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Factors Affecting Farmers' Decision to Enter Agricultural Cooperatives Using Random Utility Model in the South Eastern Anatolian Region of Turkey

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Abstract

Farmers' decision and perceptions to be a member of agricultural cooperatives in the South Eastern Anatolian Region were investigated. Factors affecting the probability of joining the agricultural cooperatives were determined using binary logit model. The model released that most of variables such as education, high communication, log of gross income, farm size, medium and high technology variables play important roles in determining the probability of entrance. Small farmers are likely expected to join the agricultural cooperatives than the wealthier farmers are. Small farmers may wish to benefit cash at hand, input subsidies, and services provided by the agricultural cooperatives since the risks associated with intensive high-returning crops are high. Some important factors playing pole role in abstention of farmers towards agricultural cooperatives are gross income and some social status variables. In addition, conservative or orthodox farmers are less likely to join agricultural cooperatives than moderate farmers are. We also found that the direct government farm credit programs mainly should be objected to providing farmers to better access to capital markets and creating the opportunity to use with allocation of capital inputs via using modern technology.

Keywords: cooperatives, participation, random utility, logit

1 Introduction

In Turkey, the history of cooperatives goes back to the late 19th century. Of these, agricultural cooperatives perform a prominent role both historically and in terms of co-ordination between its agencies and members (Arcas-Lario and Hernandez-Espallardo, 2003; Chieochan *et al.*, 2000). There are estimated to be 11,427 agricultural cooperatives, with over 4.5 million members within Turkey (Karli and Çelik, 2003). These cooperatives unfortunately process and commercialize a lower per cent of agricultural products as compared to the European Union (COGECA, 2000).

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Institutional and financial barriers, not sufficient market coordination mechanisms, which will better transmit inputs and information from the market to its farmer members, and a high government intervention, permit them not to explore its power in the market. Consequently, new forms or merging have been the route chosen by agricultural cooperatives (Karli and Çelik, 2003). Contrary to the current situation in the country, the agricultural cooperatives should have a large impact on the agricultural sector since a relatively higher gross national product (e.g., 14%) comes from agriculture and 40 per cent of active populations are currently employed in agriculture as compared to other sectors.

Turkey recently constructed a large dam in the Southern Anatolia Region (SAR) and irrigated agricultural lands increase rapidly. Despite the proliferation of irrigation system built in the region, a low number of agricultural cooperatives performed are present. The estimated number of agricultural cooperatives performed in the region is about 287 compared to the total number of agricultural cooperatives in the nation. Most of these cooperatives are held by agricultural union, credit, commercial, and irrigation cooperatives.

The lack of coordination and efficient distribution of resources to members and less membership willingness of farmers towards a cooperative, perhaps due to a lower educational attainment, can be reasons for low number of cooperatives operated in the region. Another reason could be that agricultural cooperatives are still supply oriented that is selling what has been produced by its farmer members and thus hardly find them selves in competing with private firms. Yet another possibly invisible reason is that the direct government support programs such as credit, input supplied to farmers might negatively affect the rate of participation to agricultural cooperatives (Abdulai and Delgado, 1999; Arcas-Lario and Hernandez-Espallardo, 2003; Chieochan *et al.*, 2000; Hansen *et al.*, 2002; Hudson and Herndon, 2002).

Despite the crucial role played by agricultural cooperatives in the region, there are no empirical studies using micro level data to explore the behavioral perceptions of farmers towards an agricultural cooperative. The objective of this study is to explore the farmers' characteristics affecting the decision to join agricultural cooperatives by using a binary probabilistic model (e.g., logit) in the context of random utility framework.

The remainder of this paper is organized as follows. First, we outline the random utility and draw binary logit model. Next, the data collected is described. Section 4 discuses the estimated results and findings are more explored. The final section draws conclusions and suggestions for policy implications.

2 Methodology

2.1 Model

Assuming farmer i maximizes his profit subject to a subset of given input costs. Farmers' decision whether or not to join a agricultural cooperative is modeled in a random utility framework (Cooper, 1997; Hanemann, 1984). The farmers face two choices or alternatives that the utility with a membership of the agricultural cooperative is at least as great as without it. This can be done as:

$$U(1, m_1 + P; x) \geq U(0, m_0; x) \tag{1}$$

where 1 indicates the membership to an agricultural cooperative and 0 without it, m_1 and m_0 are expected net income (profit) from agricultural product sale with and without an agricultural cooperative membership, respectively, and x is a vector of household, farm, and contextual characteristics that may affect the farmers' perception on the agricultural cooperatives and willingness to participate in the activity. P is an incentive payment usually measured as monetary value received by farmers from the agricultural cooperatives. The utility function is only partially observable to the researcher, that is $U(i, m_i; x) = V(i, m_i; x) + \varepsilon$ where $V(i, m_i; x)$ is the deterministic proportion of the utility and ε is the random proportion of the utility function (HUBBELL *et al.*, 2000; QAIM and JANVRY, 2003). The partially observable then can be written as

$$U(1, m_1 + P; x) + \varepsilon_1 \geq U(0, m_0; x) + \varepsilon_0 \tag{2}$$

As is common in literatures to assume the deterministic proportion of the utility as

$$V = x\beta^i + \alpha m_i \tag{3}$$

where $i = 0, 1$ and α is the marginal propensity of the income. The final outcome is written as

$$(x'\beta^1 - x'\beta^0) + \alpha(m_1 - m_0 + P) \geq \varepsilon_0 - \varepsilon_1 \tag{4}$$

Parameter estimates of the above equation can be obtained by assuming a $\varepsilon = \varepsilon_0 - \varepsilon_1$ with using maximum likelihood procedure.
If we let $x'\beta = (x'\beta^1 - x'\beta^0)$, $m = m_1 + P - m_0$ and $\varepsilon = \varepsilon_0 - \varepsilon_1$ equation (4) can be written as:

$$x'\beta + \alpha m_i \geq \varepsilon \tag{5}$$

The log linear in income can be modified by $\ln(m_i) = \log((m_1 + P)/m_0)$.
The invisible amount of the incentives, P, can be in terms of inputs, financing credit, services provided, and transaction facilities stemming from selling farmers' product. Farmers who are the member of the agricultural cooperatives will enjoy such incentives relative to non-union members. Since we do not observe the amount of P received by farmers, we can implicitly include m_i or log income, $\ln(m_i)$, variables in vector x. We assume that the P was as if presented to farmers or at least farmers know the amount of P for some time. The random utility model could be better framed by contingent valuation methods explicitly stating the amount of incentives received by those who are the members to the agricultural cooperatives and the randomly chosen amounts of incentives in monetary value presented to those who are non members of the agricultural cooperatives and estimate the mean value of willingness to accept which presents the amount of money that makes the farmer indifferent between with and without an agricultural cooperative scenario.

