INTENSITY OF CROP DIVERSIFICATION IN SMALL AND LARGE FARMERS: A DECISION THEORY

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Abstract: Crop diversification is a component which can bring in growth in farm incomes, productivity of crops and employment generation which has deteriorated due to wheat-paddy dominance. Over emphasis on wheat-paddy to increase economic growth and ensure food security has taken stark toll on environment. In this context, we investigate major guiding factors in the decision making by farmers to shift the area under food crops towards non-food crops. However, heterogeneity in resource and capital endowments of farmers, difference in their access to input and output markets and characteristic of the crop to which farmer is shifting to also play a role in decision-making. It could be hypothesized that though all the farmers are risk averse, large farmers are in a better position to diversify due to their economic strength with which they can overcome the risk involved in diversifying from food crops to non-food crops.

Keywords: Crop Diversification, Punjab, risk, Two-Tier model

INTRODUCTION

In India, there is a decline in the trend growth of production as well as productivity for many crops from the mid-nineties and value of output from agriculture is also declining. The growth rate per annum of the major food crops like wheat, rice and course cereals was 3.4 per cent from Triennium Ending 1981-82 to Triennium Ending 1993-94 while it fell to 1.3 per cent from Triennium Ending 1994-95 to Triennium Ending 2007-08. This decline can also be seen in the case of Punjab which has recorded Growth rate of total food crop of 3.21% from 1981-82 to 1990-91 while 1.68% from 1991-92 to 2000-01 (Sidhu and Bhullar, 2005). Various aspects of Punjab pattern of economic growth and its relation to the green revolution strategy, which is the prime factor underlying the state's achievement, have been studied in depth over time. It is important to draw attention to several problems surfacing the Punjab agriculture situation which merits serious research and requires urgent solutions.

The dominance of the wheat-paddy system has led to serious economic, social and ecological problems such as deceleration in productivity growth, drop in agricultural employment, overexploitation of ground water resources and decline in soil fertility (Singh and Sidhu, 2004).Due to this, farmers face poor returns to cultivation which indicates a socio-economic malaise in rural India. This is further accentuated by multiple risks of yield, price shocks, credit, technology and vagaries of weather. Thus, diversification within farming away from wheat-paddy rotation in favor of fruit and vegetable, fodder and oilseeds crops is recommended. This is expected to bring the sustainable solution consistent with environmental and social needs which can be adopted by the economic agents (farmers) to maintain high income levels and sustain higher productivity levels. It may prove to be of paramount importance in meeting challenges that arise from a post-green revolution scenario. However, there is a degree of risk involved in switching from food crops to non-food crops. Since large farmers are shielded with higher incomes, they can take a step towards diversification but small farmers are reluctant to diversify their cropping pattern. Large and rich farmers are those who can take such risks because they are protected against the risk by high returns, rental income etc. But a small farmer has limited ability to take risks to increase his income because of his limited economic strength. If there is limited availability of capital and land, the technology utilized by farmers may be biased towards traditional techniques and crops.

OBJECTIVES

The study attempts to answer the following questions- (i) What are the factors that determine the decision taken by a farmer whether he would diversify his cropping pattern? (ii) Does the intensity of crop diversification by small farmers differ from intensity of crop diversification by large farmers in Punjab?
(iii) What are the factors that are responsible for this difference: the market factors, wealth constraints or climatic factors?

LITERATURE REVIEW

Defining crop diversification and its scope in Punjab

In Punjab, there exists a potential to diversify and cultivate variety of non-food crops like fruits and vegetables but the future of these crops relies on developing suitable infrastructure for linking production and consumption. Punjab is specializing in favor of rice and wheat due to government pricing policies, assured procurement, high-yielding technologies, and irrigation development for these

crops. However, extensive cultivation of rice and wheat are causing negative externalities related to soil and water resources. The soil fertility with respect to macro and micro-nutrients is declining with uninterrupted cultivation of these crops. The water resource of the region is also depleting. The negative externalities have adversely affected the total factor productivity of rice-wheat based cropping system in this region (Joshi et. al, 2004).

