Risk aversion and sustainable maize production in Nigeria: Some challenges and prospects for agricultural and economic development

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Abstract

This paper determines the degree or extent of farmer's risk aversion that affects sustainable maize production in Northern Nigeria. Using a ridge regression analysis, a measure of risk aversion was derived for each individual farmer in a model of safety-first behaviour from a cross-sectional survey of 350 maize producers in northern Nigeria. The distribution of the degree of risk aversion shows a high skewness towards the risk averters (high risk farmers) and centered around 1.20, and standard deviation of 0.37. This distribution is then explained by a set of specific variables that characterize the farmers' behaviour in the study area using a Tobit model. Susceptibility to risk was found to be highly premised on the socioeconomic factors (e.g. age of household head), farm specific variables (e.g. proportion of income from maize) and farmers' attitudinal factors against risk (e.g. safety first level of probability of sale). These findings can be used to construct a framework of development programs for peasant farmers, which provide some challenging prospects

Keywords: Maize, Nigeria, Risk aversion, Tobit model

Introduction

In Nigeria, efforts to improve and sustain maize technologies have met with some success, as improved maize varieties are now grown in most areas of Northern Nigeria and in appreciable quantity across other agro ecological zones of Southern Nigeria. Nigeria has been somewhere in between two extremes (Byerlee and Eicher, 1997) of the miserable maize production performance in the Africa's regions between 1982 and 1997 and the impressive maize yield growth rates of approximately 3 percent annually as they achieved between 1967 and 1982. She experienced severe negative growth in maize yields of -1.1 percent between 1982 and 1990, but with growth rebounding somewhat annually between 1990 and 1997. The remarkable disjuncture between research efforts and technological diffusion on the one hand and yield performance on the other indicates that technological development has not been the main factor behind short-term maize yield trend. This sluggish yield response has been blamed on some factors (IFPRI, 2001), among which is limited adoption of complementary inputs such as fertilizer and other soil fertility-related practices to accompany new seed varieties. These factors have all played out in an environment characterized by frequent intense conflicts, and weak institutional arrangements. A summary of literature on sustainable maize production in Nigeria shows that most of the problems militating against the consistent expansion of the maize programme are being seriously addressed. Efforts in this regard include some viable agricultural policy instruments. However, the somewhat negative perception and of course risk attitudes of maize producers in Nigeria (Olarinde, 2004) towards crop technology has increased in the last decade, indicating why the various policy initiatives of the government may not result in any commensurate agricultural and economic gains. In effect, if maize policies arising from the various technologies and of course the Nigeria's rural development initiatives are going to be effective, they need to be tailored towards the risk attitudes of particular categories of farmers. After the introduction, the section on materials and methods describes a safety-first model that is employed to quantify the risk attitudes of major maize producers in Nigeria and to equally categorize them based on their risk aversion levels. The study also proceeds to develop a Tobit model to determine the factors influencing the degree or extent of the risk attitudes of the identified categories of farmers. Then results are discussed before the last section of the paper which provides some challenging prospects emanating from this study.

Materials and Methods

Theoretical Models

Among the approaches used by economists to capture decision making in risky situations is the "safety-first" method. One of the most celebrated applications of safety-first models is that of Moscardi and deJanvry (1977). The present study makes use of the indirect elicitation method of the safety-first model via regression parameter estimations to determine a risk aversion index for individual farmers. The factors influencing the degree of risk aversion have been found to be important considerations in the classification of farmers according to their risk bearing capabilities (Bamire and Oludimu, 2001). Based on this, we develop discrete choice model to analyze the effects of particular factors (socio economic, farm specific and farmers' attitudinal variables) on risk preferring, neural and averse farmers and on the degree or extent of their risk aversion.

Empirical models

In estimating a risk aversion index for each farmer, a "hybrid" equation from a Cobb-Douglas and a ridge regression models was used. The determinants of risk aversion and or those of the degree or extent of risk preferences (aversion) were analyzed using a Tobit model.