Assuming ε that is independently and identically distributed with the type I extreme value distribution, and then the resulting probability to join the agricultural cooperatives can be represented by the logit model as (Greene, 2003):

$$P(y_i = 1|x) = \frac{e^{x'\beta}}{1 + e^{x'\beta}} = \Lambda(x'\beta), \tag{6}$$

where $\Lambda()$ is the logistic cumulative distribution function.
The corresponding log likelihood function for the probability is

$$\ln L = \sum_{j=1}^{N} I_j \ln\left[\Lambda(x'\beta)\right] + (1 - I_j)\ln\left[1 - \Lambda(x'\beta)\right], \tag{7}$$

where I_j is a dummy indicator equal to 1, if the farmer is the member of any agricultural cooperative, 0 otherwise. The consistent maximum likelihood parameter estimates are obtained by maximizing the above log likelihood function.

2.2 Data

An interview-based survey of 110 farmers was carried out in 2001. 20 observations were excluded due to missing information. The survey comprised five provinces in SAR, namely Adiyaman, Diyarbakir, Gaziantep, Mardin and Sanliurfa Provinces. The SAR population is around six million and of which 83% live in these provinces. The numbers of agricultural cooperatives operated in SAR are 287 which are negligible in size as compared to the numbers operated in the nation. Five most agricultural cooperatives operated in the region are given in Table 1. The agricultural development cooperatives is the most operating in the region followed by credit supplied agricultural cooperatives. The less operated cooperatives is the fishery products cooperatives which could be sensible to some extend that the region is lack of access to see and the area is covered by only two major rivers, Tigris and Euphrates. Most of these five cooperatives are located in Diyarbakır, Gaziantep and Şanlıurfa provinces, respectively. It is worth noting that most of the agricultural land irrigation cooperatives are located in Gaziantep province despite the fact that the major irrigation takes place in Harran Plain located in Şanlıurfa city limit. This might be attributed due in large part to the fact that Gaziantep city is the most extensively industrialized province in SAR.

Table 1 shows descriptive statistics for agricultural cooperatives operated in SAR. The most common cooperative is an agricultural credit cooperative which aims to help and improve its members' economic condition by providing good production facilities, utilizing agricultural products and in turn increase gross marginal revenues. Despite the fact that the agricultural credit cooperatives found many agri-business or agricultural based industrial factories, it provides its members agricultural inputs and loans. Agricultural product sale cooperatives buy specified agricultural products from farmers, process and pack them for domestic and international trade. They also provide agricultural inputs to its farmers and they make also domestic and foreign product purchase in the name of the government if the government allows. Agricultural development cooperatives on the other hand participate in many agricultural activities such as provide agricultural

Table 1: Descriptive Statistics for Agricultural Cooperatives Operated in the Southern Anatolian Region

Provinces	*Agricultural Credit Cooperatives*		*Agricultural Product Sale Cooperatives*		*Agricultural Development Cooperatives*		*Agricultural Irrigation Cooperatives*		*Fishery Product Cooperatives*		*Total*	
	#	%	#	%	#	%	#	%	#	%	#	%
Adıyaman	14	0.159	2	0.091	19	0.139	5	0.185	8	0.615	48	0.167
Batman	3	0.034	1	0.045	2	0.015	0	0.000	0	0.000	6	0.021
Diyarbakır	7	0.080	3	0.137	61	0.445	4	0.148	2	0.154	77	0.268
Gaziantep	25	0.284	5	0.227	32	0.234	12	0.445	1	0.077	75	0.261
Kilis	8	0.091	1	0.045	2	0.015	1	0.037	0	0.000	12	0.042
Mardin	7	0.080	3	0.137	5	0.036	0	0.000	0	0.000	15	0.052
Siirt	2	0.022	1	0.045	7	0.051	0	0.000	0	0.000	10	0.035
Şanlıurfa	22	0.250	6	0.273	8	0.058	5	0.185	2	0.154	43	0.150
Şırnak	0	0.000	0	0.000	1	0.007	0	0.000	0	0.000	1	0.003
Total	88	1.000	22	1.000	137	1.000	27	1.000	13	1.000	287	1.000
SAR (%)	0.307		0.077		0.477		0.094		0.045		1.000	

inputs, market agricultural products, organize development activities, develop hand and households' arts.

Agricultural irrigation cooperatives develop project for how water can efficiently be supplied to agricultural lands, build irrigation channels at land entrance point, and build irrigation and drainage installations at agricultural lands. Agricultural fishery cooperatives in SAR provide and arrange aqua-culture species in Ataturk dam and in other artificial docks. It in turn utilizes aqua-culture species and markets these products. There are currently thirteen cooperatives of agricultural fishery cooperatives operated in the region.

The descriptive statistics for farmers' characteristic variables are given in Table 2. The data were, unfortunately, limited to information on farmer characteristics only. Information on farmer characteristics were farm size, gross product income, age, household size, education, communications with agricultural cooperatives, and technology levels used at farms. Approximately, 20% of farm sizes are less than 6 hectares and 70% of farmers have less than 20 hectares. The farm sizes in this region are usually above the country mean farm sizes, which are approximately 6 hectares per farm. Large farm sizes comprise 30% of the sample.

Factors that are specific to farmers include education proxy as attainment of the secondary and above schooling, total number of years worked at farm, age, and, household size. The level of education may indicate potential human capital stock on farm. An improvement in the level of educational attainment may increase the probability of entering agricultural cooperatives in leading better relationships with agricultural cooperatives.

The level of communication with agricultural cooperatives may play a key determining factor for entrance. The higher interaction with personnel or managers of cooperatives, the better understanding of the agricultural cooperatives operated in the region. An

Table 2: Descriptive Statistics of Variables

Variable	*Unit*	*Mean*	*Std. Dev.*	*Min.*	*Max.*
Age	1 if the farmer is 40 and above years old	0.288	0.456	0.000	1.000
Experience	Years	13.000	8.100	5.000	25.000
Household size	#	6.667	2.884	3.000	13.000
Education	1 if the farmer had completed secondary and above any school	0.278	0.450	0.000	1.000
Low Communication	1 if the farmer has met at least ones or a few times any personnel of the agricultural cooperatives in his lifetime	0.456	0.501	0.000	1.000
Medium Communication	1 if the farmer has met more than few times, but not as frequently as he would like, to the agricultural cooperatives' personnel	0.389	0.490	0.000	1.000
High Communication	1 if the farmer has a good communication with agricultural cooperatives	0.156	0.364	0.000	1.000
Gross product income per hectare [1]	Turkish Lira in million	1668.046	258.347	500.000	2250.000
Farm Size	Hectare	37.364	49.619	3.000	250.000
Low technology used	1 if the farmer has a traditional farming tools and equipments	0.367	0.485	0.000	1.000
Medium technology used	1 if the farmer has at least a tractor and some other farming tools and equipments	0.533	0.502	0.000	1.000
High technology used	1 if the farmer has identified himself using all necessary machinery tools and equipments	0.100	0.302	0.000	1.000
N	90				

[1] $1 was approximately equal to 1,600,000 Turkish Lira during survey period.

important implication is that the farm neighborhoods are strong because houses built in a small villages are close to each other and a relatively strong kinship among farmers can be observed. An agricultural cooperative personnel working in one's farm, perhaps because of spraying with a chemical substance against insects or controlling weed, can be quickly observed or better informed by other neighboring farmers. Thus, observing the agricultural cooperative personnel in one's farm may increase the probability of some other farmers' entrances to the agricultural cooperatives. The non-members may be further affected by the agricultural cooperatives having a slide shows once a year to its member in the village.

