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Identifying the Determinants and Extent of Crop Diversification at Household Level: An Evidence from Ukhrul District, Manipur

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ABSTRACT

Crop diversification is a risk management strategy for the farming community and an important step for poverty alleviation and transition from subsistence to commercial agriculture. The paper aims to recognize those factors which influence household decision to crop diversification and further attempts to identify what factors influence the degree to which this diversification takes place. The study adopts, Heckman's Two Stage Model to estimate separately the determinants of household diversification decision and intensity of diversification by the households'. The results of the study found that education of the household head is found to have positive association with the level of crop diversification. The farming experience of the farmer is found to have positive influence only while taking decision to diversify crops. Access to plough has positively affected both the household's decision to diversify crop as well as level of crop diversification. Access to fertilizer and availability of irrigation has effect on propensity to diversify crops. Exposure to farming information by the households significantly affected level of diversification. Farmers who attend farming training regularly are more likely to diversify crop. The distance to the nearest market from homestead also positively affected crop diversification level.

Keywords: Crop Diversification, Heckman's Two Stage Model, Risk management, identify, estimate

Crop diversification is a risk management strategy for the farming community and an important step for poverty alleviation and transition from subsistence to commercial agriculture. Crop diversification is suggested as a viable solution to stabilise and raise farm income, increase employment opportunities, boost exports and conserve and enhance natural resource base when combined with the comparative advantage of the region (Sharma, 2007). Doubling income of farmers by the 2022 has also been one of the main objectives of the Government of India (Chandrasekhar and Mehrotra, 2016).

Moreover, NITI Ayog has stated increasing agricultural productivity as one of the five issues identified which needs attention to improve the livelihood of the farming households (Anonymous, 2015).

Many studies have reported several factors which influence crop diversification. Agricultural diversification in North Eastern Region of India are affected by labor, occupation, irrigation, road density, market facility significantly (Birthal *et al.*, 2006). Landholding size, age, educational level, farming experience of farmer, off farm income, distance of farm from main road, distance of farm from main market and farm machinery are also the factors affecting crop diversification (Ashfaq *et al.*, 2008). Apart from age and level of education of the household head, the extension contact, availability of tractor hiring services, returns from crop production

and road condition significantly determine the level of crop diversification (Ibrahim *et al*., 2009). Among the agronomic factors like landholding size, quantities of fertilizer, tillage time and tillage (using a plough) and also distance to the market determine crop diversification significantly (Kiru *et al*., 2014). The gender of household head, education, number of livestock units, access to irrigation, membership to a farmers group, access to markets, farming experience, farms on flat terrains, farmer to farm extension, routine extension, agro ecological zone and household income are significant contributors to increasing crop diversification (Dube and Guveya, 2016).

The study was conducted at Ukhrul district which is almost a hilly region with beautiful scenic characteristics. The district is entirely rural economy and agriculture is the most important source of livelihood for the people of the district. The introduction and adoption of the modern agricultural system – use of improved and high yielding seeds; use of mechanical devices for ploughing, harvesting, *etc.*; use of chemical fertilizers, pesticides or insecticides; *etc.* is no more a distant dream in the district. In the hilly region, agricultural productivity is low as the topography does not permit the intensive use of irrigation and modern inputs but is endowed with temperate climatic conditions which will favor the cultivation of off-season vegetables and temperate fruits. In such a situation, crop diversification towards high value crops can significantly enhance farm income and livelihood of people in the region. In this background, the present study attempted to to recognize those factors which influence household decision to crop diversification and further attempts to identify what factors influence the degree to which this diversification takes place. The study adopts, Heckman's Two Stage Model to estimate separately the determinants of household diversification decision and intensity of diversification by the households'.

METHODOLOGY

Sampling and Data

The study adopted multistage random technique. In the first stage, the district was selected purposively since it has highest cropping intensity (%) among the districts of the state based on 2013-14 crop area data. Secondly, out of the six Community Development (C.D.) Block, Ukhrul C.D. block was selected randomly. Thirdly, a clusters of 5 villages were selected from the selected block randomly. Finally, a sample of 80 households were selected proportionate to the population size of the respective villages. Data were then collected using a well structured schedule through personal interview method.

Analytical framework

Different indices are in use for diversification studies such as Simpson Index (SID), Margalef Index (MI), Herfindahl Index (HI), Entropy Index (EI), Modified Entropy Index (MEI), Composite Entropy Index (CEI) *etc*. (Feroze and Singh, 2011, Rehima *et al*. 2013, Girish, 2004, Basavaraj *et al.* 2016, Acharya *et al*. 2011). Out of these diversity measures, the current study uses SID to compute diversity index values of the households because of its wide range of application and computational simplicity.

