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Role of agricultural diversification in mitigating income risk in Eastern India

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ABSTRACT

The study attempts to verify the role of agricultural diversification as a mechanism of coping with income risk. For this purpose, the study estimates the level of agricultural diversification across the eastern Indian states sourcing secondary data on value of output for the period spanning from 1999–00 to 2013–14. Further, income risk at state level also measured through a comprehensive and comparable risk index. It was observed that in eastern Indian states, Chhattisgarh had highest level of risk and Bihar had lowest risk level. Further, factors which can positively influence level of agricultural diversification were segregated and it was observed that, fertilizer usage, percentage of irrigated area, cropping intensity, market access and farm sizes had direct impact on level of diversification for overall agriculture and in cereals, pulses and oilseeds sub-sectors, though in varying degrees. The study also established that level of agricultural diversification reduces risk level while land fragmentation increases risk level.

Keywords: Agricultural diversification, Eastern India, Risk index, SURE model

Role of agriculture sector in the growth, stability and sustenance of a developing economy cannot be refuted. Not only in terms of providing food security, but agriculture serves as one of the major sectors for availing employment, income and distributive equity (Economic Survey, 2016-17). Numerous studies have reported increased riskiness in Indian agriculture after green revolution (Ray 1983, Larson *et al*. 2004). However, this hypothesis is refuted in other studies (Sharma *et al*. 2006, Chand and Raju 2009). So, the debate on of risk and agricultural growth is still relevant in present agricultural situation. Previous studies on risk assessment tend to focus on point estimates of risk over the study period while ignoring the directional dimension of risk (Chand and Raju 2009). Moreover, studies tend to focus exclusively on either one of the two components namely price risk or yield risk. To mitigate this risk, crop diversification has been extensively used as a mechanism for stabilizing income (Akca and Sayili 2005, Birthal *et al* 2015). It is also reported that crop diversification is integral to agricultural systems in eastern India (Sen *et al.* 2017). Hence, strategizing agricultural diversification to moderate risk level is of substantive policy requirement.

In the present study we strive to develop a measure of income risk that encompasses both magnitude and directional dimensions. The study is undertaken for eastern Indian states wherein agriculture is perceived to be increasingly risky. The analysis further discerns factors influencing diversification in various sub-sectors namely cereals, pulses and oilseeds. Further, the role of crop diversification as a risk mitigating strategy was explored using the income-based risk Index. Finally, the study validates the role of crop diversification as a risk reducing mechanism in agriculture.

MATERIALS AND METHODS

To suffice the objectives of the study, data on value of output of agriculture and allied activities was retrieved from Ministry of Statistics and Programme Implementation (MoSPI), Government of India, for period, i.e. 1999–00 to 2013–14 for Bihar, Chhattisgarh, Jharkhand, Odisha and West Bengal. Eastern Uttar Pradesh is dropped from the analysis due to unavailability of apportioned data. All values were converted to 2011–12 base year with agricultural GDP data series. The information on irrigated area and other parameters were obtained from Department of Economics and Statistics (DES) and Agricultural Census, Ministry of Agriculture and Farmers Welfare, Government of India, for the same period. Data on other socio-economic variables like, state-wise number of major markets over time, per ha fertilizer consumption etc. were collected from various government and non-government sources. *viz*. planning commission, various state agriculture department, Fertilizer Association of India (FAI) publications etc. for the same period. Forward and backward interpolation technique has been put in use to convert a discontinuous time series to

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continuous over the study period, wherever necessary.

Concept of risk in agriculture: Risk in agriculture is mainly defined as fluctuation in yield level, price level or in income level (Akca and Sayili 2005). Higher fluctuation or instability signals higher risk. In the present study, we considered income risk by assessing instability in gross value of output, which entails both risk in yield level and price risk.