3 Results and Discussions

The estimated parameter results are given in Table 3. Most signs on the all estimates make intuitive sense. The probability of a membership declines with increases in the age, household size, gross income, farm size-squared, and higher technology used variables. The membership probability increases with increases in the experience, education, high communication level with cooperatives, farm size and medium technological level variables. Age variable is statistically significant at 10% level. Younger farmers are more likely to enter agricultural cooperatives than elderly farmers. The education variable shows the expected sign and is statistically significant. The increased probabilities of the decision to enter agricultural cooperatives with higher educational attainment is presumably due in large part to foreseeing the diversification and make the use of available opportunities provided by the cooperatives. The higher the communication with the cooperatives, the more will be the farmer's attachment to the agricultural cooperatives. It is worth to note here that the better educated farmers have a larger human capital stock and exchange the information with the cooperatives and thus more attachment to cooperatives will results. Farmer's gross income variable is also statistically significant and negatively related to the decision to join an agricultural cooperative. A plausible explanation might be that the monetary value of gross income is quickly visible to the farmers as cash favoring a short term relaxation with an easy-going confidence. The farm size (hectares) variable has a positive impact on the probability level. We also compute the non- linear relationship of the farm size variable on the probability level. This non linearity relationship shows as farm size measured as hectares increases, thus gross income, producers show less willingness to be a member of agricultural cooperatives. The sign of the non-linearity variable is in line with the gross income variable indicating at a higher farm size, the probability of the membership decreases with increases in the farm size.

Table 3: Original Parameter and Marginal Effect Estimates of Binary Logit Model

Variables	*Binary Logit Model*			
	Initial Parameter Estimates		*Marginal Effects*	
	Coefficient	*t-value*	*Coefficient*	*t-value*
Constant	8.239	1.027	0.325	18.288
Age	-1.877^b	-1.848	-0.216^a	-4.562
Experience	0.027	0.501	0.001	0.054
Household Size	-0.009	-0.076	$-0.360 * 10^{-3}$	-0.018
Education	2.625^a	2.649	0.165^a	7.922
High Communication	3.181^b	1.767	0.122^a	13.277
Log of Gross Income	-1.203	-1.363	-0.047^a	-2.122
Farm Size	0.093^b	1.772	0.004	0.194
Farm Size-Squared	$-0.302 * 10^{-3\ a}$	-1.645	$-0.119 * 10^{-4}$	-0.001
Medium Technology Used	2.221^a	2.870	0.010^a	5.108
Higher Technology Used	-1.310	-0.697	-0.152	-3.052
Log-Likelihood		-36.219		

Note: ^{a}, ^{b} indicate significant levels at 5% and 10%, respectively.

Medium technology used at farms compared to the conventional (low) technology variable used as base variable is statistically significant. Farmers who are members of the agricultural cooperatives may be supplied with the new innovations as viewed services provided by the agencies. High technology used at farms is negatively related to the probability of entering agricultural cooperatives relative to the low and medium technological levels. Wealthier farms may operate such technology levels compared to the small farms usually growing larger proportion of intensive high-return crops and may thus seek to get cash credits or inputs/services supplied by the agricultural cooperatives.

The effects of schooling, high communication and medium technology used in farms on the probability decision are negligible in magnitudes. However, the true effect of each variable on the probability decision can be assessed deriving from marginal effect formulation.

The marginal impact of each variable on the probability level at the sample data mean is computed as:

$$\frac{\partial E(y_i=1|x)}{\partial x_k} = \frac{\partial \Phi(y_i=1|x)}{\partial x_k} = \Lambda(x'\beta)\left[1-\Lambda(x'\beta)\right]\beta_k \ , \tag{8}$$

where $\Lambda(x'\beta) = \frac{e^{x'\beta}}{1+e^{x'\beta}}$

Marginal effects for indicator variables, say q, is the difference between two derivatives evaluated at the dummy indicator value 1 and 0, respectively:

$$\frac{\partial E(y_i=1|x)}{\partial x_k} = \left[\Lambda(x'\beta)\left[(1-\Lambda(x'\beta)\right]\beta_k\right]_{q=1} - \left[\Lambda(x'\beta)\left[(1-\Lambda(x'\beta)\right]\beta_k\right]_{q=0} \tag{9}$$

If we let $C = \Lambda(x'\beta)\left[(1-\Lambda(x'\beta)\right]$, then $\frac{\partial E(y_i=1)}{\partial x_k}$ has a logistic distribution with mean $C\beta$ and variance $C\Sigma C'$ where Σ is the variance-covariance matrix of initial parameters, β (Greene, 2003).

The signs of marginal effect variables are in line with the signs obtained from parameter estimates, however, larger t-values attributed to the significant variables. We will drive only intentions on the significant variables. The marginal impacts of dummy variables, surprisingly statistically significant variables, on probability of entering the agricultural cooperatives have fewer impacts in magnitude than that of the original parameter estimated impacts. One unit change in education, better to say one year increase in schooling, high communication and using medium technology variables will in turn increase the probability of participation by 0.165, 0.122, and 0.010 units, respectively. A unit change in using higher technology will in turn reduce the probability of entering the agricultural cooperatives by 0.152 units relative to the base variable. Noticeably, the impacts of these variables in magnitude are negligible when compared to each other on the probability decision model. As gross income increases by one unit, the probability of entrance decreases by 0.047 units and the variable is statistically significant. Although the age variable was statistically significant at 10% level in the probability model, the statistical significance of its marginal effect gains more. The impacts of the marginal effect estimates for continuous variables on the probability decision are higher in absolute values than the original parameter estimates. Farm size variable losses its significance as compared to the initial model.

We might be interested in the probabilities as a function of farm size or log of gross income keeping all other variables constant, *ceteris paribus*. Keeping all other variables at their means (e.g., dummy variables scaled at 1 indicating the presence of all dummy variables), the probability of the decision to enter an agricultural cooperative as a function of land size and log of gross income variables each as:

$$P_{1FS}(y_1 = 1) = \Lambda(-0.323 + 0.093 * Farm\,Size)\ , \tag{10-a}$$

$$P_{1LnGI}(y_1 = 1) = \Lambda(15.696 - 1.203 * Log\,of\,Gross\,Income) \tag{10-b}$$

The constant value, -0.323 comprises of all variables at mean (e.g., age, education, high communication, medium technology variables are scaled at 1) except the land variable and 15.696 captures all effects at mean values except the log of gross income variable. The probability as a function land size without present of education, high communication and medium and high technology variables, respectively, is as

$$P_{2FL}(y_1 = 1) = \Lambda(-2.984 + 0.093 * Farm\,Size)\ , \tag{11-a}$$

$$P_{3FL}(y_1 = 1) = \Lambda(-3.504 + 0.093 * Farm\,Size)\ , \tag{11-b}$$

$$P_{4FL}(y_1 = 1) = \Lambda(-2.544 + 0.093 * Farm\,Size)\ , \tag{11-c}$$

$$P_{5FL}(y_1 = 1) = \Lambda(-0.987 + 0.093 * Farm\,Size) \tag{11-d}$$

The probability of entering the agricultural cooperatives as a function of log of gross income with absence of education, high communication, medium and high technology variables, respectively, is as

$$P_{2LnGI}(y_1 = 1) = \Lambda(13.071 - 1.203 * Log\,of\,Gross\,Income)\ , \tag{12-a}$$