Generally, Ordinary Least Square (OLS) is not applicable since all the households did not grow all types of crop or practice crop diversification assuming that OLS regression will create a sample selectivity bias, Heckman Two Stage Model is adopted for the study, given not all households diversify crops despite having the option to do so. The first stage estimates the probability of observing a positive outcome and the second stage estimates the level of participation which is conditional on observing positive values (Dow and Norton, 2003). The model assumes that different sets of variables can be used in the two step estimation and it is important to note that at least one of the explanatory variable in the first equation is not included in the second step for identification (Maddala, 1992).

The study has considered Simpson Index of Diversification (SID) to compute crop diversity of the households. A zero value of SID indicates specialization and its value approaches one with increase in the extent of diversification. The study also used the index values to create a dummy variable portraying whether or not a household diversified their crop activities by computing the median (0.48) of the SID values. Crop diversification is observed if the household has SID $\geq$ 0.55 represented by dummy variable 1 while 0 for not diversified households.

$$SID = 1 - \sum_{i=1}^{n} P_i \quad (1)$$

$$P_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \quad (2)$$

Where proportionate area of the i[th] crop in the gross cropped area,

A_i = area under i[th] crop,

$\sum_{i=1}^{n} A_i$ = Total cropped area.

Application of Heckman Two Step procedure involves Probit model in the first stage (probability of diversification) and OLS model in the second stage (level of diversification).

a) A selection equation is formulated which estimates the probability of observing a positive outcome, i.e., to diversify crops (Probit model). The dependent variable in this stage is a probabilistic binary choice of being a diversified household (1) or otherwise (0).

$$D_i^* = \gamma_1 + \gamma_2 X_{1i} + e_{1i} \quad (3)$$

where,

D_i^* = latent variable that denotes binary censoring,

γ_1 and γ_2 = parameters,

X_{1i} = vector of variables that affect diversification decision,

e_{1i} = error term,

D_i = binary variable (1 if crop diversification is observed, 0 otherwise).

$$D_i = \begin{cases} 1; & D_i^* > 0 \\ 0; & otherwise \end{cases} \quad (4)$$

The marginal effect at the mean for the Probit model is calculated as the estimated co-efficients do not quantify the influence of the independent variables on the probability that the dependent variable takes on the value one. While in Ordinary Least Square (OLS) regression, the marginal effects are the same as the slope coefficients due to linear relationship and do not vary depending on the values of the other variables.

b) An output equation is set up to estimate the level of crop diversification which is conditional on observing positive values (OLS). The dependent variable in this stage is continuous (SID) and the variable gender of the head of the household is not included for identification as most of the household heads are male.

$$\ln\_SID_i = \beta_1 + \beta_2 X_{2i} + e_{2i} \quad (5)$$

where,

ln_SID_i = observable random variable,

β_1 and β_2 = parameters,

X_{2i} = vector of variables that explain the levels of diversification, and

e_{2i} = error term.

It is assumed that the random disturbances of the two equations are distributed as,

$$\begin{bmatrix} e_{1i} \\ e_{2_i} \end{bmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}\begin{pmatrix} 1 & \rho \\ \rho & \sigma^2 \end{pmatrix}\right] \quad (6)$$

A selectivity problem arises when $\ln\_SID_i$ is observed only when $Di = 1$ and $\rho \neq 0$. To control or correct for potential bias emerging from sample selectivity, the second stage regression includes Inverse Mills Ratio (IMR) denoted by λ, estimated from the first stage regression, as one of the explanatory variables.

The new regression equation based on conditional mean of $\ln\_SID_i$ given that it is observed is then given by:

$$E\left[1n\_SID_i \mid D_i > 0\right] = \beta_1 + \beta_2 X_{2i} + \beta_\lambda \lambda_i \quad (7)$$

$$\lambda_i = \frac{\phi(\gamma_1 + \gamma_2 X_{1i})}{\Phi(\gamma_i + \gamma_2 X_{1i})} \quad (8)$$

where, λ = *Inverse Mill's Ratio*; $\varphi(\cdot)$ is the standard normal probability density function and $\Phi(\cdot)$ is the cumulative density function of the standard normal random variable.

Adding a random disturbance yields (selectivity corrected model):

$$1n\_SID_i = \beta_1 + \beta_2 X_{2i} + \beta_\lambda \lambda_i + e_{3i} \quad (9)$$

RESULTS AND DISCUSSION

Characteristics of the households

Table 1 presents the variables used in the Heckman Two Stage Model. Since, the state is patriarchial society, most of the (94 %) the sampled household heads were male unless the male counterpart has expired. On an average, the household head's age was 51 years while the average family size of the household was 6 numbers. About 84 per cent of the household heads were educated. The households had an average of 1.45 ha farm-land to grow different crops. The average farming experience of the cultivators of the households was about 20 years. About 3 persons in the households were non-working.

