sale by the flock masters in the market was not found to be a common practice. About 60 per cent of the flock masters sold their wool by number of sheep without weighing and only 40 per cent by actual weighment.

Before selling the wool to the wholesale merchants, the contractors remove the vegetable matter like burr, etc., and grade the fleeces on the basis of colour. There are two wool processing units (one at Fazilka and other at Panipat) within the area covered. No co-operative credit facilities are available to the flock owners.

On enquiry, it was found that a kilogram of wool sold by the flock master fetched him on an average about Rs. 4.62 (range Rs. 4.00 to 5.25). The contractors sold the wool to the wool merchants in the wool markets at the rate of Rs. 7 (range Rs. 6 to 8).

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COST OF CULTIVATION IN RELATION TO THE SIZE OF HOLDING‡

Introduction

The question of relation of size of holding and cost of cultivation has been frequently discussed by research workers and it is generally expected that an in-

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‡ The author wishes to thank Shri S. D. Bokil, Senior Statistician, Institute of Agricultural Research Statistics (I.C.A.R.) for guidance in the preparation of this paper. Thanks are due to Dr. Jai Krishna, Agricultural Prices Commission, Government of India, and Dr. S. C. Gupta, Agricultural Economics Research Centre, University of Delhi for their valuable comments and suggestions. The author is also grateful to Dr. D. Singh, Deputy Statistical Adviser, Institute of Agricultural Research Statistics for encouragement and advice without which the preparation of this paper would not have been possible.

creasing size of holding would lead to economies in cost and consequently to greater return per acre. A study of bearing of size of holding on cost per acre and cost per maund is relevant to a discussion of farming efficiency. The purpose of the present paper is to analyse some data on cost of cultivation of wheat taken from a survey for estimating cost of cultivation of cotton, oilseeds and rotation crops with this objective. Details regarding the survey and the data studied are given in the next section.

Data Studied

A survey for estimating cost of cultivation of cotton, oilseeds and rotation crops was taken up by the I.C.A.R. jointly with the Central Cotton and Oilseeds Committees in important cotton tracts of the country. In Punjab the survey covered the districts Ludhiana, Bhatinda, Sangrur and Hissar. The districts Ferozepur and Amritsar were not included in the enquiry though they were important cotton districts as they had already been covered by the farm management surveys undertaken by the Directorate of Economics and Statistics, Union Ministry of Food and Agriculture. The survey commenced in the year 1960 and the data for 1960-61 for a number of crops became available from the survey. Data for wheat were taken for study as it represents the principal foodgrain of the region.

The design of the survey was stratified two stage random sampling design with districts as strata, village as first stage unit and holding as the second stage unit. For selection of holdings-size, stratification was adopted at the second stage of selection to facilitate estimation of cost of cultivation separately for three broad size-classes, *viz.*, small, medium and large. Class limits of the three size-classes were as follows: small: less than 15 acres, medium : 15-30 acres and large : 30 acres and above.

In all, 40 villages were selected for the survey and in each village 8 holdings were selected, 2 from large size-class and 3 each from the other two classes, selection within the size-class being done by simple random sampling. Crop-cutting experiments were conducted for various crops to arrive at an independent estimate of production. The data used in this study relate to 155 holdings for which such crop-cutting data on wheat were available. Other holdings did not either grow wheat or crop-cutting data for these holdings were not available.

TABLE I—DISTRIBUTION OF HOLDINGS ACCORDING TO SIZE-CLASS AND DISTRICTS

District	Size of holdings			Total
	Small	Medium	Large	
Bhatinda	7	9	9	25
Ludhiana	15	16	8	39
Sangrur	26	29	11	66
Hissar	9	11	5	25
Total	57	65	33	155

The concept of cost adopted for this study is that of the prime cost which appears to be the one appropriate to the study of efficiency of cultivation. This concept does not involve many problems of evaluation and allocation. Wage-paid labour and purchased stores were costed at the wages and prices paid. Family labour was costed at the rates for casual labour. Depreciation on implements was allocated to various crops at a flat rate according to area. The gross cost per acre was worked out for each of the 155 holdings. Net cost, *i.e.*, cost taking into account the bye-product, *bhusa*, was taken as 0.7394 times the gross cost, the fraction having been arrived at on the basis of data on contribution of grain and *bhusa* to gross output. Similar results for output of grain per acre, costs of human labour and bullock labour per acre were also worked out. The averages for three size-classes for these characters are given in Table II.