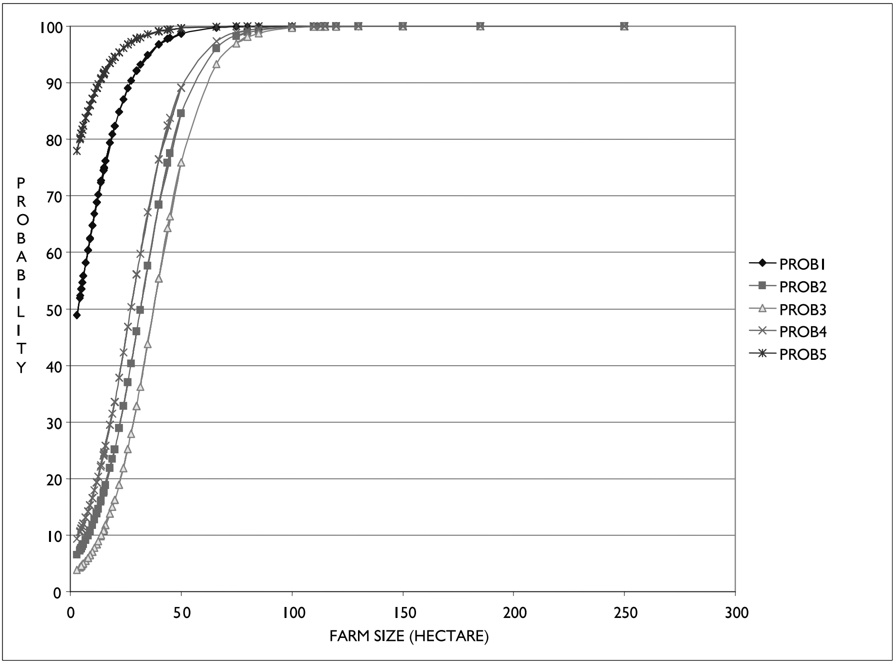
$$P_{3LnGI}(y_1 = 1) = \Lambda(12.515 - 1.203 * Log\,of\,Gross\,Income)\ , \tag{12-b}$$

$$P_{4LnGI}(y_1 = 1) = \Lambda(13.475 - 1.203 * Log\,of\,Gross\,Income)\ , \tag{12-c}$$

$$P_{5LnGI}(y_1 = 1) = \Lambda(17.006 - 1.203 * Log\,of\,Gross\,Income) \tag{12-d}$$

The calculated probabilities against farm size and log of income variables are depicted in Figure 1 and 2, respectively. The P_{1FS} represents the cumulative distribution function of logit model as a function of land size assuming all other variables scaled at their means, *ceteris paribus*. P_{1FS}, P_{2FS}, P_{3FS}, P_{4FS} and P_{5FS} account individually for when schooling, higher communication, medium and higher technologies used at farms are not present, respectively. For example, the P_{2FS} shows the cumulative distribution of the logit model as a function of farm size with the absence of the secondary or above educated farmers keeping all other variables constant at mean values, *ceteris paribus*. Other probabilities as well as the cumulative distribution function of the logit model as a function of log of gross income variable are constructed likewise.

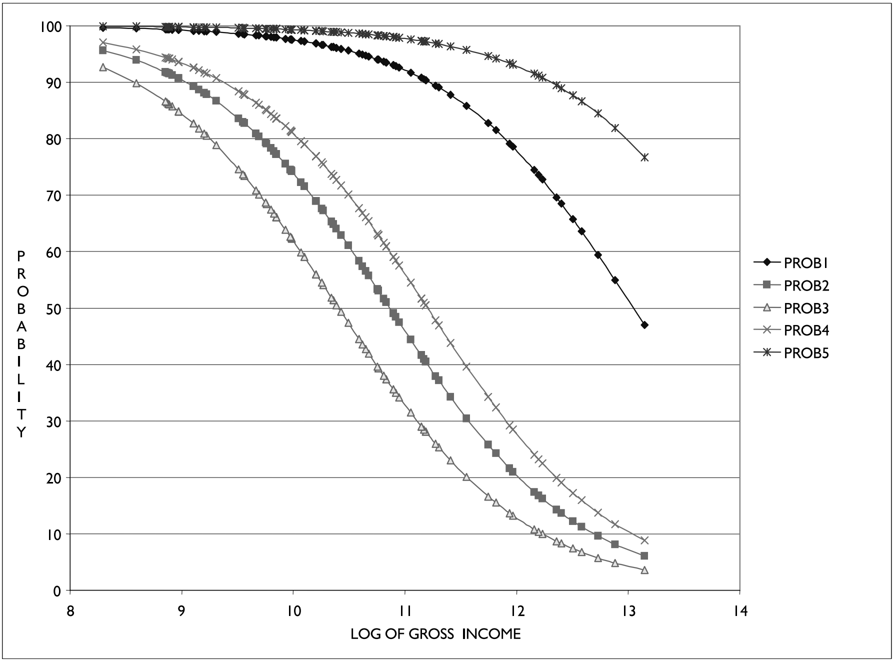
Figure 1: Estimated percentage of farmers participation probabilities at different farm size for different levels of farmer characteristics



It is worth noting when the farm size is scaled at the mean value (e.g., 37.5 hectares), the secondary school and above educated farmers using a high communication with an agricultural cooperative and having medium and higher technologies at farm are more likely expected to be a member to an agricultural cooperative than illiterate or elementary school educated farmers who use less communication with an agricultural cooperative and traditional conservative machinery-equipment used at farms. Farmers who do not use medium technology at farms are more likely expected to participate to the agricultural cooperative than those farmers not having secondary and above schooling. These farmers show also more willingness towards an agricultural cooperative than those who do not have a good communication with the cooperatives. We can say that the effects of these three factors on the probability level are negligible.

An interesting point can be said here that farmers who do not use higher technology at farms are highly expected to be a member to the agricultural cooperatives than those using such technology at farms. This can be related in some extent that the wealthier farmers using high technology levels always have more enthusiasms towards innovations and thus benefiting from incomes at hands. Noticeably, farmers using high technology level at farms are presumably wealthier farmers and thus the impact of this variable with

Figure 2: Estimated percentage of farmers participation probabilities at different log of gross income for different levels of farmer characteristics



the gross income effect move together. As land sizes rise, the probability of participation becomes constant neglecting the effects of all significant variables used in the model.

4 Conclusions

We present factors affecting the probability of joining the agricultural cooperatives using binary logit model. Most of variables such as education, high communication, log of gross income, farm size, medium and high technology variables play important roles in determining the probability of entrance. Small farmers are more likely expected to enter the agricultural cooperatives than the wealthier farmers are. Small farmers may wish to benefit cash, input subsidies, and services provided by the agricultural cooperatives since the risks associated with intensive high-return crops are high. Some important factors playing a pole role in abstention of farmers towards agricultural cooperatives are gross income and some social status variables. Although gross income and farm size variables move opposite direction on the joining decision process, the quick cash realization factor from gross income might give a temporary relief to the land owner and thus restrain the participation process towards agricultural cooperatives as compared to the role of farm size factor. In addition, as the gross income rises farmers become financially better off and they might think that all desired economic goals are achieved. Moreover, small farms are risk averse in nature relative to large farms. We, thus, expect small farms to join the agricultural cooperatives more frequently as the degree of risk increases. With anticipation to agricultural cooperatives, small farms may find more confidence if natural disasters happened because expenses incurred to the farms might be compensated by the agricultural cooperatives.