Wealth and Market Constraints

A study by Saleth (1995) found that farms with less than 2 acres devote over 50 percent of their Gross Cropped Area (GCA) to food-grains, while those with 4-8 acres devote over 50 percent of their GCA to non-food grains especially commercial crops and oilseeds and pulses. Although vegetable and horticultural crops have only a marginal share in the GCA of all groups, they impound essentially to farms larger than 2 acres.

A paper by Mesfin et al. (2011) investigated the pattern, trend and covariates of crop diversification in eastern Ethiopia based on data collected from 167 household randomly and proportionately selected. Tobit model result indicated that farmers with more extension contacts and larger livestock size are likely to specialize whereas those who have access to market information and irrigation, those who own machinery and more number of farm plots are more likely to diversify. The variable used to measure crop diversification is a modification of the Entropy index that lies strictly between zero and one.

Large numbers of farmers practice crop rotation and intercropping for different important reasons which include reducing disease and pest infestations, manage with land scarcity, improving soil fertility and reducing risks. The Tobit estimates indicates that access to market information, irrigation intensity, machinery ownership, livestock size, extension contact, number of farm plots and location of farms are found to be significantly influencing crop diversification.

A paper by Immink and Alarcon (1991) addressed whether it depends on preferences of the farmers because crop diversification and commercialization among farmers with small landholdings in developing countries is signaled as detrimental to food security.

Risk faced by the small farmers when they diversify

Risk also could be considered as a strong behavioral force affecting decision making in land allocation to food crops and commercial crops (Blank, 1990, Braun, 1995 and Dercon, 1996). A vital perspective of risk is how far and how often returns unable to reach a below the mean level of return. Risk is also taken as a cost of decision in farmers' decision pertaining to land allocation to high value crops (Roumasset, 1976). Though, cash crops are more remunerative, there is always a risk attached to its production. This risk may pertain to pricing, production or yield. Joshi et.al (2006) found in case of Uttar Pradesh that viability of small farms can be improved through diversification of agriculture into higher-value crops like fruits and vegetables. It studied the impact of crop diversification towards vegetables on farm income and employment and found that a switch to vegetables would augment incomes of small farmers but prevailing constraints do not allow smallholders to fully pocket the emerging opportunities in vegetable production. Major constraints in vegetable production are lack of assured markets and a well-developed seed sector which lower the productivity and augments the risk. Another important factor that they figured out which restricts expansion of area under vegetables are higher price and yield risks as compared to cereals and low marketable surplus that increases transaction costs. The coefficients of variation in the yield of vegetables and cereals were computed to compare the magnitude of risk. The coefficient of variation in yield was much higher for vegetables than cereals. High price volatility was another major constraint in vegetable production.

A study by Johnson (1967) assumes that farm decision makers are risk averse and analyses the solution of diversification problem. Here, it is assumed that the individual or farm decision maker views the outcome of any enterprise in probabilistic terms, so, individual farmer is willing to act on the basis of two parameters of the associated probability distributions of net returns-the expected value and the standard deviation. This paper finds that the strategy implied for combining the risky crops and the riskless crops will maximize the net benefits to the farmers. This combination is interpreted as a proportionate combination of land devoted to risky and riskless enterprises.

With this background of literature, this study favors crop diversification at least to some extent. In case of Punjab, the most pressing issue today is decelerating productivity and hence employment in agrarian sector. Switching completely away from wheat-paddy to non-food crops is not a proposition which this study supports. But, for the soil to regain its fertility, for water levels to be maintained at appropriate levels and for farmers to gain higher incomes a minimal crop diversification is need of this hour. Considering the risk averse behavior of farmers, the study looks at the factors influencing decisions of the farmers. This study attempts to look at the difference between intensity of crop diversification of small farmers

and large farmers in India by looking at the micro-level differences among these categories of farmers and also study the factors which drive some landowners to diversify while not providing any incentives to others.

Empirical Model

The decision about whether to undertake an activity and the extent to which that activity is undertaken can be considered a two-step decision process or two-tier hurdle model. This model initially proposed by Cragg (1971) is found to be appropriate for disaggregate analysis of selection and outcome decision problems such as in this study. The first hurdle is the decision about whether or not to diversify the cropping pattern away from food crops like wheat, paddy, maize etc. to remunerative non-food crops like fruits, vegetables, sugarcane and oilseeds. The second hurdle is about measuring the extent to which the individual farmer has diversified which is reflected by the share of total area which he has put under cultivation of non-food crops. Since, some farmers may not have switched from food crops to non-food crops at all, some may have put all the potential area under non-food crops and some may have put only a portion of the land under non-food crops, the dependent variable in the second tier consists of both continuous and zero cases. Thus, tobit analysis is a common method for making consistent estimates in a model that has dependent variables containing zero values, since the estimation method treats zero values as part of continuous values. While in the decision equation, zero is a part of a binary dependent variable (0 or 1).