TABLE II—AVERAGES FOR PRODUCTION PER ACRE AND FOR DIFFERENT COSTS

Size of holding	No. of holdings	Production seer/ acre	Cost of human labour Rs./acre	Cost of bullock labour Rs./acre	Prime cost (gross) Rs./acre	Prime cost (Net) Rs./acre	Net cost Rs./maund
Small ..	57	619	85	120	236	165	10.69
Medium ..	65	650	99	93	211	154	9.49
Large ..	33	677	72	68	175	123	7.29

Discussion

It is seen from the table that there is an increasing trend in output per acre with increase in holding-size. The differences between size-classes are, however, non-significant at 5 per cent level. Similarly, human and bullock labour inputs decrease with increase in holding-size and consequently the cost per acre decreases. These differences are also non-significant. The cost per maund also declines with holding-size and these differences are, however, significant.

The correlation coefficients for size of holding and inputs of human labour, bullock labour, cost per acre and cost per maund were also calculated which are as under :

1. Human labour and size of holding ... —0.23**
2. Bullock labour and size of holding ... —0.35**
3. Cost per acre and size of holding ... —0.24**
4. Cost per maund and size of holding ... —0.21**

** Significant at 1 per cent level.

The coefficients of correlation in all the cases are found to be negative, as is expected. Though the values of coefficients of correlation are small, they are highly significant as the number of holdings available for analysis was sufficiently large (155). Similarly, the coefficient of correlation between size of holding and output was found to be 0.02, a non-significant value which shows that the output per acre is not related to the size of holding.

The trend of cost with holding-size can also be studied with the help of regression analysis. This was done by working out initially the linear regression and subsequently the quadratic regression of net cost per maund on holding-size. The analysis of variance in that case is given below.

Source of variation	D.F.	S.S.	M.S.	F
Regression (linear)	1	191.30	191.30	7.18**
Curvilinearity of regression	1	75.14	75.14	2.85
Constants due to linear and quadratic ..	2	266.44	133.22	5.06*
Deviation from quadratic regression ..	152	4003.09	26.34	
Total	154	4269.53		

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

It is clear that the second degree equation has provided a closer fit to the data than the linear equation. However, the variation ascribable to curvilinearity of regression is much less than that ascribable to the linear trend. It does not appear likely that a third degree curve would give a significantly better fit or result in any material change in the shape of the curve within the range of values represented by the data. The following second degree equation represents the relation between net cost per maund and holding-size.

$$Y = 14.44 - 0.306x + 0.0037x^2$$

(net cost Rs./maund)

On the basis of this equation it is seen that upto a size of 40 acres there is gain in efficiency inasmuch as the cost per maund declines with increase in holding-size upto this point.

Similar analysis was also done with cost per acre and holding-size and it was found that the linear regression coefficient as well as the curvilinearity of the regression was significant. The relation of cost per acre and holding-size is given by the following equation :

$$Y = 207.69 - 4.358x + 0.0545x^2$$

(net cost Rs./acre)

On the basis of this equation also the minimum cost is reached for a holding-size of about 40 acres (39.98). It appears from the above analysis that upto a size of 40 acres there is perceptible gain in efficiency.