Religious factors may be a key determinant against an agricultural credit cooperative since the cooperative imposes an interest rate as paying back delayed by farmers. Thus, conservative or orthodox farmers are less likely to join agricultural cooperatives than moderate farmers are.

The direct government farm credit programs mainly is objected to provide farmers better access to capital markets and create the opportunity to use and allocate capital inputs with modern technology. The government credit programs may sometimes take the form of direct finance cash. This intervention, in turn, has a negative impact on the membership of the agricultural cooperatives especially on those farmers who seek to obtain the credit from agricultural cooperatives.

The effect of net income gain is lacked in this study. One way to elicit the effect of this factor is to use the contingent valuation (CV) method in dealing with the perceptions about the agricultural cooperatives. Eliciting CV method may further aid to policy makers for implication in emerging agricultural cooperatives. The development of the agricultural cooperatives in order for better access in market as well as the coordination between its members and managers should be objected by the policy makers.

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Farmers' Choice of the Modern Rice Varieties in the Rainfed Ecosystem of Nepal

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Abstract

In an effort to increase the productivity of rice in Nepal, several modern varieties have been released. Farmers have adopted these varieties to varying degrees depending upon the types of production environment and the considerations for attributes. This paper attempts to identify factors that condition the adoption of selected modern varieties of rice using a multinomial logit model including both production and consumption attributes valued by the farmers and farm and farmer related variables. The results show that both categories of variables are significant in determining the demand for a specific variety. The results of this paper have implications for crop improvement and the modern variety adoption. Research approaches that incorporate farmers' preferences for various attributes of rice in breeding programs and extension strategies have to be adopted. Various types of methods such as demonstration and farmer- participatory trials could be effective vehicles in this regard. Also the research system should develop a range of varieties in order to meet the multiple concerns of the farmers as a single variety may not be able to fulfill all of their concerns.

Keywords: attributes, demand, farmer, Nepal, rainfed, rice, variety

1 Introduction

Rice is the staple food crop of Nepal. It occupies about 50 percent of the total area under food crops of 3.2 million hectares and its contribution to the total food supply is more than 50 percent. This crop alone contributes to about 40 percent of the total calorie intake. In Nepal, the area under modern varieties (MVs) has increased from about 40 percent in 1993/94 to about 83 percent in 2003/04 (Ministry of Agriculture and Cooperatives, 2004). Compared to other ecological regions, this proportion is higher in *Terai* region where irrigation, roads and market infrastructures are well developed.

Nepal's experience with rice research and technology development illustrates the need to put this important sector on a high productivity path beyond what is currently attained. The rice sector in Nepal has experienced some developments especially in the spheres of

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varietal development. Over four dozens MVs have been released since 1960s. However, there has not been much progress in the productivity. The growth trend in yield of rice in Nepal during the last 30 years is about 1.5 percent per annum whereas this has been slightly higher (1.90%) for *Terai* region, which is considered the granary of the country.

The adoption of rice varieties may differ depending upon the concerns of the farmers, which are defined by the attributes. Farmers can view some attributes as positive and others as negative. The choice of one variety technology over others is greatly influenced by the balance between these two attributes. Depending on the preferences, resources, and constraints that individual farmers face, a beneficial attribute for one farmer may be a negative one for other, or the balance between positive and negative traits may be acceptable for one farmer but not for another (BELLON, 2001).

Farmers may assess a new technology such as crop variety, in terms of a range of attributes, such as grain quality, straw yield, and input requirements, in addition to grain yield (TRAXLER and BYERLEE, 1993). Crop improvement could potentially benefit from farmers' assessments of the relative performance of different varieties under farmer management. Information on the attributes desired by farmers and their knowledge of the production system could be invaluable in setting the goals of breeding program, delineating the target environment, identifying the parents for breeding and defining the management treatment for breeding work (SPERLING *et al.*, 1993; EYZAGUIRRE and IWANGA, 1996).

It is an established fact that farmers' are also capable of commenting on the design of particular technologies and suggesting changes that would make such technologies and innovations more appropriate for their needs. Taking farmers' input on technology design seriously would accelerate the ultimate adoption of new technologies (PINGALI *et al.*, 2001).Most of the experimental work in crop improvement evaluate the rice varieties often using yield as the sole criterion. Most often these varieties have either not been adopted or adopted for a shorter period. Understanding farmers' variety preference serves as an input to future variety development and diffusion. Thus, for a successful intervention, policy has to be informed on: 'who prefers what kinds of variety most?'

The varieties released in Nepal have been recommended for different agro-ecological zones and ecosystems. JOSHI (2003) reported that out of 48 varieties released, 13 for main season and 10 for spring season have been recommended for cultivation under irrigated condition of Terai region. Only about 5 varieties have been developed for rainfed lowland of Tarai. So far only 2 varieties have been released for upland ecosystem. There are 14 varieties recommended for mid-hills and 4 for high hills. Most of them do best under irrigated conditions.

The main objective of this paper is to identify the factors affecting the demand of modern varieties of rice using a discrete choice model. The paper is organized as follows. The research methodology and analytical techniques are presented in Section 2 while results and discussions are presented in section 3. The paper ends in section 4 with conclusions and recommendations.

2 Methodology and Analytical Techniques

2.1 Sampling and Data Collection

The data for this study were collected from Banke and Nawalparasi districts in the western *Terai*[1] region of Nepal. The farmers were selected from 3 Village Development Committees (VDCs) of each district using stratified random sampling. The VDCs where survey was carried out are Manikapur, Bethani and Bageswori from Banke district and Kushma, Deurali and Ramnagar villages from Nawalparasi district. A total of 222 rice growing farmers were randomly selected from these 6 VDCs of two districts.

The survey included collection of data on number and types of rice varieties grown, area under different varieties, seed sources, farmers' preference for variety characteristics, farm and farmer characteristics and associated socio-economic characteristics. The relevant data for the cropping year 2001/02 were collected by using structured questionnaires.

The farmers' preference/demand for varieties was determined following the two steps procedure. In the first step, most dominant variety (in terms of area) grown by the households in the study area were identified. Hence, five types of varieties were selected. In the second step, the selected varieties were offered to farmers and were requested to make a choice among them.

2.2 Empirical Model

Although the farmers in the study area cultivate about two dozen MVs, few varieties are prominent as exhibited by their area share. Based on the this, only 5 categories of the varieties are selected for this analysis. They are Radha 4, Janaki, Masuli, Sarju 52 and others. The multinomial logit (MNL) model was used to analyze the factors affecting the choice of these varieties. The MNL is based on the random utility model. The utility U to an adopter form choosing a particular alternative is specified as a linear function of the farm and farmer characteristics (β) and the attributes of that alternative (X) as well as a stochastic error component (e):

$$U = \beta X + e \tag{1}$$

Suppose the observed outcome (dependent variable) is choice j. This implicates for a given adopter: $U_{alternative\, j} > U_{alternative\, k}\ \forall\ k \neq j$, or

$$\beta X_j + e_j > \beta X_k + e_k\ \forall\ k \neq j \tag{2}$$

The probability of choosing an alternative is equal to the probability that the utility of that particular alternative is greater than or equal to the utilities of all other alternatives in the choice set.