On an average about 3 man days were engaged in growing different crops other than cereal crops. Access to plough, tools and machineries, fertilizer, High Yielding Variety (HYV) or improved seed and irrigation were considered to be an important factor for crop production as well as to alleviate food shortage in the household. On an average, 60 per cent of the households reported access to plough while only about 24 per cent reported access to tools and machineries. Fertilizer application in hill is almost negligible i.e. only about 18 per cent of the total households in the study area reported access to fertilizer. About 58 per cent of the households reported availability of HYV or improved seed. There is no proper irrigation facility in the study area but some of the households do irrigate the fields from the nearby streams in the hill (18 %). Exposure to farming information and participation in training are also beneficial to gain information on technology, market and practical know-how that helps farmers to diversify crop. However, only about 41 per cent and 38 per cent of the households reported that they have access to farming information and attended training, respectively. The average distance of nearest market from homestead was about 22 km in the study area.

Table 1: Summary of the explanatory variables used in Heckman Two Stage Model

Explanatory variables (Xi)	Type	Measurement	Frequency / Mean	Expected Sign
Gender_Hh	Dummy	Gender of head of the household (male =1, female = 0)	75 (93.75)	+/-
Age_Hh	Continuous	Age of household head (years)	51.13	+/-
Family_size	Continuous	Persons in household (number)	6.36	+
Education_Hh	Dummy	Education of household head (literate = 1, 0 = otherwise)	67 (83.75)	+
Farm_size	Continuous	Land operated for farming by the household (ha)	1.45	+/-
Farming_ experience	Continuous	Experience in farming of the cultivator (years)	20.10	+
Dependency _ratio	Continuous	Non-working members/ Family size (Numbers)	2.69	-
Hired _labour	Continuous	Labour employed for wages in agricultural activity (man-days)	2.78	+
Access_Plough	Dummy	Access to plough (Yes=1, 0 otherwise)	48 (60)	+
Tools and machineries	Dummy	Access to tools and machineries (Yes =1, 0 otherwise)	19 (23.75)	+
Access_ fertilizer	Dummy	Access to fertilizer (Yes =1, 0 otherwise)	14 (17.5)	+
HYVor improved seed	Dummy	Availability of HYV or Improved seed ((Yes =1, 0 otherwise)	46 (57.5)	+
Irrigation_ facility	Dummy	Availability of irrigation facility (Yes =1, 0 otherwise)	15 (18.5)	+
Exp_farming_ info	Dummy	Exposure to farming information (Yes =1, 0 =otherwise)	33 (41.25)	+
Attended_ training	Dummy	Attended training in relation to farming (Yes =1, 0 otherwise)	30 (37.5)	+
Market_ Distance	Continuous	Distance from homestead to nearest market (km)	21.69	+

Figures in parentheses are percentage to the total

Determinants of crop diversification: Econometric estimates

The results of Heckman Two Stage Model, *i.e*, estimates of Probit and OLS are presented in Table 2. While estimating the model, several miss-specification problems such as non-normality of residuals, multicollinearity, omitted variables and wrong functional form were taken into account (Gujarati and Sangeetha, 2007). The Jarque-bera normality test indicated that the residuals were normally distributed. The Wald test statistics (Chi-square (16) = 79.95), indicate that the coefficients of the level of diversification equation are significantly different from zero, confirming that the model fulfilled the conditions of good fit. According to Variance Infaltion Factors (VIF), which all were less than 10, indicated that there was no multicollinearity among the explanatory variables. Selection bias was tested by including the Inverse Mills Ratio (IMR), which was not significant suggesting that selection bias is not a big problem in the estimation of output equation.

The relationship between crop diversification and educational of the household head is an empirical question but it is believed that if the household head attended formal school, the more likely a farmer is able to make constructive decisions to accept new ideas and this enhances their willingness to diversify crop. As expected, education of the household head is found to have positive association with the level of crop diversification. Increase in the formal education by one year led to 5 per cent increase in the level of crop diversification of the households. While it has no effect on propensity to diversify crops or households decision to diversify crops which implies that households heads who doesn't attend formal school earlier may also diversify.