Delineating risk in agriculture: The study examines risk in agricultural production by analyzing temporal instability of total value of agricultural output, *i.e.* gross value of output (GVO). For this purpose, a comprehensive and comparable measure of risk was estimated and its theoretical range is $-\infty$ to $+\infty$. The gross value of output has been used extensively to measure risk in financial sector (Gao and Hong 2017) and service sectors (Basu *et al.* 2011).

$$\text{Risk Index} = \frac{\mu_{it}}{(GVO/ha)_{it}}$$

where, Risk Index (RI) is a unit free measure of risk with spatial and temporal comparability. μ_{it} (where i denotes the state and t denotes the time period) denotes the de-trended GVO/ha. RI was estimated by using de-trended data which purely describes cyclical and irregular fluctuations. Higher score indicates higher fluctuation, i.e. higher risk. The sign denotes whether risk in income is increasing or income dampening. To describe the distribution of risk kernel density plot of estimated risk index is plotted. This measure has several advantages over existing measures, *viz.* as the index is normalized by mean value of GVO/ha of each cross-sectional unit, it can be used for cross sectional and temporal comparison. Again, while in case detrended data where Coefficient of Variation (CV) cannot be calculated (as mean of detrended residual is technically zero), RI can serve the same intentions for CV. Further, the limitation of detrended residual is muted by normalizing it with GVO/ha of each cross-sectional unit. Additionally, RI also acts as directional measure of risk where, the other measures acts as point measure indicating only true value.

Measuring level of diversification: To measure level of diversification overall and across different sectors, Simpson Index of Diversification (SID) was constructed by the information elicited from data on value of output for the period 1999-00 to 2013-14 (Joshi *et al.* 2004, Ali 2015, Sen *et al.* 2017).

$$SID = 1 - \sum_{i=1}^{n} P_i^2$$

$$\text{where } P_i = \frac{\text{Value of output for } i^{th} \text{ crop/enterprise}}{\text{Total value of output from all agriculture and allied enterprises in farm}}$$

The rationale underlying the use of value of output of each individual crop was to encapsulate the role of all agricultural and related allied enterprise like livestock, poultry, fishery etc. in the determination of level of diversification where area approach is not a meaningful measure.

Econometric modeling of risk: To discern the factors which affect level of agricultural diversification in different sectors, viz. overall, cereals, pulses and oilseeds, seemingly unrelated regression (SURE) model was used (Equation 1-4) as estimated errors associated with the dependent variables are correlated and literature suggested to apply SURE model in such cases (Zellner 1962, Cameron *et al.* 2010, Greene 2012). Breusch-Pagan test was employed to verify the independence of estimated residuals.

$$Y_{it} = \beta_1 + \beta_2 X_{1t} + \beta_3 X_{2t} + \beta_4 X_{3t} + \beta_5 X_{4t} + \beta_6 X_{5t} + \beta_7 X_{6t} + \beta_8 X_{7t} + \beta_9 X_{8t} + \varepsilon_6 \quad (1)$$

where, Y_1, measures level of diversification. Similar to equation 1, three more models were identified with y as overall agricultural diversification, diversification in cereals, pulses and oilseeds respectively and X_{it} (i = 1, …, 8) describes set of independent variables.

To investigate the factors which affect risk level following econometric model was used. The exogenous variables through a comprehensive review of literature to depict the impact of diversification of different sectors on risk level (Mandal and Kumar *et al.* 2012, Bezbaruah 2013, Chattre *et al.* 2016). After estimating parameters in Equation 5 by ordinary least square technique (OLS), estimated residuals were tested for normality and further checked for homoscedastic distribution to validate the inferred results.

$$(\text{Risk Index})_t = \alpha_1 + \alpha_2 (\text{SID\_overall})_t + \alpha_3 (\text{SIDa\_cereals})_t + \alpha_4 (\text{SID}_{pulses})_t + \alpha_5 (\text{SID}_{oilseeds})_t + \alpha_6 (\text{proportion of large farmers})_t + \alpha_6 (\text{proportion of medium farmers})_t + \alpha_7 (\text{proportion of irrigated area})_t + \varepsilon_1 \quad (2)$$

where, ε_1 is estimated residual and SID measures level of diversification, i.e. overall agricultural diversification, diversification in cereals, pulses and oilseeds respectively.