Let the probability that the i^{th} farmer chooses the j^{th} variety be P_{ij} and denote the choice of the i^{th} farmer by $Y_i' = (Y_{i1}, Y_{i2}, \cdots, Y_{iJ})$ where $Y_{ij} = 1$ if the j^{th} variety is

[1] The *Terai* is a sub-tropical plain region located in the South of Nepal which borders with India.

selected and all other elements of Y_i' are zero. If each farmer is observed only a single time, the likelihood function of the sample of values $Y_{i1}, \cdots, Y_{iJ}$ is:

$$L = \prod_{i=1}^{T} P_{i1}^{Y_{i1}} P_{i2}^{Y_{i2}} \cdots P_{iJ}^{Y_{iJ}} \tag{3}$$

Assuming that the errors across the variety (e_{ij}) are independent and identically distributed leads us to the following multinomial logit (MNL) model.

$$P\{y_i = t\} = \frac{\exp\left(X_{it}'\,\beta\right)}{1 + \exp\left(X_{i2}\,\beta_2\right) + \cdots + \exp\left(X_{iJ}\,\beta_J\right)} = \frac{\exp\{X_{it}'\,\beta\}}{1 + \sum_{j=2}^{J} \exp\{X_{ij}\,\beta_j\}} \tag{4}$$

The multinomial logit model is used to predict the probability that a farmer demands a certain variety and how that demand is conditioned by different farm and farmer characteristics and attributes of the variety valued by the farmers.
By differentiating equation (3) with respect to the covariates we can find the marginal effects of the individual characteristics on the probabilities as

$$\frac{\partial P_j}{\partial X_j} = P_j \left[\beta_j - \sum_{k=0}^{j} P_k \beta_k\right] = P\left[\beta_j - \bar{\beta}\right] \tag{5}$$

The MNL model is general enough to be useful as a tool for studying different circumstances faced by farmers and different problems encountered in the context of choice among multiple varieties. The marginal rate of substitution (MRS) between two varieties is shown to be a weighted sum of the marginal contribution of each variety to the total amount of each attributes demanded (supplied). Households might simultaneously plant multiple varieties if certain attributes are unique to a particular variety. For this reason, we consider a multitude of production and consumption attributes preference of farmers as explanatory variables. The production characteristics considered are duration of maturity (MATURE), irrigation requirement (IRRIG), and threshability (THRESH) where as the consumption characteristics considered are the preference for taste (TASTE), and suitability of the grains for preparing special products (OTHUSE) that are valued by the farmers. Similarly, other farm and farmer's characteristics considered as explanatory variables are education of the household head (EDN), experience of the farmer in rice farming (EXPERI) and the source(s) of seed (SEEDSOU). The definition of the variables and their measurement is presented in Table 1.

3 Results and Discussion

3.1 General Features of the Production System

The basic features of the production systems in the two sampled districts are presented in Table 2. The average farm size is much larger in Banke than in Nawalparasi. While rice is the dominant crop in both the locations, the share of MV was higher in Banke than in Nawalparasi. The cropping intensity and the proportion of irrigated area are higher in Nawalparasi than in Banke.

Table 1: Definition of the variables used for variety demand analysis

Variable	*Definition*	*Measurement*	*Mean*
Attribute	Dependent variable used in multinomial logit	0 = Radha-4 1 = Janaki 2 = Masuli 3 = Sarju-52	-
EDU	Educational attainment of the household head	No. of years of schooling	3.90
EXPERI	Experience of the household head in rice farming	Number	26.3
SEEDSOU	Sources of seed	Binary; 1= if received from formal sources, 0 = otherwise	0.27
THRESH	Farmers' preference for easy threshability of the grains	Binary; 1= if a farmer considers easy threshing as an important attribute, 0 = otherwise	0.73
MATURE	Farmers' preference for early maturity of the variety	Binary; 1= if a farmer considers early maturity as an important attribute, 0 = otherwise	0.62
IRRIG	Farmers' preference for less irrigation requirement	Binary; 1= if a farmer considers less irrigation requirement as an important attribute, 0 = otherwise	0.36
TASTE	Farmers' preference for taste attribute	Binary; 1= if a farmer considers taste attribute as an important attribute, 0 = otherwise	0.88
OTHUSE	Farmers' preference for preparing other speciality products such as *murahi* and *chiura*	Binary; 1= if a farmers considers preparing speciality product(s) is an important attribute, 0 = otherwise	0.63

Table 2: General feaures of the production systems in the study area.

Description	*Districts*	
	Banke	*Nawalparasi*
Average size of land holding per household (ha)	2.3	1.1
Cropping Intensity (%)	151	185
Area under rice (% of total cropped area)	53	52
Area under MV of Rice (%)	81	73
Average Yield of MV (t/ha)	3	3
Percentage Area Irrigated (including seasonal)	35	72

3.2 Description of the Modern Varieties (MVs) Grown

Farmers in the study area grew about two dozens MVs. The most popular MVs and thir area share is presented in Table 3. Among them, Radha 4 ranked number one followed by Janaki, Masuli and Sarju 52 in terms of area coverage. The Radha 4, and Masuli were popular in both the districts whereas Janaki was popular among the farmers in the Banke district. Farmers have also cultivated Indian varieties such as Sarju 52 which was popular in Nawalparasi district. Based on the quality of the grains, the varieties such as Radha 4 and Janaki are considered as coarse rice and Masuli is considered as fine rice.

The discussions with District Agricultural Development Office, Banke revealed that the area under Janaki is decreasing in this district. This is mainly because of the difficulty in pulling of seedlings for transplantation and threshing of the grains manually. This variety is being replaced by Radha 4 in the recent years.

Table 3: Area share (%) of popular modern varieties in the study area

S.No.	*Variety*	*No. of households*	*Percentage share*
1	Radha 4	122	45.0
2	Janaki	59	19.3
3	Masuli	36	8.8
4	Sarju-52	34	6.1
5	Other Radha types[1]	46	6.5
6	Others[2]	-	14.3

[1] includes Radha 17, Radha 9, Radha 32, and Radha 9.

[2] includes Indian varieties such as Indrashan, Sona Masuli, Orissa (OR) and Nepalese varieties such as IR- 22, Sabitri, hybrids etc.

The maturity days and years of cultivation of some of the popular MVs is presented in Table 4. The varieties such as Radha 4, and Radha 17 are early maturing , Sabitri, Sarju 52 and Janaki are medium maturing and Masuli is a late maturing . The Masuli is grown as high as for 30 years since its release in 1973. Sabitri is being cultivated for 23 years since it was released in 1979. Janaki and Sarju-52 were released respectively by NARS of Nepal and India during 1979. These varieties are being cultivated for about 20 years. Radha-4 released during 1995 and recommended for western/mid-western Terai is also being cultivated for about 7 years.