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ECONOMICS OF CONSOLIDATION OF HOLDINGS IN UTTAR PRADESH— A CASE STUDY OF LUCKNOW DISTRICT*

Sub-division and fragmentation of agricultural holdings is one of the greatest hindrances in the way of agricultural development in India. Consolidation of scattered and small plots into compact blocks is, therefore, considered one of the important measures of land reforms in India. Consolidation means rearrangement of fragmented holdings in any area among several tenure holders in such a way as to make the holdings held by them more compact. Thus, the basic purpose of consolidation of holdings is to consolidate the scattered parcels of holdings and to reduce their number to the minimum.

Progress in Uttar Pradesh

In Uttar Pradesh, the Consolidation of Holdings Act was passed in April, 1953; President's assent was received on March 4, 1954. Since then, the Act has been amended a number of times. The consolidation operations under the Act start with the correction of land records and village maps and the classification and valuation of lands. Thereafter, the 'Statement of Principles' and the 'Scheme of Consolidation' are prepared. After the Scheme has been finalised and the possession of land transferred, new land records are prepared.

The consolidation work in Uttar Pradesh was first started, on an experimental basis, in the tehsils of Musafirkhana in the Sultanpur district and Kairana in the Muzaffarnagar district on April 1, 1954. Encouraged by the response of the tenure holders, an area of about 146 lakh acres at a cost of Rs. 1,550 lakhs was consolidated by the end of March, 1965. In areas, where the Scheme has been finalised, the number of plots has been reduced to nearly one-sixth, from 367.53 lakhs before consolidation to 63.66 lakhs after consolidation. The work of consolidation has so far been undertaken in 119 tehsils of 40 districts of the State. The entire work (excluding the districts lying in hill areas and Bundelkhand Division and the portion of Mirzapur district south of Kaimur Range) spread over an area of 300 lakh acres is expected to be completed by the end of 1975-76.

In the course of consolidation work, many administrative, technical and other difficulties were experienced owing to several factors such as wrong selection of area, inadequate number of forms and their untimely supply, dilatory and unphased procedures, incomplete and wrong maps and land records, corrupt practices, lack of public co-operation and factionalism, and rivalry among the village people.

In 1958-59, the cost of consolidation was calculated at about Rs. 9.50 per acre and after providing for any unforeseen expenditure, the State Government fixed the cost at Rs. 11 per acre. It also decided that one-half of this cost be realized from the tenure holders whose holdings were affected by consolidation operations and the other half be shared in equal proportions by the Central and the

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* Summary of the thesis submitted for the degree of Doctor of Philosophy in Economics, Lucknow University, 1965.

The author is grateful to Dr. Shridhar Misra, Lucknow University, and Dr. Vidya Sagar, Planning Commission, for their valuable criticism and suggestion.

State Governments. Apart from this, every cultivator has to pay Re. 0.37 per acre for the land taken for public purposes and Re. 0.75 for rectangulation of their holdings.

Programme of Work

To make an economic assessment of the programme, five consolidated villages (*viz.*, Tikra, Sadrapur, Raghauna, Maghwan and Tamoriya) from Mohanlal Ganj tehsil and five unconsolidated villages (*viz.*, Samda, Shakurpur, Plehanda, Yusufnagar and Narainpur) from Sadar tehsil of Lucknow district having, as far as possible, identical economic and agricultural conditions in all other respects except consolidation of holdings, were selected. The number of cultivators selected for intensive study from these two categories of villages was 165 and 153 respectively. Conditions were compared over a period of time, *i.e.*, 'before' and 'after' consolidation of holdings in the consolidated villages. Comparisons have also been drawn between the present conditions in the consolidated villages on the one hand and those in the unconsolidated villages on the other. The relevant data relating to the year 1962-63 were collected with the help of three enquiry schedules.

Population

The total number of persons in the sample households of consolidated and unconsolidated villages was 877 and 787 respectively. The average number of persons per sample household worked out at 5.3 in the case of consolidated and 5.1 in the unconsolidated villages. About 19 per cent of the persons were earners and about 90 per cent of the total earning dependents were engaged in agriculture in the consolidated as well as in the unconsolidated villages. The percentage of literates was 17.1 in the project and 15.0 in the control group of villages.