The model consists of two equations. In the context of this study, the equations are-(i) a regression model to estimate whether or not the farmer would diversify (YD), and, (ii) a regression model to estimate area under non-food crops (YO).

$YD = âXi + ei$ (1)

$YO = áZi + ui$ (2)

Where,X is a vector of explanatory variables for diversifying decision. â is a vector of coefficients of diversification variables.

Z is the vector of explanatory variables for the extent of diversification. Á is a vector of coefficient for the extent of diversification variables ei and ui are the independently distributed normal random error terms with mean 0 and variance ó2

Variables used in the study

Tier 1: In this study, the first step includes the dependent variable as a binary variable which takes a value 1 if the landowner diversifies and takes the value 0 if he does not. The explanatory variables would be-

Market access- This was measured as number of markets in a village per acre of area under cultivation. **Irrigation**-Irrigation is defined as percentage of irrigated area of the total area under cultivation. **Landowner's income level**-The income of the landowners from agricultural activities affects the diversification decision. **Off-farm income level**-This is measured in percentages. It is the share of off-farm income in the total income earned by the land owners. **Perception about effect of diversification on profitability of the landowners-** If the landowners perceive that the profitability is going to increase with diversification, they would allocate some area to non-food crops. To capture this variable, a risk coefficient is calculated.

This risk coefficient is the difference between the yield from food crop and non-food crop divided by the variance of farmer's income (Joshi and Birthal, 2006).

Tier 2: In the second step the dependent variable would be **Extent of land use for cultivation of non-food grains (percentage).**

The explanatory variables are defined as follows-

Land holding size- Larger land holding is expected to drive the land owner towards diversification. **Landowner's income level, Off-farm income level, Profitability of diversification relative to specialization (as measured by risk coefficient), market access, rainfall (millimeters)** are the other variables used in the second tier.

Study Area and Socio Economic profile of sample households

Punjab was chosen as the study area. To address the major objectives of the study, primary and secondary data is used. The data on relevant aspects was collected from Punjab Agricultural University under income and expenditure scheme. The data pertains to year 2008 and provides information about 177 farmers: Income they earn (farm, off-farm, rentals and transfers), Land possessed (leased in, leased out, owned), Area under different crops they grow, its output, yield and net returns. The data is collected from districts of Punjab: Ludhiana, Kapurthala, Amritsar, Gurdaspur, Ferozpur, Ropar, Sangrur, Hoshairpur, Faridkot and Mansa. From each district, 2 villages were chosen at random and therefore, data was collected from total of 20 villages of Punjab.

Table 1: Descriptive Statistics of the farmers

Variable	Mean	St. Dev.	Min.	Max.
Agricultural Income per acre	18790.6	20969.3	0	240416
Non Agricultural Income	57220.46	116799.1	0	729000
Land operating (%)	8.83	10.18	0.2	64
Market access(markets per acre of GCA)	0.01836	0.0057	0.012	0.034
Rainfall	586.7509	295.8907	170.9	1183.8

Source: Calculated through data collected from PAU, Ludhiana

In this study, the choice of variables for the first and second stage equations is done through a lengthy selection procedure that involves trying out many different combinations of variables from the list of explanatory variables identified to be relevant in explaining the two-step decisions. Accordingly, a set of market incentives (irrigation, market access, farmers' income) are included in the decision equation of the double-hurdle model as determinants of the decision to diversify. For the second-stage decision equation, individual characteristic are identified as determinants of the actual area put under non-food crops. The double-hurdle model is estimated by maximizing the log-likelihood function.