RESULTS AND DISCUSSION

Basic profile and agricultural diversification of eastern Indian states: Data (Table 1) shows the various levels of diversification, agricultural productivity (₹/ha), proportion of small and marginal farmers and cropping intensity. The level of diversification was found to be highest in West Bengal and lowest in Chhattisgarh. There was substantial variation in agricultural productivity across eastern Indian states with West Bengal recording the highest (₹ 126191/ha) and Chhattisgarh the lowest (₹ 43520/ha). The proportion of small and marginal farmers was substantially higher in West Bengal and Bihar (over 95% of total holdings) indicating fragmented land holdings. Cropping intensity was substantially higher in West Bengal (178%) in comparison to Bihar (138%), Chhattisgarh (118%), Jharkhand (114%) and Odisha (138%).

Risk in agriculture in eastern Indian States: The state-wise risks were estimated through RI (Table 1). The values were compared with other risk measures such as risk index developed by Ray (1983) and used by Chand and Raju (2009) and Coefficient of Variation (CV). It was seen that RI is lowest for Bihar and highest for Chhattisgarh followed

Table 1 Basic and risk profiles of eastern Indian states (1999–00 to 2013–14)

Variable	SID	GVO/ha# (₹/ha)	Marginal and small farm (%)	Cropping Intensity	Risk Index (RI)	Chand and Raju Index	Coefficient of Variation (CV)
					(2)	(3)	(4)
Bihar	0.85	75108	95.81	1.38	-0.096	0.115	0.182
	(0.01)	(14140)	(1.34)	(3.53)	(0.11)	0.167	0.225
Chhattisgarh	0.79	43520	78.32	1.18	-0.891		
	(0.06)	(10134)	(2.33)	(4.27)	(0.28)		
Jharkhand	0.85	108571	85.45	1.14	0.242	0.185	0.409
	(0.05)	(45978)	(1.6)	(3.98)	(0.25)		
Odisha	0.84	58180	88.12	1.38	-0.415	0.154	0.411
	(0.06)	(24751)	(4.09)	(18.83)	(0.19)		
West Bengal	0.88	126191	95.65	1.78	0.348	0.037	0.100
	(0.03)	(13044)	(0.3)	(6.7)	(0.08)		

VOA = $\Sigma_i$value of all agriculture crops and allied sector. Figures in parentheses indicates standard deviation

by Odisha among eastern Indian states. However, in all the three states risk was found to be income dampening, i.e. over the time cyclical and irregular component of the time series contributed for reduction of income. On the other hand, in Jharkhand and West Bengal, the risk is found positively related with income. The positive values of the risk index indicate an increase in risk index while a negative value implies a decline in risk index values. If overall measure of risk is considered without inferring about its direction, Chand and Raju Index highlights that overall risk is highest in Jharkhand and lowest in West Bengal, whereas CV was observed to be highest for Odisha and lowest for West Bengal.

The trend analysis of risk indicates the presence of temporal variation of risk for the aforementioned states. It strengthens the above-mentioned results, that over the study period (1999-00 to 2013-14) risk level has reduced incessantly for Bihar, Chhattisgarh and West Bengal. For Odisha except for the year 2009-10 (drought year), risk was observed to be falling throughout the study period. However, for Jharkhand the risk trend is found to be positive indicating more instability in recent years.

Factors affecting level of diversification: This section seeks to identify the various factors that could potentially influence diversification of agriculture in Eastern India. The analysis also attempted to quantify the impact of cropping practices and socio-economic factors on agricultural diversification. As the independent variables were identical for the four regression models the correlation matrices of error terms was computed and a usage of a SURE model was found to be appropriate from the results of the Bresusch-Pagan test of independence (Table 2). Proportion of irrigated area and proportion of large farmers were found to decrease level of diversification in the agriculture sector while increased access to markets and increase in proportion of small and marginal farmers were found to increase level of diversification in agriculture. While assessing the influence of various factors on diversification of cereal sub-sector we found that increase in fertilizer usage had a detrimental impact on cereals diversification while increase in irrigated area positively influenced diversification.