3.3 Analysis of the Variety Demand

The descriptive statistics show that the response for five varieties was 35.7%, and 16.3% respectively for Radha 4 and Janaki, 10.9% each for Masuli and Sarju 52 and 26.2% for other category.

Table 4: Maturity days and years of cultivation of some of the important MVs.

Variety Name	*Characteristics*		
	Maturity days based on		*Years cultivated* †
	*Research system**	*Farmers' response* †	
Radha 4	125-130	110-134	1-7
Janaki	135	125-150	1-18
Masuli	145-165	140-155	1-30
Sarju 52	NA	125-145	1-17
Radha 17	NA	115-140	1-4
Radha 9	135-140	125-145	2-5
Sabitri	140	115-140	2-23

Source: * NARC(1997); † Field survey.

The factors that could affect farmers' demand for specific variety using the multinomial logit model (MNL) is presented in Table 5. Taking the most preferred variety in MNL model should not imply that farmers are exclusively looking for a single variety. Of course, farmers are looking for multiple varieties with different intensity of preferences. The results show that estimated MNL model is significant in explaining farmers' preferences for variety. The Pseudo R^2 was 0.37 and the log-likelihood ratio was also highly significant.

The key and significant variables affecting demand for rice variety are attributes such as easy threshability, usage of grains for preparing special products (such as *murahi*-fried rice and *chiura*-beaten rice), early maturity, and less irrigation requirement. The variables related to farm and farmer characteristics affecting demand for variety are the sources of seed, education level and the experience of the farmers.

The contrasting results appear for Radha 4 and Janaki varieties. Farmers who are educated, having more experience in farming, preference for early maturity of the variety and easy threshability significantly increase the probability of demanding Radha 4 over Janaki. This is because Janaki is a variety with longer duration for maturity and difficult to thresh manually. The farmers who have to cultivate succeeding winter crops prefer early maturing variety. In Nepalese *Terai*, winter crops such as wheat and lentil are cultivated after rice. Due to the rainfed condition of the study area, farmers prefer early maturing varieties so as to cultivate winter crops when there is enough moisture in the soil. As a result the farmers are less interested to cultivate Janaki and Masuli varieties because of their long duration for maturity. Instead farmers prefer to cultivate Sarju 52 and Radha 4 because of their short duration. The negative and significant coefficient of IRRIG indicates that the probability of farmers' demand for Masuli and

Janaki decreases with their preference for less irrigation requirement increases, as these two varieties require high amount of water to grow and are mostly suitable to lowland areas.

The results also indicate that the probability of demanding Masuli variety decreases while that for Sarju 52 increases when the farmers consider the attribute such as suitability for preparing speciality products from rice. This is because farmers in the study area prepare other products such as *murahi* and *chiura* in addition to boiled rice. The experienced farmers do cultivate Masuli as exhibited by its cultivation to date since its release in 1973 where as its cultivation goes on decreasing as the farmers' consider early maturity attribute important. Farmers may not be able to cultivate succeeding winter crops because of the long duration of Masuli.

Farmers' probability of cultivating all varieties except Sarju 52 increases with the availability of seed from formal sources (SEEDSOU). As the seeds of these varieties are multiplied and distributed to farmers from the existing extension and research system as well as from NGOs, farmers demand for cultivating these varieties increases.

Table 5: Factors affecting the farmers' demand for rice variety .

Variables	*Coefficients for different variety preferences*			
	Radha 4	*Janaki*	*Masuli*	*Sarju 52*
constant	-4.572***(1.12)	2.806***(1.07)	-1.640(1.26)	-4.526***(1.40)
EDN	0.167***(0.06)	-0.159*(0.08)	0.042(0.08)	0.140**(0.07)
EXPERI	0.059***(0.02)	-0.014(0.03)	0.053*(0.03)	0.022(0.03)
SEEDSOU	1.890***(0.57)	1.602*(0.90)	2.322***(0.76)	-0.575(0.91)
THRESH	1.479**(0.71)	-3.826***(0.91)	0.883(0.78)	0.576(0.88)
MATURE	1.588***(0.50)	-0.552(0.66)	-1.720***(0.70)	1.820***(0.72)
IRRIG	-0.296(0.43)	-1.988***(0.74)	-1.862***(0.71)	-0.047(0.54)
TASTE	-0.515(0.38)	-0.422(0.48)	0.042(0.51)	-0.333(0.49)
OTHUSE	0.492(0.52)	-0.704(0.73)	-1.949***(0.70)	1.487**(0.77)
Pseudo R^2		0.37		
Log likelihood function		-205.95		
Likelihood ratio		246.61***		

***, ** and * imply statistical significance at 1% , 5% and 10% levels, respectively.

Figures in the parentheses are the standard errors.

Dependent variable is Variety. Other varieties as the reference.

4 Conclusion and Recommendation

The farmers in the study area have cultivated many modern varieties (MVs) of rice and some of them are being cultivated as long as for 30 years. The farmers also have multiple concerns and these are reflected in the selection of the variety(ies). In this paper, we have investigated the factors contributing the adoption of selected MVs of rice. We have considered the multitude of production and consumption attributes that are valued by the farmers, as well as farm and farmer specific variables. The key and significant variables affecting farmers' demand for variety are both production and consumption attributes valued by the households and farm and farmer characteristics. They are easy threshability, usage of grains for preparing special products, early maturity of the variety, less irrigation requirement, sources of seed, education and the experience of the farmers.

The results of this paper have implications for crop improvement and the modern variety adoption. The preference for irrigation and early maturity is the reflection of the production environment that the farmers are facing. Also their perceptions of the labor requirement for threshing and preparation of the special products are other variables that are the reflection of management aspects and the usage. As the farmers are the eventual consumers of the product of the agricultural research such as variety, their knowledge of the production environment and preference for the variety attributes are critically important in influencing not only the decision to adopt but also the level of the adoption. Hence, farmers' involvement in participatory varietal improvement and development programs needs to be emphasized so as to address their concerns and preferences.

The results also show that although the farmers value many attributes important, but there is no single variety that can supply all the attributes valued by them. Hence, the breeding efforts should be oriented to supply a range of varieties that can address the concerns of the farmers.

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Identification of Factors that Influence Technical Efficiency of Food Crop Production in West Africa: Empirical Evidence from Borno State, Nigeria

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Abstract

The objective of this study was to examine the determinants of food crop production and technical efficiency in the guinea savannas of Borno State, Nigeria. A stochastic frontier production function, using the maximum likelihood estimation (MLE) technique was applied in the analysis of data collected from 1086 sample farmers in 2004. The MLE results reveal that farm size; fertilizer and hired labour are the major factors that are associated with changes in the output of food crops. The effect of land area on output is positive and the coefficient found to be significant ($p = 0.01$). Fertilizer and hired labour have positive effects on output and their coefficients are significant ($p = 0.01$). Mean farmers' technical efficiency index was found to be 0.68. Farmer-specific efficiency factors, which comprise age, education, credit, extension and crop diversification, were found to be the significant factors that account for the observed variation in efficiency among the farmers. The implication of the study is that technical efficiency in food crop production could be increased by 32 percent through better use of available resources, given the current state of technology.