Table 2: Regression Results using Two-Tier Model

Tier 1	**b (Coefficients)**	**z**	**P>|z|**
mkt_acc (Market access)	131.200700*	3.73	0.00
IRRI(irrigation)	-0.133170*	-4.24	0.00
AGRIYLAND(Agricultural Income per acre)	0.000030	1.53	0.12
Int_risk(Interaction of risk coefficient and land operating)	-0.039190	-0.11	0.91
RISKCOEF(perception about profitability)	-0.009260	-0.19	0.82
_cons	-13.832000	-4.35	0.00
Tier 2	b	z	P>z
IRRI(Percentage of land Irrigated)	-4.180533	-1.5800	0.113
mkt_acc(market access)	-7393.410000	-1.8700	0.061
RAIN (Rainfall in mm)	0.085536	2.0600	0.039
Int_risk(Interaction of risk coefficient and land operating)	3.250399	0.3900	0.694
RISKCOEF(perception about profitability)	0.192158*	0.3400	0.017
LANDOP (Percentage of land operating)	6.839342*	2.8600	0.004
RENTALY (Rental Income)	-0.001823*	-2.3500	0.019
_cons	255.542700	1.0800	0.281

Source: Punjab Agricultural University, Ludhiana
Number of observations: 177, Log likelihood: -246.1934, Wald Chi-square: 40.84, Prob> chi sq.: 0.0000, * indicates significance at 5% level of significance. Note: Robust Standard Errors.

The coefficients in the first hurdle indicate how a given variable affects the likelihood (probability) to switch area allocated from food crops to non-food crops. Those in the second hurdle denote how a variable influences the level of diversification, given that a decision is made to allot some area to non-food crops. The results are indicated in Table 2.

Tier 1 (Decision equation)

Turning to the analysis of the parameter estimates, factors that significantly increase the probability of crop diversification by farmers (Tier 1) are-

Market access (mkt_acc) and irrigation (IRRI) are the two variables which have turned out significant for the first tier. Market access is expected to positively impact

the decision of the farmer to diversify, and the actual results are running parallel to these expectations.

Irrigation negatively impacts the decision to switch from food crops to non-food crops. With greater irrigational facilities farmers desire to cultivate crops which require availability of abundant water. Wheat and paddy are such crops which need rich availability of irrigational facilities. Thus, it is this easy accessibility of irrigation in Punjab which makes both small and large farmers cultivate only wheat and paddy and plays a significant role as the factor affecting farmers' decision.

This reflects that farmers are very responsive to market incentives. If farmers have greater access to markets and do not have incentives to grow wheat and paddy because of availability of irrigation, all the farmers would decide to diversify.

Variables like farmers' risk coefficient i.e. his perception about profitability of non-food crops over food crops and income from agriculture have turned out to be insignificant in the first tier. Thus, it can be inferred that for the decision problem, it is not the household characteristics which are influential while taking the decision to diversify but it is the market incentives availability that promotes farmers to put a proportion of the land under non-food crops.

Tier 2 (Extent Equation)

Factors that significantly affect the extent of crop diversification by farmers are highlighted by tier 2- Individual characteristics of the farmers which are reflected by land under operation (LANDOP), risk coefficient (RISKCOEF) and rental income (RENTALY) earned have turned out to be significant in driving the extent to diversification. While the factors, irrigation and market access, which were significant in influencing the decision have turned out to be insignificant in impacting the extent of diversification.

Higher is the percentage of land operating as the total land in acres, higher will be the extent to which he can diversify. Once the farmer has decided to diversify, he will put a higher proportion of land under non-food crops if he possesses larger land holding compared to another farmer who has also decided to diversify but has a smaller land holding. Large farmers have surplus lands so they can put greater acres of land under non-food crops relative to small farmers.

Similarly, risk coefficient which is again a characteristic of individual farmer persuades the extent of area allotment under non-food crops. Higher the negative value of risk coefficient lower will be the area under non-food crops i.e. lower is the risk coefficient (higher yields from food crops) lesser is the incentive for taking risk and switching to non-food crops. Since the farmer is earning higher yields from wheat and paddy he would not want to switch to non-food crops which provide him lower yield due to higher risk involved for him. Market incentives are not significant i.e. irrigation, rainfall and market access are insignificant. This reflects that the farmer once decides to diversify then the extent to which he diversifies will not be influenced by the same factors. The area he decides to put under non-food crops is the function of his personal characteristics.