Among socio-economic factors the increase in market access accentuated diversification while increase in holding size tends to drag down diversification. For pulse sub sector, increasing in cropping intensity and fertilizer usage facilitates diversification while increase in irrigated area and fragmentation of land holdings tend to decrease diversification. Increase in irrigated area and greater access to markets were found to assist diversification, while increase in cropping intensity and fragmented land holdings impeded diversification of oilseed production in Eastern India. Evidences from the analysis reveal that increase in land holding size facilitate diversification towards oilseeds whereas in pulses increase in land holding size impedes diversification. Then inclination of farmers to meet household demand for food grains before diversifying towards commercial crops is distinctly visible.

Determinants of risk in agriculture: In this section, we attempted to delineate various factors that are likely to influence risk levels in agriculture in eastern Indian states using a regression model (Table 2). The assumption of normality and heteroscedasticity of residuals were tested and no issues were found. The analysis has discerned that diversification of agriculture (measured using SID) dampens risk levels. It clearly indicates that as the level of diversification increases the risk index declines. The impact of diversification as a measure of risk reduction was found to be highest in case of pulses across crop classes. This finding is in line with our expectations as pulses are cultivated extensively on marginal lands with limited access to irrigation (Mukherjee 2010). Moreover, the conspicuous absence of an assured procurement mechanism akin to cereals leads to high levels of volatility in incomes of pulse sectors. The higher level of risk inherent in pulse

Table 2 Determinants of agriculture diversification and risk

Factors affecting level of agricultural diversification				
Dependent variable: Diversification (SID)	Overall agricul-ture	Cereals	Pulses	Oilseeds
Independent variables				
Fertilizer usage	0.001	-0.002*	0.001**	0.001
Irrigated area (%)	-0.002***	0.003***	-0.002***	0.006***
Cropping intensity	0.001	-0.001	0.001**	-0.002***
Market access	0.001*	0.001**	0.001	0.001**
Share of large farms (%)	-0.085**	-0.457***	0.011	0.376***
Share of medium farms (%)	0.005	0.070***	-0.002	-0.043***
Share of small farms (%)	0.009***	-0.034***	-0.001	0.019***
Share of marginal farms (%)	0.006***	0.021***	0.004**	-0.015***
Intercept	0.174	-1.087***	0.513***	1.708***
Model adequacy check				
Number of observations	75	75	75	75
R-squared	0.48	0.92	0.51	0.73
Chi square	70.15	812.25	78.03	201.77
Prob. > Chi square	0.001	0.001	0.001	0.001

Factors influencing risk levels in agriculture			
Dependent Var.: [Risk Index]			
Independent variable list:	*Coefficient*	*Std. Err.*	*t value*
(1)	*(2)*	*(3)*	*(4)*
Diversification level : Overall (SID)	-2.054***	0.551	-3.730
Diversification level : Sector-wise (SID)			
Cereals (SID)	-0.752***	0.228	-3.300
Pulses (SID)	-3.215***	0.599	-5.370
Oilseeds (SID)	-0.915**	0.379	-2.410
% irrigated area	0.003	0.003	1.180
% share of large farms	-0.486***	0.097	-5.010
% share of medium farms	0.042***	0.012	3.630
Intercept	4.820	0.819	5.890
Model adequacy check			
Number of observations		75	
F(7, 67)		23.93***	
R-squared		0.71	
Adj R-squared		0.68	
Root MSE		0.18	

*,** and *** indicates significance at 10%, 5% and 1% level respectively.

cultivation drives cultivators to resort to diversification as a risk minimizing strategy. Increase in land holding size was found to reduce risk levels as indicated by the negative relationship between proportion of large farmers and risk levels. Risk levels were found to increase with increase in proportion of medium farmers indicating that fragmentation of land holdings subsequently led to an increase in risk levels. Increase in proportion of irrigated holdings was found to have a non-significant impact on risk levels which could to be attributed to the agro-climatic profile of the study area. A majority of the districts in the study area receive ample rainfall and studies have identified that the income augmenting role of irrigation is more prominent than the risk reducing role.