Cobb-Douglas (Log linear) versus ridge regressions. A log linear (Cobb-Douglas) production function was first estimated in which the relationship between the direct input vectors (x) and maize yields was established. Implicitly, the function is expressed as:

$$\ln Y_i = \ln \beta_o + \sum \ln \beta_j X_{ji} + \varepsilon_i \quad (1)$$

Where Yi = maize output of the *ith* farmer in ton/ha, X_j = explanatory variables (i = 1, 2… k, k = number of variables), β_j = estimated coefficient of parameters of explanatory variables, β_o = constant term, ε_i = error term. For this study; X_1 = quantity of maize seed planted in kg/ha, X_2 = fertilizer (NPK) in kg/ha, X_3 = fertilizer (Urea) in kg/ha, X_4 = labour utilization in manday/ha, X_5 = insecticide in litre/ha, X_6 = herbicide in litre/ha, X_7 = tractor hour/ha and X_8 = animal (traction) hour/ha. The model adopted suggests individual introduction of agrochemical variables (vectors) into the production function (see Moscardi and deJanvry, 1977). This could result in a multicollinearity problem. In economic theory, multicollinearity commonly occurs because of the nature of aggregation of economic data (Wethrill, 1986; Gujarati 1995). Multicollinearity in itself has been discovered to be a phenomenon that can cause serious problem in estimation and prediction. The most popular method of ameliorating multicollinearity has been discovered to be the use of ridge regression (Pasha and Shah, 2004). Ridge regression overcomes problem of multicollinearity by adding a small quantity to the diagonal of X^I (which is in correlation form). In the presence of multicollinearity the ridge estimator is much more stable (i.e. has smaller variance) than the Ordinary least square (OLS) **.** The ridge estimator is obtained by solving $(X^IX + RI)\,\beta^{\wedge *} = g$ to give $\beta^{\wedge *} = (X^IX + RI)^{-1}g$, where $g = X^IY$ and R is ridge parameter and holds when $R \geq O$. In general, there is an "optimum" value of R for any problem. But it is desirable to examine the ridge solution for a range of admissible values of R.

In this research, the most "optimum" (most) suitable ridge parameter R was determined from the fitted equation (1) to select the most significant direct (variable) determinant of yield, which was used to solve the following equation:

$$K_{(s)} = \frac{1}{\theta}\left[1 - \frac{P_i X_i}{P_y f_i \mu_y}\right] \quad (2)$$

Where $K_{(s)}$ = the risk aversion parameter, θ = coefficient of variation of yield, P_i = input (most significant variable) price, P_y = output price, X_i (most significant input vector), fi = elasticity of production of the *ith* input, μ_y= mean yield.

Following Moscardi and deJanvy (1977), the risk aversion parameter $K_{(s)}$ was used to classify sampled farmers into three (3) distinct groups as: low risk ($O < K_{(s)} < 0.4$), intermediate risk ($0.4 \leq K_{(s)} \leq 1.2$), high risk ($1.2 < K_{(s)} < 2.0$).

The Tobit Model. The adopted Tobit model combines the properties of multiple regression and probit/logit model (Rhaji, 2000). In this study, it captures the intrinsic risk decision of the sampled maize farmer (whether or not the farmer is attitudinally lowly or highly averse to risk). More importantly, it simultaneously considers the degree or extent of risk aversion. The dual purpose of the Tobit model necessitated its choice for this aspect of the analysis. The model is specified as follows:

$$W_i = W_i = \alpha V_i + \mu_i \qquad (3)$$

Following (3);

W_i = 0; if $\alpha V_i + \mu > W_o$ (i = 1, 2, 3, ………, N) (4)

if $\alpha V_i + \mu \leq W_o$

Where W_i is the dependent variable (risk aversion level) e.g. $0 < k < 2$, the independent variables (V_i) were as follows: age (AGE, V_1), household size(HSZE,V_2), leadership position(dummy) held by the farmer(LDSP,V_3), proportion of maize income to total farm income (MTFI, V_4), proportion of maize income to total household income (MTHI, V_5),number of farm holdings (NFH, V_6),first level probability of sales (safety-first$_1$ /FSTYF, V_7) and second level probability of sales (safety-first$_2$/SSTYF, V_8).

Those independent variables belong to three classes: the socio economic characteristics, which included the age, household size and whether or not the respondents held a leadership position within the farming community. The second class consists of farming characteristics which included the proportion of maize income to total farm income (most respondents grow other crops in light quantities), proportion of maize income to total household income (total household income include farm and non-farm income), and total number of farms owned by the respondents on scattered holdings. The third class consists of essentially the definition of farmers' attitudes to respond to risky market situations in the short run. This is based on the concept of probability of winning demanded (Feinerman and Finkelshtain, 1996). These sets of variables are labeled first and second levels (safety-first) of probabilities of sales respectively.

