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# FACTORS AFFECTING CROP DIVERSIFICATION: AN EMPIRICAL ANALYSIS

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## I

Research studies in India on farm diversification have mainly focused on normative issues of diversification.[1] Adequate empirical evidences are not available as to the diversification motives on Indian farms and factors affecting diversification level.[2] There are many physical, economic and sociological factors which influence the choice of product-mix. Therefore, the purpose of this paper is to examine the empirical relationship, within a static framework, between crop diversification and selected socio-economic variables; and whether these relationships are sensitive to different diversification measures used.

For the purpose of the study, two villages each from three physical tracts of district Allahabad in Uttar Pradesh, namely, Katka and Annava from Trans-Ganga tract, Faridpur and Purehazari from Doab tract, and Asarbai and Khantkia from Trans-Yamuna tract were selected using three-stage random sampling. Using the probability proportionate criteria, 60 farm households were selected on the basis of simple random sampling. Necessary data were collected from the sample farmers for the year 1981-82. The data from the selected farmers drawn from the three physical tracts were pooled for analysis as no perceptible difference was noticed in the average cropping pattern and yield levels for the sample farms.

### MEASURES OF CROP DIVERSIFICATION LEVEL

For cross-sectional analysis, both net crop income and crop acreages are considered to be potentially interesting variables over which to define crop diversification, because a crop may have low (high) proportion in acreage but high (low) proportion in net crop income. The approach adopted in this study is to utilize a variety of measures of crop diversification. Four measures of crop diversification are used in the empirical analysis: each defined on acreage proportion and net crop income proportion.

$$\text{Let } P_i = \frac{A_i}{\sum_{i=1}^{N} A_i}$$

where

$P_i$ = proportion of ith crop,

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1. B.V.S. Baliga and S.B. Tambad, "Risk and Uncertainty in Irrigated Crops", *Indian Journal of Agricultural Economics*, Vol. XIX, No. 1, January-March 1964, pp.121-128; G.K. Sarkar, "Agricultural Income and Diversification of Crop Culture", *Margin*, Vol.5, No. 1, October 1972, pp.22-26; A.J. Singh and K. K. Jain, "The Trade-off between Return and Risk in Farm Enterprise Choice", *Agricultural Situation in India*, Vol. XXXIV, No. 6, September 1979, pp.375-380; K. Singh and P.S. Sandhu, "Analysis of the Diversification on Productivity, Income and Employment on Different Categories of Farms in Punjab", *Financing Agriculture*, Vol. XI, No.1, April-June 1979, pp.40-47.

2. Raj Krishna, "Rapporteur's Report on Economics of the Cropping Pattern", *Indian Journal of Agricultural Economics*, Vol.XVIII, No.1, January-March 1963, pp.171-181.

In acreage proportion

$A_i$ = area under ith crop (ha.),

$\sum_{i=1}^{N} A_i$ = total area cropped (ha.),

i = 1,2,3,..... N (number of crops).

In income proportion

$A_i$ = net income from ith crop (Rs.),

$\sum_{i=1}^{N} A_i$ = net income from all crops (Rs.),

i = 1,2,3,. . . N (number of crops).

Then the following diversification measures were used in the study.

1. *Index of Maximum Proportion*

$D_1 = \text{Max. } P_i$

Index of maximum proportion is a measure of concentration. This measure was applied both in acreage proportion and net crop income proportion. For increasing diversification, $D_1$ is decreasing. That is, with increase in diversification, maximum proportion held by any crop in the total cropped area/net crop income decreases, $D_1$ takes a value one when there is a complete specialisation.

2. *Number of Enterprises*

$$D_2 = \sum_{i=1}^{N} I(P_i)$$

where I is zero-one indicator, *i.e.*, when $P_i$ exists I takes a value one and, if $P_i$ does not I takes a value zero. For increasing diversification, $D_2$ is increasing. That is, with increase in diversification, the number of crops increases. $D_2$ may take a value of more than one, it takes a value one when there is a complete specialisation. This measure cannot be defined on income proportion.

Though $D_1$ and $D_2$ measures do not consider the actual size of area/income of an individual crop, yet they are potentially interesting variables for defining diversification.

3. *Herfindahl Index*[3]

$$D_3 = \sum_{i=1}^{N} P_i^2$$

Herfindahl index defined as the sum of squares of all N proportions is a measure of concentration. This measure was applied both in acreage proportion and net crop income proportion. For increasing diversification, $D_3$ is decreasing. That is, with increase in diversification, the sum of squares of all crop acreage/income proportions decreases. $D_3$ takes a value one when there is a complete specialisation and, approaches zero as N gets large, that is, if diversification is 'perfect' such that

$$A_i = \frac{1}{N} \sum A_i \text{ and } N \to \infty; \text{ then } P_i^2 = \frac{1}{N} \to 0$$

Thus, $D_3$ is bounded by zero and one.