Table 2: Heckman Two Stage Model Estimates (Probit and OLS)

Variables	1st Stage (Probit)		2nd Stage (OLS)
	Coefficient	Marginal effect	Coefficient
Gender_Hh	−1.036 (1.36)	−0.273	
Age_Hh	−0.088 (0.06)	−0.032	−0.001 (0.00)
Family_size	0.434 (0.28)	0.157	0.006 (0.01)
Education_Hh	−0.709 (1.47)	−0.221	0.059 (0.03)**
Farm_size	0.133 (0.41)	0.048	−0.007 (0.01)
Farming_experience	0.187 (0.08)	0.068**	−0.0001 (0.00)
Dependency _ratio	−0.366 (0.39)	−0.132	−0.008 (0.01)
Hired _labour	−0.513 (0.54)	−0.185	0.005 (0.01)
Access to plough	2.618 (1.16)	0.802**	−0.009 (0.03)**
Access to tools and machineries	0.254 (0.86)	0.089	0.017 (0.02)
Access to fertilizer	2.047 (1.13)	0.448*	0.045 (0.02)
Availability of HYVor improved variety of seed	0.96 (0.77)	0.346	−0.017 (0.02)
Availability of irrigation facility	2.22 (1.01)	0.476**	0.024 (0.02)
Exposure to farming information	0.375 (0.86)	0.133	0.136 (0.02)***
Attended training	3.837 (1.28)	0.837***	0.006 (0.03)
Market_Distance	0.016 (0.03)	0.005	0.001 (0.00)*
Const	−2.676 (3.89)	−0.687	0.506 (0.08)***
IMR			−0.044 (0.03)
Wald Chi-Square Chi-square (16) = 79.9492***			
Total observations: 80			
Censored observations: 37 (46.2%)			
Uncensored Observations: 43			

****, ** and * denote that statistically significant difference at 1%, 5% and 10% level, respectively. Figures in parentheses are standard errors.*

Similar findings was reported by Rehima *et al.* (2013).

The farming experience of the farmer is expected to have positive relationship since experienced farmers have more knowledge about farming and it may influence him/her to diversify crops. In line with expectation, the farming experience of the farmer is found to have positive influence only while taking decision to diversify crops indicating that the farmer who has more farming experience are more likely to diversify crops by about 6.8 per cent. Access to plough has positively affected both the household's decision to diversify crop as well as level of crop diversification. Household's who has access to plough are more likely to diversify crop (p=0.80) with a level of 0.9 per cent crop diversification. the finding is in agreement with the findings by Kiru *et al.* (2014). One of the potential constraints to farming households in the production of their crops is not having access to inputs such as fertilizers (Xu, 2009). Access to fertilizer affected positively and significantly the household's decision to diversify crops indicating that the probability of crop diversification increased by about 44 per cent for those household's having access to fertilizer, probably because fertilizer is one of the important input for crop production.

Similar result was also reported by De and Chattopdhay, (2010). Irrigation facility appears as a significant determinant for crop diversification decision and the households having regular irrigation facility are more likely to diversify crop (P= 0.47). Kumar and Gupta (2015) also found a positive relationship between access to irrigation and crop diversification. Households' having exposure to farming information may gather more knowledge and thereby encourage them to diversify crops.

Similarly, farmers who participate training regularly may have more advanced knowledge about farming and is expected to have positive influence. Exposure to farming information in the second stage positively and significantly affected level of diversification. It implies that households who had access to farming information increased their level of diversification by 15 per cent indicating that farming information may decrease the uncertainty of the household's associated with crop production. Similar finding was observed by Dube and Guveya (2016). As expected, farmers who attend farming training regularly are more likely to diversify crop with a probability of about 83 per cent. The distance to the nearest market from homestead is an indicator of access to market and it provides better opportunity to the households to market their farm produce.

The study indicated that the distance to nearest market influenced only in determining the level of diversification showing that nearer the market distance, the level of crop diversification increases by about 0.6 per cent. The finding is in consistent with the findings of Benin *et al.* (2004) and Rehima *et al.* (2013). The effect of other variables *viz.* gender of household head, age of household head, family size, farm size, dependency ratio, hired labour, access to tools and machineries and availability of HYV or improved seed are found to be non-significant while deciding to diversify crops.

CONCLUSION

The study identified the factors that drive households' decision to diversify crops and the level of crop diversification stimulated by the decision to diversify. The result also indicates that the different drivers of crop diversification have different effect on propensity to diversify and intensity of diversification at household level. Education of the household head is found to have positive association with the level of crop diversification. The farming experience of the farmer is found to have positive influence only while taking decision to diversify crops. Access to plough has positively affected both the household's decision to diversify crop as well as level of crop diversification. Access to fertilizer and availability of irrigation has effect on propensity to diversify crops. Exposure to farming information by the households significantly affected level of diversification. Farmers who attend farming training regularly are more likely to diversify crop. The distance to the nearest market from homestead also positively affected crop diversification level.

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