The independent variables were included in the Tobit regression model based on "a priori" theoretical expectations of their roles in influencing the degree or extent of the sampled maize farmers' risk attitudes. The Tobit model at the same time has an advantage to the extent that the coefficient estimates can be further disaggregated to determine the effect of a change in the *ith* variable on changes in the probability of aversion and the expected degree or extent of farmer's risk aversion. These are necessarily elasticity estimates (McDonald and Moffit, 1980; Adesina and Baidu-Forson, 1995). The estimates of the Tobit model were computed using the SAS version 8 (IITA, 2002).

Data sources and sampling procedure

The survey was conducted in Kaduna State, Northern Nigeria in 2004. The data used for this study were derived from farmers participating in the Kaduna State Agricultural development (KADP) and the Sasakawa Global (SG) 2000 programmes. The main data consisted of socio economic, production and risk data. These were collected by using structured questionnaire from a cross-sectional sample of 350 farmers across the four KADP Zones of the study area and through a multistage sampling procedure.

Results and Discussion

Determination of risk aversion and categorization of sampled farmers

We proceeded with the ridge regression analysis as multicollinearity was found among two exogenous variables (NPK and urea fertilizers). The coefficient and parameter estimates of the ridge regression were an improvement over the ordinary log-linearized Cobb-Douglas, e.g. $\overline{R}^2$ = 0.805; ridge parameter = 0.1. Seed use (X_1) was found to be the most significant input for increasing maize yields in the study area. The marginal productivity derived from the sampled farmers was then used to calculate the risk-aversion parameter K_s for each maize farmer. The results obtained show that 31 (8.91 %), 148 (42.53%) and 169 (48.56%) farmers are low, intermediate and high risk farmers respectively (348 out of 350 copies of questionnaires were used in the analysis). (Table 1)

The average age of the risk prefers was found to be more than that of the total sample and it was also more than the average age of the risk neutral and risk averters. This means that the farmers that are moderately old prefer to take risk and this can be due to their fairly long experience in farming and because most of them may no longer have the privilege of engaging themselves in any other activity for a living. The average numbers of people in the farming households are about 17, 13 and 12 for the risk preferers, neutral and averters respectively. Larger family sizes here, particularly for the risk preferers implies greater availability of labour on the farm, which is particularly necessary at peak periods and also to generate off-farm income. This supports the capacity of the risk preferers to assume or take risk with increasing family size. It was discovered that most family members were actively engaged in productive activities.

As can be seen (Table 1), more of the risk neutral farmers occupy one leadership position or the other. A mean value of 0.39 is well above the figures for the mean total and the mean for the two groups of farmers. Occupying a leadership position in a farming community also implies leading opinion. Opinion leaders are usually consulted in the process of introducing any innovation to such community. They are therefore expected to be among the early adopters and of course risk bearers of such innovations. The proportion of maize income to total farm income, proportion of maize income to total household income and the total number of farms for the risk preferers have higher mean figures. These observations are in line with expectation since these variables increase the willingness to take risk. The risk neural farmers will mostly sell their maize output even with increasing levels of loosing more money per bag of maize sold. This implies a critical evidence of the neutrality of this group of farmers in taking risk. The other two groups of risk preferers and averters would rather put in some considerations before taking the risk. This is evident in the results where less risk prefers and averters offer themselves for the lottery during the survey period.

The pattern of the estimated frequency distribution of *K* obtained from its cumulative distribution function shows that of the degree of risk aversion is highly skewed towards the risk averters and centered around 1.20 with a standard deviation of 0.37 (Figure1).

Determinants of Risk Aversion

Results of the Tobit analysis (Table2) show that all of the variables in the socio economic class were negatively related to the intensity or degree of the farmers' risk aversion. Out of the three variables included in this class, age and leadership position held by the farmers are significant at 10 and 5 percent levels respectively. Out of these two variables however, the negative sign of age is unexpected. The negative sign on age may be due to negative correlation between this variable and other socio economic variables not included in the model. The negative coefficient of the variable on leadership position held by the farmer is however adequate in the sense that though, few of the risk preferers held leadership position, their role in the community position made them to be less risk averse. Though the negative sign of the variable on household size is expected in order to confirm the theory that large number of people in farming household implies greater availability of labour and capacity to take risk, the variable is not significant. This is most likely due to the few number of identified risk preferring farmers. Coefficient estimates for the second class of included variables show that the proportion of maize income to that of total farm income and the number of farm holdings are significantly and negatively related to the degree of risk aversion. The coefficient of proportion of maize income to total household was not significant in explaining its effect on the degree of risk aversion. Though theory supports its importance in farmers' risk attitudes, these farm characteristics may not be applicable to the farming situation in the study area. The coefficient estimates of the third class of variables show that the first and second levels of probability of sale are both negatively related to the degree of farmers' risk aversion. However, only the sign on the coefficient of the first level probability of sale meet "a priori" theoretical expectation and is significant at 5 percent probability level, while the second level probability of sale is barely significant at the 10 percent level with unexpected negative sign.