4. Entropy Index [4]

3. H. Theil : Economics and Information Theory, North-Holland Publishing Co., Amsterdam, 1967, pp.290-316; and M.M. Hackbart and Donald A. Anderson, "On Measuring Economic Diversification: Reply", *Land Economics*, Vol. 54, 1978, pp 111-112.

4. Theil: *op. cit.*, and Hackbart and Anderson, *op. cit.*

$$D_4 = \sum_{i=1}^{N} P_i \log \frac{1}{P_i}$$

Entropy index is regarded as an inverse measure of concentration having logarithmic character. This measure was applied both in acreage proportion as well as net crop income proportion. For increasing diversification, $D_4$ is increasing. $D_4$ approaches zero when a farm is specialised, and takes maximum value but always less than or equal to one when diversification is 'perfect', *i.e.*, $P_i = 1/N$. $D_4$ is bounded by zero and one.

## RESULTS AND DISCUSSION

Regression results on the empirical relationship between different crop diversification measures defined on acreage proportion and net crop income proportion with selected socio-economic variables are given in Tables I and II respectively. The results are based on

TABLE I. REGRESSION RESULTS ON DIVERSIFICATION MEASURES DEFINED ON ACREAGE PROPORTION

| Independent variable / Dependent variable | Diversification measures | | | |
|---|---|---|---|---|
| | Index of maximum proportion $D_1$ | Number of enterprises $D_2$ | Herfindahl index $D_3$ | Entropy index $D_4$ |
| Constant (A) | 373.246 | 5149.39 | 190.647 | 656.457 |
| Farm size ($X_1$) (ha.) | 16.088 * (3.072) | −175.494 * (28.671) | 15.585 * (4.614) | −22.644 * (5.314) |
| Experience ($X_2$) (years) | Dropped | Dropped | Dropped | Dropped |
| Distance of farm from market (km.) ($X_3$) | 3.352 (2.798) | −42.278 * (8.954) | −1.620 (4.199) | −4.536 (4.836) |
| Land rented-in (dummy) ($X_4$) | 13.537 (16.647) | −920.318 ** (37.716) | 35.495 (24.893) | −67.798 ** (28.658) |
| Share-cropping (dummy) ($X_5$) | −2.311 (15.505) | 3.565 (351.279) | 2.332 (23.188) | 2.098 (26.697) |
| Non-crop income (Rs.) ($X_6$) | Dropped | Dropped | Dropped | Dropped |
| Price risk ($X_7$) | −3.618 * (1.329) | 88.282 * (30.084) | −4.063 ** (1.986) | 6.842 * (2.286) |
| Yield risk ($X_8$) | −2.178 (1.771) | 142.415 * (40.059) | −6.034 ** (2.644) | 9.573 ** (3.042) |
| Number of family members ($X_9$) | 3.160 (4.788) | −37.060 (99.176) | 10.533 (7.163) | −2.517 (8.249) |
| Irrigation intensity ($X_{10}$) | −85.629 * (19.753) | 1174.061 ** (447.586) | −52.626 *** (29.528) | 92.321 * (33.988) |
| Farm net worth per hectare ($X_{11}$) | 0.002 *** (0.001) | −0.042 *** (0.022) | 0.003 ** (0.001) | −0.003 ** (0.002) |
| Adjusted coefficient of multiple determination ($\bar{R}^2$) | 0.73 | 0.69 | 0.56 | 0.76 |

The original coefficients have been multiplied by a constant figure of 1000 to improve the readability. Interpretations have to be, therefore, made accordingly. $D_1$ and $D_3$ decreasing (increasing), $D_2$ and $D_4$ increasing (decreasing) imply increased (decreased) diversification.

Figures in parenthess indicate standard errors of regression coefficients.

* Significant at 1 per cent.