Effects of Consolidation

Area sown:—As a result of consolidation of holdings, the portion of 'net sown' to total village area registered an increase of nearly 13 per cent in the consolidated villages, while in the unconsolidated villages, it actually declined by about one per cent during the same period. The percentage of current and fallow land to the total village area declined from 37.2 before consolidation to 35.2 after consolidation of holdings in project villages. In the control villages, this percentage, however, registered an increase from 30.3 to 32.3 during the same period. Similarly the area 'not available for cultivation' in the project villages was reduced from 14.5 per cent of the total area before consolidation to 8 per cent after consolidation of holdings despite an increase in the area under village sites and roads. Contrary to this, the percentage of area not available for cultivation to the total area in the villages increased from 5.1 to 6.3 in the control villages during the same period. Irrigated area also increased from 531.5 acres before consolidation to 548 acres after consolidation in the project villages. In the unconsolidated villages, it declined from 579.5 acres to 468.5 acres.

The gross irrigated area of the sample households in the project villages exceeded that in the control villages by 9.65 per cent. The gross cropped area registered an increase of more than 21 per cent in the project as compared to about 8 per cent in the control villages during the five-year period. High income yield-

ing crops were grown proportionately on a larger area in the project than in the control villages. Area sown more than once was 47.3 per cent in the consolidated as compared to 24 per cent in the unconsolidated villages.

Number of plots:—The total number of plots was reduced from 7,526 before consolidation to 4,553 after consolidation in the project villages. The average size of plots increased from 0.37 acre before consolidation to 0.61 acre after consolidation showing an increase of 65 per cent in their size. In the ownership holdings, the number of plots per holding, on an average, was reduced from 5.4 plots per holding before consolidation to 3.1 plots per holding after consolidation. The average size of plot increased from 0.59 acre before consolidation to 0.99 acre after consolidation of holdings, in case of ownership holdings of sample households. The subletting of land was reduced from 6.2 per cent of the total owned land before consolidation to 2.8 per cent after consolidation of holdings.

Costs and returns:—While the total value of inputs was calculated for all the crops grown by the sample households, separate calculations were also made for six important crops, *viz.*, paddy, wheat, jowar and *arhar* (mixed), gram, *bejhar* (wheat, barley, pea and/or gram) and sugarcane. These crops together accounted for nearly 85 per cent of the gross cropped area in the project and about 55 per cent in the control villages. All these calculations made in this section refer to operational holdings. The cultivation expenses on all the crops worked out at Rs. 138.91 per acre on consolidated holdings and Rs. 149.16 per acre on unconsolidated holdings—showing a difference of Rs. 10.25 per acre in favour of consolidated holdings A study of the various items of inputs showed that this saving in terms of money was the highest (nearly Rs. 6 per acre) in the case of human and bullock labour. Among crops, the money value of labour saved varied from Rs. 2.92 per acre in the case of *bejhar* to Rs. 12.45 per acre for wheat on consolidated holdings. The cost of production of various crops was lower on consolidated than on unconsolidated holdings.

The value of farm output was calculated to be Rs. 162.96 per acre on consolidated and Rs. 154.91 per acre on unconsolidated holdings—showing a difference of about Rs. 8 per acre or 5.2 per cent as a result of consolidation of holdings.

The difference in the value of the output was the greatest (about Rs. 32 per acre) in *juar*, the value of the output being Rs. 124.22 and Rs. 92.27 on sample and control villages respectively.

As regards yield, it was higher in respect of all important crops grown on the farms of sample households selected from the consolidated villages. The differences varied from 2.2 per cent in sugarcane to 15.1 per cent in *juar*. The net farm output worked out at Rs. 24.06 per acre or Rs. 102.67 per sample household for consolidated area and Rs. 5.74 per acre or Rs. 21.59 per sample household for unconsolidated area.