The diagnostic statistics (Table 2) show that both the scale and Weibull shape distributions are highly significant at the 5 percent level of probability. This indicates that they are significantly different from zero at that level and also implies a good fit and correctness of the specified distribution assumptions of the function. The log-likelihood of Weibull distribution is quite high (-69.3460).

The log-likelihood value can be used to compare the goodness of fit for different models, its high value here, in combination with the high significance of the scale and Weibull shape represent one that maximize the joint densities in the estimated model. At 5% significant level, the combined socio economic, farm specific and farmers' attitudinal characteristics prove that the relative differences in the farmers' risk attitudes are as a result of the differences in the degree or extent of risk aversion resulting from the differences in individual effects of the hypothesized independent variables. These results imply that the specific characteristics in the three classes of variables are actually important in identifying different categories of farmers based on their risk attitudes.

Results of the decomposition of the total elasticity change of the dependent variable (risk aversion parameter *k*) show that a 10 percent increase in the proportion of maize income to the total household income (MTHI) leads to about 3 (2.6%) percent elasticity change in the dependent variable. This is decomposed into about 1.2 percent decrease in the probability of risk aversion and 1.4 percent decrease in the expected level of the degree or extent of risk aversion. The results here show that activities (farm and non-farm) from which farmers expect a high return will render them (farmers) less risk averse, thereby increasing their willingness to go for such activities. In this study, the variable (MTHI) exerts the greatest influence on risk aversion. Other variables which have slightly high influence on risk aversion are age (AGE), number of farm holdings (NFH) and proportion of maize income to total farm income (MTFI). In essence, the results imply that an improvement on the variables considered can actually reduce high risk aversion. This will in effect, result in increase in maize productivity.

Conclusion

The above results have specific challenges and implications for crop and agricultural development in Nigeria in particular and in the African sub-region in general. First, they show that yield performance of maize technologies needs to be evaluated by the farmers under their own attitude towards risk. Second, three categories of maize farmers were identified on the basis of their attitude towards risk: risk preferers, risk neutral and risk averters. Third, the main factors that affect farmers' attitude to risk are: age, leadership position held by the farmer, income realizable from maize as compared with the one realized from all the crops, and with the overall household income, the total number of farm holdings and the willingness or otherwise of the farmer to release his/her maize output for sale at a particular market condition. Therefore, constructing crop development programmes on the basis of the identified challenges and factors above holds promises for success. The implementation of such a framework will complement the various research and efforts hitherto aimed at increasing food production, increasing small holder farmer's income and alleviating their poverty in Nigeria and elsewhere.

References

Adesina, A.A. and J. Baidu – Forson. 1995. "Farmers' perception and adoption of new Agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa". Agricultural Economics 13: 1-9

Bamire, O. S. and O.L. Oludimu. 2001. "Determinants of Risk among smaller holder farmers: A Nigerian case study". The interface 1(1): 72-80.

Byerlee, D. and C.K. Eicher (eds). 1997. Africa's Emerging Maize revolution. Boulder, Colo, U.S.A. Lynne Reiner.

IFPRI (International Food Policy Research Institute). 2001. Recent trends in Food Supply and Demand: Sustainable Options for ending hunger and poverty Global Food Projections to 2020. IFPRI

Feinerman, E. and I. Finkelshtain 1996. "Introducing Socio-economic Characteristics into production analysis under risk". Agricultural Economics 13: 149 – 161

Gujarati, D. N. 1995. Basic Econometrics. Mc Graw-Hill, Inc.

IITA, 2002. Statistical Computing and Data Analysis with SAS (v8), Module 3. Regression type and classification analysis.