** Significant at 5 per cent.

*** Significant at 10 per cent.

TABLE II. REGRESSION RESULTS ON DIVERSIFICATION MEASURES DEFINED ON INCOME PROPORTION

| Independent variable / Dependent variable | Diversification measures | | |
|---|---|---|---|
| | Index of maximum proportion $D_1$ | Herfindahl index $D_3$ | Entropy index $D_4$ |
| Constant (A) | 492.872 | 374.668 | 545.025 |
| Farm size ($X_1$) (ha.) | 14.058* (5.627) | 16.096* (4.962) | -20.314* (6.026) |
| Experience ($X_2$) (years) | Dropped | Dropped | Dropped |
| Distance of farm from market (km) ($X_3$) | 4.165 (5.121) | 0.627 (4.516) | -6.307 (5.484) |
| Land rented-in (dummy) ($X_4$) | 14.519 (30.343) | 21.369 (26.767) | -8.641 (32.485) |
| Share-cropping (dummy) ($X_5$) | -2.490 (28.267) | -7.156 (24.935) | 7.893 (30.264) |
| Non-crop income (Rs.) ($X_6$) | Dropped | Dropped | Dropped |
| Price risk ($X_7$) | -6.494* (2.420) | -6.231* (2.136) | 9.226* (2.590) |
| Yield risk ($X_8$) | -3.126 (3.219) | -4.785** (2.842) | 7.094* (3.448) |
| Number of family members ($X_9$) | 3.126 (6.733) | -10.801 (7.703) | -14.905 (9.355) |
| Irrigation intensity ($X_{10}$) | -100.353* (35.982) | -91.733* (31.749) | 136.067* (38.518) |
| Farm net worth per hectare ($X_{11}$) | 0.002 (0.002) | 0.002 (0.002) | -0.004*** (0.002) |
| Adjusted coefficient of multiple determination ($\bar{R}^2$) | 0.42 | 0.52 | 0.62 |

The original coefficients have been multiplied by a constant figure of 1000 to improve the readability. Interpretations have to be, therefore, made accordingly. $D_1$ and $D_3$ decreasing (increasing), $D_2$ and $D_4$ increasing (decreasing) imply increased (decreased) diversification.

Figures in parenthess indicate standard errors of regression coefficients.

* Significant at 1 per cent.

** Significant at 5 per cent.

*** Significant at 10 per cent.

linear regression which emerged to be empirically appropriate functional form over the log-linear regression.

The results suggest that farm size ($X_1$) has a significant negative effect on diversification (*ceteris paribus*). In other words, larger farms are relatively less diversified. One might expect larger farms to be more specialised when there are scale economies in an enterprise, and larger farms are less risk averse. Experience ($X_2$) and non-crop income ($X_6$) variables had to be dropped due to multicollinearity between each of the above variables and farm size (correlation coefficient 0.89 and 0.85 respectively). Farm size variable was retained in the final analysis due to its greater policy significance (Tables I and II).

It was found that distance from the market ($X_3$) has a significant negative effect on diversification when it is measured as number of enterprises taken ($D_2$) (Table I). This means that farms located nearer to market are relatively more diversified in terms of number of crops

(*ceteris paribus*). This seems plausible as marketing of a number of enterprises from a greater distance would be cumbersome and full of managerial difficulties because infrastructural facilities are usually more developed in the vicinity of markets. The variable emerged insignificant in all the other measures of diversification.

The results indicate that land rented-in ($X_4$, dummy variable) has a significant negative effect on diversification when it is measured as number of enterprises ($D_2$) and Entropy Index ($D_4$) defined on acreage proportion (Table I). This suggests that with increase in renting-in of land diversification decreases (*ceteris paribus*). The results corroborate, to some extent, the findings on relationship between diversification and farm size. The variable appeared insigificant in other measures of diversification.

Price risk ($X_7$) and yield risk ($X_8$), measured here as weighted sum of standard deviations of prices/yields of different crops obtained in the last five years, show significant positive effect on diversification (*ceteris paribus*). It confirms the hypothesis that farmers adopt diversification as a measure to face their business risk (Tables I and II).

The results show that irrigation intensity ($X_{10}$), measured here as a ratio of gross irrigated area to net irrigated area, has a significant positive effect on diversification indicating that with the availability of irrigation all-round the year, diversification will increase (*ceteris paribus*) (Tables I and II). Percentage irrigated area was, initially, tried as a variable. But it was found to have multicollinearity with farm size variable (correlation coefficient 0.83). Hence, the irrigation variable was respecified as irrigation intensity.

Farm net worth variable ($X_{11}$) was found to have a significant negative effect on diversification (insignificant only when diversification measured as Index of Maximum Proportion and Herfindahl index defined on net crop income proportion, Table II). It means that wealthier farms are more specialised (*ceteris paribus*). This result would be consistent with a decreasing (in wealth) type risk aversion in a cross-sectional sense. That is wealthier farms are less risk averse and less diversified.

Share-cropping ($X_5$, dummy variable) and number of farm family members ($X_9$) were found to be insignificant in affecting the level of crop diversification (Tables I and II).