Thus, the objectives of the paper can be answered well with the above analysis. Very interestingly, it can be said that there is a difference in the extent to which small and large farmers diversify due to the heterogeneity of assets they possess, income they earn, facilities they can avail and risk they can face. Large farmers are fortunate to earn greater income, possess substantial amount of assets and hence, they can face higher risks. This gives them opportunity to try different combination of crops which can definitely earn higher returns, though, with some amount of risk attached.

Regarding the decision making, the size of the land holdings does not influence the behavior of the farmer; rather, it is the provisions made by the state like access to markets, which can drive farmers to choose combinations of food crops and non-food crops. However, there is a possibility that such provisions are biased in favor of large farmers. There are evidences in case of Punjab, of existence of lobbying in favor of rich and large farmers. Although the results are largely consistent with theory predictions it is important to recognize that they are based on a data from a survey which may be subject to limitations due to only 177 responses. Nevertheless the results provide initial ground for assessing the appropriateness of the model and potential for a larger, more in-depth study of farmers' acreage decisions given his wealth, market incentives and risk considerations.

Policy Recommendations

The decision of the farmer is influenced by the market incentives, provision of efficient and equitable market incentives can encourage all the farmers to diversify at least to a minimum extent. Further regarding the extent, a farmer decides the area to be allocated to high value crops based on his will and capability.

Among others, the immediate measures include ensuring markets, developing roads, creating appropriate infrastructure and encouraging private sector participation

for value addition and processing. Domestic market reform is a pre-condition for agricultural diversification in favor of high-value crops. Measures should be taken to reform institutional arrangements, which can appropriately integrate production and markets.

In an increasingly complex agricultural landscape, enhancing the efficacy and evolution of newer risk management tools is essential for the viability and sustainability of the sector. In this regard the establishment of a Centre for Risk management in Agriculture in Public –Private Partnership mode for research, capacity building and popularizing risk management solutions in agriculture is important.

Large farmers can allocate the area to high value commodities like cotton, onion and sugarcane. Such crops involve greater risk which can be borne by large farmers. Any decision making in the process of diversification towards non-food crops could be best analyzed using Time Series data for quantities, cost and prices. But, such data was not available, which is one of the limitations of this study. Also, while considering risk and acreage response, input markets also play a crucial role i.e. while taking decisions farmers take into account not only profitability or relative prices but also input availability. This is another aspect which can be part of the future study.

REFERENCES

1. Bhatia, S. S., 1965.'Patterns of Crop Concentration and Diversification inIndia'.*Economic Geography*, Vol. 41, No. 1, pp. 39-56.

2. Chand, R., 1999. 'Emerging crisis in Punjab agriculture, Severity and options for future', *Economic and political weekly*, Vol.34, No.13, pp. A2- A10.

3. Chand, R. andHaque, T., 1997.'Sustainability of Rice-Wheat Crop System in Indo-GangeticRegion'.*Economic and Political Weekly*, Vol. 32, No. 13, pp. A26-A30.

4. De, U. K. and Chattopadhyay, M., 2010.'Crop diversification by poor peasants and role of infrastructure: Evidence from West Bengal'.*Journal of Development and Agricultural Economics* Vol. 2(10), pp. 340-350.

5. Dhakal, B., Bigsby, H. and Cullen, R., 2008.'Determinants of Forestry Investment and Extent of Forestry Expansion by small holders in New Zealand'; *Review of Applied Economics*, vol. 4, No.1-2, pp. 65-76.

6. Fafchamps, M., 1992.'Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World'.*American Journal of Agricultural Economics*, Vol. 74, No. 1, pp. 90-99

7. Feder, G., 1980.'Farm Size, Risk Aversion and the Adoption of New Technology under Uncertainty'.*Oxford Economic Papers*, New Series, Vol. 32, No. 2, pp. 263-283.

8. Haque, T., Bhattacharya, M., Sinha, G., Kalra, P. and Thomas, S., 2010. 'Constraints and Potentials of Diversified Agricultural Development in Eastern India'.Council for Social Development.

9. Hazra, C.R., 2001-03.'Agricultural diversification in India', Ministry of Agriculture.

10. Henrich, J. and McElreath, R., 2002.'Are Peasants Risk Averse Decision Makers?',Current Anthropology, Vol. 43, No. 1, pp. 172-181.