To trace the relationship between diversification and risk levels fit plots were sketched between the risk index and Simpsons index of diversification. Plots were sketched for cereals, pulses, oilseeds and agriculture sector separately. All four plots tend to reiterate the risk reducing role of diversification. The marginal effect of diversification on risk reduction was found to be highest for pulse subsector (-3.22) followed by diversification in overall agriculture (-2.05), oilseed subsector (-0.92) and cereal subsector (-0.75).

The study established the relation between level of diversification and risk with empirical evidence. Diversification level in overall agriculture and different sub-sectors were mapped and presence of high diversification level was found. Risk level for the same unit was also profiled. Further, the study attempted to build up a comprehensive and comparable measure of risk in agriculture in eastern India. The nature of agriculture in eastern India was found to be risky as represented by the comprehensive risk index (RI). It was observed that measured risk across the states is asynchronous and risk in agriculture is lowest in case of Bihar and highest in case of Chhattisgarh. Land fragmentation and access to irrigation were found to impede diversification while increased access to markets facilitated diversification of agriculture in Eastern Indian states. Evidences from the study reveal that diversification of agriculture moves in tandem with a reduction in riskiness of agriculture enterprise. The risk reducing role of diversification is more pronounced in pulse cultivation. So, in the eastern states where level of risk is high, agricultural diversification can provide for a solution to stabilize production and farm income. The study suggests to make suitable policies for promotion of diversification for mitigating income risk.

REFERENCES

Akca H and Sayili M. 2005. Risk and uncertainty (variability) in wheat production in Turkey. *Journal of Applied Science* **5**(1): 101–03.

Basu S, Inklaar R and Wang J C. (2011). The value of risk: measuring the service output of US commercial banks. *Economic Inquiry* **49**(1): 226–45.

Birthal P S, Jha A K, Joshi P K and Singh D K 2006.Agricultural diversification in North eastern region of India: Implications for growth and equity. *Indian Journal of Agricultural Economics*

61(1): 902–10.

Birthal P S, Roy D and Negi D S. 2015. Assessing the impact of crop diversification on farm poverty in India, *World Development* **72**(1): 70–92.

Colin A C and Trivedi P K. 2010. Microeconometrics using Stata, revised edition. StataCorp LP .

Chand R and Raju S S. 2009. Instability in Indian agriculture during different phases of technology and policy. *Indian Journal of Agricultural Economics* **64**(2): 187–207 .

Chhatre A, Sripad D and Seshadri S.2016. Crop diversification and risk management in Indian agriculture. *Decision* **43**(2): 167–79.

Gao W and Hong K. 2017. The portfolio balanced risk index model and analysis of examples of large-scale infrastructure project. *Complexity* 21: 1–13.

Greene W H. 2012. Econometric analysis, 71e. Stern School of Business, New York University.

Larson D W, Jones E , Pannu R S and Sheokand R S. 2004. Instability in Indian agriculture—a challenge to the green revolution technology. *Food Policy* **29**(3): 257–273.

Mandal R and Bezbaruah M. P. 2013. Diversification of cropping pattern: its determinants and role in flood affected agriculture of Assam Plains. *Indian Journal of Agricultural Economics* **68**(2): 169–81.

Kumar A, Kumar P and Sharma AN. 2012. Crop diversification in Eastern India: Status and determinants. *Indian Journal of Agricultural Economics* **67**(4): 600–616

Ray S K. 1983. An Empirical Investigation on the Nature and Causes for Growth and Instability in Indian Agriculture: 1950-80. *Indian Journal of Agricultural Economics* **38**(1): 459–74.

Sen B, Venkatesh P, Jha G K and Singh D R. 2017.Agricultural diversification and its impact on farm income: A case study of Bihar. *Agricultural Economics Research Review* **30**(1): 77–88

Sharma H R, Singh K and Kumari S. 2006. Extent and source of instability in foodgrains production in India. *Indian Journal of Agricultural Economics* **61**(4): 647–66

Zellner A. 1962. An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American statistical Association* **57**(298): 348–68.