Constant term in the regression results would be interpreted here as indicating family farm. The adjusted coefficient of multiple determination ($\bar{R}^2$) appeared in the range of 0.56 to 0.76 under different diversification measures defined on acreage proportion and in the range of 0.42 to 0.62 under diversification measures defined on net crop income proportion indicating the percentage variation explained by the variables, discussed above, in the level of crop diversification. The unexplained variation could be largely attributed to physio-climatic factors such as soil type, topography, rainfall and economic factors such as availability of draft power, labour, etc. A re-run of the model after dropping the insignificant variables did not make any perceptible improvement in the results. The mean values and elasticity coefficients of the selected variables are given in the Appendix. By and large, irrigation intensity, farm net worth, price risk and farm size appeared to be the strong variables affecting the level of crop diversification.

Few discrepancies are noted in the results under crop diversification measures defined on crop acreage proportion and net crop income proportion. Income-based crop diversification measures being more appropriate, positive economic analysis of diversification based on such measures needs further research.

## CONCLUSIONS AND POLICY IMPLICATIONS

Using different measures of crop diversification defined both on acreage and net crop income proportion, a sample of Allahabad farms revealed evidence that larger farms, and

wealthier farms are relatively less diversified. Tenancy (cash renting) discourages diversification. Farms with higher irrigation intensity, and located nearer to market are relatively more diversified. Farms which perceive greater business risk practice relatively more crop diversification. Share-cropping, and family size do not affect the level of crop diversification. In general, the results are consistent with risk theories, that is, the farm diversifies to spread risk and wealthier farms are less risk averse.

Farm diversification may take place as a means of profit maximization through reaping the gains of complementary relationships or in equating substitution and price ratios for competitive products. Farm diversification may also be used as a risk precaution: Studies indicate that under the situation of risk and capital constraint, diversification stabilises farm income at a higher plane. These considerations make a strong case for farm diversification in Indian conditions. The results of the present study shed some light on policy instruments which can be used for affecting the crop diversification level. In this regard, effective implementation of land ceiling policy may encourage, to some extent, crop diversification. Tenancy (cash renting) is required to be discouraged for promoting crop diversification. Improvement in irrigation and marketing facilities may encourage crop diversification. However, with improvement in irrigation and marketing facilities, yield and price risk are expected to reduce, but in that new situation diversification may be adopted more as a means of profit maximization than as a risk precaution. However, it is possible that this may have some dampening effect on the level of crop diversification. Further, smaller farms are more diversified, therefore, farm benefit programmes may be tied to such farms. Even other farms may be required to practise a certain minimum level of diversification to be eligible to participate in farm benefit programmes. However, such a participation may lead to stronger financial position which in turn may bring a reduction in the level of crop diversification. These implications indicate that an initial thrust on diversification promoting policies may finally lead to betterment in the economic position of farmers.

## APPENDIX

### MEAN VALUES AND ELASTICITIES OF THE VARIABLES

| Dependent variable / Independent variable | Diversification measures: Defined on acreage proportion: Index of maximum proportion $D_1$ | Defined on acreage proportion: Number of enterprises $D_2$ | Defined on acreage proportion: Herfindahl index $D_3$ | Defined on acreage proportion: Entropy index $D_4$ | Defined on income proportion: Index of maximum proportion $D_1$ | Defined on income proportion: Herfindahl index $D_3$ | Defined on income proportion: Entropy index $D_4$ | Mean values of independent variable |
|---|---|---|---|---|---|---|---|---|
| Farm size ($X_1$) (ha.) | 0.18 | 0.11 | 0.22 | 0.12 | 0.12 | 0.19 | 0.13 | 3.71 |
| Distance of farm from market (km.)($X_3$) | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 | 0.01 | 0.04 | 4.17 |
| Price risk ($X_7$) | 0.18 | 0.24 | 0.26 | 0.17 | 0.25 | 0.33 | 0.26 | 16.59 |
| Yield risk ($X_8$) | 0.03 | 0.12 | 0.12 | 0.07 | 0.04 | 0.08 | 0.06 | 5.05 |
| Number of family members ($X_9$) | 0.06 | 0.04 | 0.25 | 0.02 | 0.05 | 0.22 | 0.15 | 6.22 |
| Irrigation intensity ($X_{10}$) | 0.37 | 0.28 | 0.30 | 0.20 | 0.34 | 0.43 | 0.33 | 1.46 |
| Farm net worth per hectare ($X_{11}$) (Rs.) | 0.18 | 0.27 | 0.44 | 0.20 | 0.16 | 0.45 | 0.23 | 39096.98 |
| Mean values of dependent variable | 0.34 | 6.03 | 0.26 | 0.68 | 0.43 | 0.31 | 0.60 | |

Elasticity coefficient = $\left(\partial D_j / \partial x_i\right)\left(\bar{X}_i / \bar{D}_j\right)$