11. Immink, M.D.C. and Alarcon,J.A., 1991.International food policy research institute, 'Household Food Security, Nutrition and Crop Diversification among Smallholder Farmers in the Highlands of Guatemala' Vol. 25, No. 4.

12. Roumasset, J., 1976. 'Handbook of Agricultural Economics: Agricultural development, Farmers, Farm production and farm markets', Volume 3.

13. Johnson, S.R., 1976.'A Re-Examination of the Farm Diversification Problem', Journal of Farm Economics, Vol. 49, No. 3, pp. 610-621.

14. Joshi, P.K., 2005.'Crop diversification in India: Nature, pattern and drivers'.

15. Joshi, P.K., Gulati, A., Birthal, P.S.Tewari, Laxmi, 2004.'Agriculture Diversification in South Asia: Patterns, Determinants and Policy Implications'; *Economic and Political Weekly*, Vol. 39, No. 24, pp. 2457-2467.

16. Joshi, P.K., Joshi, L. and Birthal, P.S., 2006.'Diversification and Its Impact on Smallholders:Evidence from a Study on VegetableProduction'; *Agricultural Economics Research Review*Vol. 19,pp 219-236.

17. Mathur, A.S., Das, S. and Sircar, S., 2007.'Status of Agriculture in India: Trends and Prospects'. *Economic and Political Weekly*, Vol. 41, No. 52 , pp. 5327-5336.

18. Mesfin, W., Fufa, B. and Haji, J., 2011.'Pattern, Trend and Determinants of Crop Diversification: Empirical Evidence from Smallholders in Eastern Ethiopia'.*Journal of Economics and Sustainable Development*, Vol.2, No.8.

19. Mishra, S., 2007.'Risks, Farmers' Suicides and Agrarian Crisis in India: Is There A Way Out?'.Indira Gandhi Institute of Development Research, Mumbai.

20. Mythili, G., 2008.'Acreage and Yield Response for Major Crops inthe Pre- and Post-Reform Periods in India:A Dynamic Panel Data Approach', Indira Gandhi Institute of Development Research, Mumbai.

21. Nyholm, K.,Hetirik, S. M.,Westergaad,K., 2008.'Socio-Economic Aspects of Dairy Development'. Report from the Bangalore Milkshed Area.

22. Saleth, R.M., 1995.'Agricultural Diversification in Tamil Nadu: Potentials and Prospects', Institute of economic Growth, Delhi, 710 pp.

23. Shahabuddin, Q. and Butterfield, D., 1986.'The Impact of Risk on Agricultural Production Decisions: Tests of a Safety-First Model in Bangladesh'.*The Bangladesh Development Studies,* Vol. 14, No. 3 , pp. 13-37.

24. Sharma, R. K., 2010.'Analysis of Profitability and Risk in New Agriculture Using Dynamic, Non-Linear Programming Model'.*Journal of Agricultural Science*, Vol. 2, No. 1.

25. Shergill, 2005.Punjab University (Chandigarh); 'optimal cropping in Punjab; Wheat and paddy cultivation and the question of optimal cropping pattern for Punjab'.

26. Sidhu, H.S., 2002.'Crisis in Agrarian Economy in Punjab: Some Urgent Steps'; *Economic and Political Weekly*, Vol. 37, No. 30, pp. 3132-3138.

27. Sidhu,R.S and Bhullar, A.S., 2006.'Patterns and Determinants of Agricultural Growth in the Two Punjabs'.*Economic and Political Weekly*, Vol. 40, No. 53, pp. 5620-5627.

28. Singh, J. and Sidhu,R.S., 2004.'Factors in declining crop diversification, Case study of Punjab', Economic and political weekly, vol. 39, No. 52, pp. 5607-5610.

29. Singh, R.B., 2000.'Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India'; Agriculture, Ecosystems and Environment 82, 97–103.

30. Singh, S., 2000.'Crisis in Punjab Agriculture'.*Economic and Political Weekly*, Vol. 35, No. 23, pp. 1889-1892.

31. Wodjao, T. B., (n.d.). 'A Double-Hurdle Model of Computer and Internet Use in American Households, Department of Economics', WesternMichigan University.

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