On an analysis of the net farm output data of the important crops, all the crops reported profit in the case of project villages but in the control villages, out of seven, three crops, namely, paddy, wheat and *bejhar* incurred losses. The value of non-farm products per sample household was calculated to be Rs. 267.21 for consolidated and Rs. 326.15 for unconsolidated holdings. The combined

value of net farm output and non-farm produce was calculated to be Rs. 369.88 per sample household for project and Rs. 347.74 per sample household for control areas.

Utilization of labour:—The amount of human labour utilized per acre by the sample households on all crops worked out at 40.2 days in the consolidated area and 41.6 days in the unconsolidated area—showing a saving of 1.4 days or 3.4 per cent as compared to unconsolidated holdings. Among the different crops, maximum saving in human labour days was reported in sugarcane (10.3 days per acre) followed by paddy (6.1 days per acre).

In the case of utilization of bullock labour per acre, these worked out at 7.6 days on consolidated farms and 8.4 days on unconsolidated farms—showing a difference of 0.8 day per acre in favour of consolidated holdings. As regards crops, wheat reported the maximum saving of 1.3 days per acre.

The number of days of employment was 308 per head of sample household in the consolidated and 294 days in the unconsolidated area mainly because of high intensity of cultivation on consolidated holdings than on unconsolidated holdings.

Farm practices:—As regards farm practices, 13.3 per cent of the cultivators used improved varieties of wheat and paddy seeds on consolidated holdings and only 5.9 per cent on unconsolidated holdings. The percentage of the cultivators using fertilizers was 17 in the consolidated area and 15.1 in the unconsolidated area. Insecticides and improved agricultural implements were also used to a greater extent by cultivators having consolidated holdings than by those having unconsolidated holdings. Interculture operations were practised by about 98 per cent of the cultivators in the consolidated area as compared to 53 per cent of the cultivators in the unconsolidated area. The same pattern was discernible in the case of individual crops.

Value of assets:—The value of all assets of sample households which was calculated at Rs. 2,497 per household before consolidation increased to Rs. 2,992 per sample household after the consolidation of holdings. In the case of unconsolidated holdings, the value of assets worked out at Rs. 2,560 per sample household.

Among the various items of assets, the average value of land and buildings before consolidation was Rs. 1,653 and it increased to Rs. 1,773 per sample household after consolidation of holdings, thus showing an increase of Rs. 120 or 7.3 per cent per sample household. Similarly, the value of livestock per sample household increased from Rs. 343 before consolidation to Rs. 443 after consolidation—showing an increase of Rs. 100 or 28.9 per cent. The value of farm equipment increased by about 7 per cent after consolidation of holdings. As regards 'other' assets (such as ornaments, household goods, etc.), the increase reported was of the order of nearly 50 per cent after consolidation of holdings. As between project and control villages, the difference in the value of all assets was to the extent of Rs. 361 per sample household or 14.1 per cent in favour of consolidated holdings. Indebtedness and outstanding dues were calculated to be Rs. 166.88 per sample household in the consolidated villages and Rs. 227.72 per sample household in the unconsolidated villages.

Need for comprehensive legislation:—There is need for a more comprehensive legislation which should provide for consolidation of holdings in those areas also where the Act does not apply at present. Adequate legislation is also necessary for prevention of fragmentation of holdings in future and for consolidation of plots of a holding lying in neighbouring villages. Likewise, there is need for co-ordination of development work including consolidation of holdings at various levels. Along with consolidation of holdings the cultivators have also to be provided with other essential facilities for the development of land and for improving agriculture. It is equally necessary that the cost of consolidation should be worked out on a more scientific basis and its burden should fall on beneficiaries as little as possible.

To sum up, it may be stated that as a result of consolidation of holdings, an allround improvement in the economic conditions of the cultivators was reported as compared to the conditions in the control villages.

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