McDonald, J. F. and R.A. Moffit 1980. "The uses of Tobit analysis". Review of Economics and Statistics 62: 318-321

Moscardi, E., and A dejanvry 1977. "Attitudes towards risk among peasants: an econometric approach". American Journal of Agric. Econs 59(4): 710-716

Olarinde, L. O. 2004. Resource Optimization strategies under differential risk attitudes among maize farmers in Kaduna State, Nigeria. Unpublished Ph.D. Thesis, University of Ibadan, Nigeria.

Pasha, G. R. and M. A. Shah. 2004. "Application of Ridge regression to multicollinear data". Journal of research (Science) 15(1): 97-106.

Rahji, M.A.Y. 2000. "An analysis of the determinants of agricultural credit approval/loan size by commercial banks in south western Nigeria". Nigerian .Agricultural Development Studies 1(1): 16-25.

Wethrill, P. 1986. "Evaluation of ordinary ridge regression". Bulletin of Mathematical Statistics 18: 1-35.

Table 1: Characteristics of risk-aversion groups of maize farmers

Risk-aversion group	AGE (yrs)	HSZE (No)	LDSP (dummy)	MTFI	MTHI	NFH (No)	FSTYF	SSTYF
Total sample (N=348) mean	44..27	12.66	0.31	44.93	41.72	4.71	0.49	0.21
SD	9.13	6.78	0.46	23.75	28.33	3.34	0.24	0.15
Risk prefers (n=31) mean	51..50	17.32	0.29	49.87	52.47	11.42	0.31	0.15
Mean SD	8.67	8.81	0.46	25.54	28.50	6.05	0.18	0.09
Risk neutral (n_2=148) mean	43..80	12.88	0.39	45.41	38.70	4.56	0.62	0.26
SD	9.63	6.38	0.49	21.94	27.23	2.20	0.23	0.14
Risk averters (n_3=169) mean	43.40	11.64	0.25	43.64	41.94	3.62	0.42	0.19
SD	8.24	6.36	0.43	25.25	28.80	1.66	0.20	0.15

Source: Data analysis, 2006.

SD is Standard Deviation

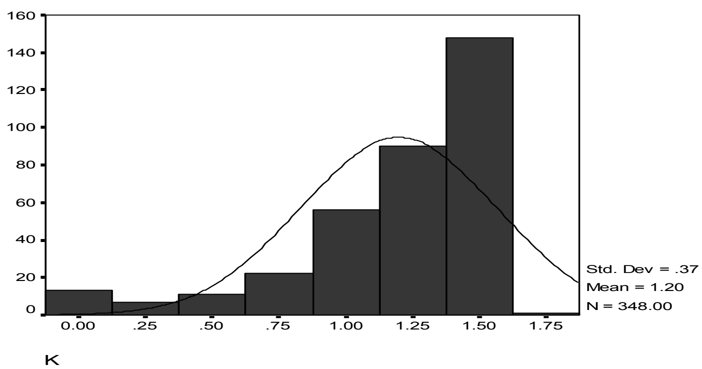

Figure 1: Frequency Distribution of Cumulative Function of k

Table 2: Estimated Tobit Model for factors influencing the degree or extent of risk Aversion and their elasticity change (k = risk aversion)

Variable	Expected Sign	Parameter Estimate: Coefficient	Standard error	T-ratio	Elasticity of: Total Elasticity	Probability of risk aversion	Expected level of degree of risk Aversion
Constant		0.6652	0.0871	7.6372			
AGE	+	-0.0031	0.0017	1.8235***	-0.2504	-0.1138	-0.1366
HSZE	±	-0.0006	0.0024	-0.2500	-0.0143	-0.0065	-0.0078
LDSP	-	-0.0765	0.0305	-2.5082**	-0.0491	-0.223	-0.268
MTFI	-	-0.0018	0.0006	-3.0000*	-0.1369	-0.0622	-0.0747
MTHI	-	0.0005	0.0005	1.000	-0.2634	-0.1198	-0.1436
NFH	-	-0.0148	0.0050	-2.9600*	0.1386	0.0630	0.0756
FSTYF	-	-0.1386	0.0623	-2.2247**	-0.1272	-0.0578	-0.0694
SSTYF	+	-0.1569	0.0842	1.8634***	-0.0576	-0.0262	-0.00314
Scale		0.2301	0.0118	19.500**			
Weibull Shape		4.3454	0.2225	19.5299**			

Source: Data analysis, 2006

Log likelihood, -69.3460

- ** and *** = significance at 1%, 5% and 10% respectively