Keywords: stochastic frontier, productivity, technical efficiency, food crops, farmers

1 Introduction

The Guinea savanna zone of West and Central Africa covers a large area of sub-Saharan Africa. Most of the countries in the zone have low per capita income and are characterized by high incidence of poverty and food insecurity. The rapid increases in human population and exploitative use of non-renewable resources have exacerbated food supply. Hence, providing adequate food supplies is a major challenge.

It is estimated that the annual food supply in Nigeria would have to increase at an average annual rate of 5.9 per cent to meet food demand and reduce food importation significantly (Federal Ministry of Agriculture, 1993). Most studies show that aggregate food production in Nigeria has been growing at about 2.5 percent per annum in recent years. But the annual rate of population growth has been as high as 2.9 percent

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(Olayemi, 1998). The reality is that Nigeria has not been able to attain self-sufficiency in food production, despite increasing land area put into food production annually. The constraint to the rapid growth of food production seems to mainly be that of low crop yields and resource productivity. This is revealed by the actual yields of major food crops, compared with their potential yields (Federal Ministry of Agriculture, 1993). The low yield of crops may also be attributed to a relative decline in rainfall in recent years. Studies by Jagtap (1995) showed that annual rainfall in Nigeria during 1981-90 declined from that in 1961-70. The greatest change occurred in the onset of the rainy season and the extent of early rainfall, which resulted in a reduction by nearly one month in the growing season. There were fewer wet days and higher rainfall intensities in most of the country. The rainfall series showed prolonged dry periods, especially since 1970. The rainfall decline is unprecedented in duration; spatial, temporal character and seasonal expression (Kamara *et al.*, 2006) Thus, drought is one of the major causes of yield loss in the guinea savannas. This has aggravated the food supply situation in the area resulting in low food security index (Federal Republic of Nigeria, 2002).

This paper examines the determinants of food crop production and technical efficiency in the Guinea savannas of Nigeria. A pre-requisite for enhanced efficiency is the identification of those factors which prevail at the farm-level and which affect efficiency of production. Thus, it will help in providing information for the formulation of appropriate policies.

2 Materials

The study used primary data obtained through a farm management survey of farm-families in Borno State of Nigeria. The State is demarcated in four ecological zones: southern and northern guinea savannah in the south, Sudan savannah in the south and central, and the sahel in the north.

Farming is the predominant occupation in the study area, where rain-fed food crop farming and livestock rearing characterize the major land-use pattern. The cropping system is largely determined by both the amount and the duration of the rainy season (Amaza and Gwary, 2000).

The main instruments for data collection were well-structured questionnaires administered on farm-families. Multi-stage, random sampling techniques were employed in the selection of a sample of 1086 food crop farmers by 30 trained enumerators. The range of data collected covered those on household's farm activities. These include material input (input purchase cost); family and hired labour supply and use, sources of credit, tenurial arrangement, farm size, quantities of farm outputs and their farm gate and market prices. In addition, data were collected on household socio-economic variables, such as age, level of education, household size, and so on.

3 Methods

The stochastic efficiency frontier model independently proposed by Aigner *et al.* (1977) and Meeusen and van den Broeck (1977) was applied in the analysis of data. The approach has the advantage because it accounts for the presence of measurement error in the specification and estimation of the frontier production function. The stochastic frontier function differs from the traditional production function in that the former consists of two error terms. The first error term accounts for the existence of technical efficiency and the second accounts for factors such as measurement error in the output variable, weather and the combined effects of unobserved inputs on production.

In the literature, the econometric approach has generally been preferred in the empirical application of stochastic frontier production model in agriculture. This is probably due to a number of factors. First, the assumption that all deviations from the frontier arise from inefficiency, as assumed by data envelopment analysis (DEA) is difficult to accept, given the inherent variability of agricultural production due to uncontrollable factors such as weather, pests and diseases.

Second, because many farms are small, family-owned enterprises farm records are seldom kept. Consequently, available data on production are likely to be subject to measurement errors.

3.1 The Stochastic Frontier Production Model

The frontier production model is based on the stochastic efficiency model by PARIKH and SHAH (1994), which in turn, derives from the composed error model of AIGNER *et al.* (1977), MEEUSEN and VAN DEN BROECK (1977) and FORSUND *et al.* (1980).

The frontier production model begins by considering a stochastic production function with a multiplicative disturbance term of the form:

$$Y = f(X_a; \beta)\, \varepsilon(v, u) \tag{1}$$

Where:

Y	is the quantity of agricultural output;
X_a	is a vector of input quantities;
β	is a vector of parameters and
ε	is a stochastic disturbance term consisting of two independent elements u and v, where

The symmetric component, v, accounts for random variation in output due to factors outside the farmer's control, such as weather and diseases. It is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$. u is a one-sided component, where $u \leq 0$ reflects technical inefficiency relative to the stochastic frontier, $f(X_a; \beta)e^{\varepsilon}$. Thus, $u = 0$ for a farm output which lies on the frontier and $u < 0$ for one whose output is below the frontier as $|N(0, \sigma_u^2)|$, i.e. the distribution of u is half-normal.
The variance of σ^2 is, therefore

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \tag{2}$$

The ratio of two standard errors[1] is defined by

$$\lambda = \sigma_u + \sigma_v \tag{3}$$

[1] BATTESE and CORRA (1977) define γ as the total variation in output from the frontier and which is attributable to technical efficiency i.e. $\gamma = \sigma_u^2/\sigma^2$ so that $0 \leq \gamma \leq 1$

JONDROW *et al.* (1982) have shown that measures of efficiency at the individual farm level can be obtained from the error terms $\varepsilon = u + v$. For each farm, the measure is the expected value of u conditional on ε, i.e.

$$E(u|\varepsilon) = \frac{\sigma_u \sigma_v}{\sigma} = \left[\frac{f(\varepsilon\lambda/\sigma)}{1 - F(\varepsilon\lambda/\sigma)} - \frac{\varepsilon\lambda}{\sigma}\right] \tag{4}$$

Where f and F are the standard normal density function and the standard normal distribution function evaluated at $\varepsilon\lambda/\sigma$. Estimated values for ε, λ and σ are used to evaluate the density and distribution functions. Measures of efficiency for each farm can be calculated as:

$$TE = exp\,[E(u|\varepsilon)] \tag{5}$$

A number of empirical works (PARIKH and SHAH, 1994; LLEWELYN and WILLIAMS, 1996) and recently AMAZA and OLAYEMI (2002) have investigated the determinants of technical efficiency among firms in an industry by regressing the predicted efficiencies, obtained from an estimated stochastic frontier on a vector of farmer-specific factors such as age of the farmer, educational level of the farmer, access to extension, and so on, in a second-stage regression. The identification of those factors, which influence the level of technical efficiencies, is a valuable exercise because the factors are significant for policy formulation.

It is assumed that the inefficiency factors are independently distributed and that u arises by the truncation (at zero) of the normal distribution with mean μ and variance σ^2, where u in equation (5) is defined as:

$$u = f(Z_b; \delta) \tag{6}$$

Where
Z_b is a vector of farmer-specific factors, and
δ is a vector of parameters

The β- and δ- coefficients in equations (1) and (6) respectively are unknown parameters to be simultaneously estimated, together with the variance parameters which are expressed in terms of:

$$\sigma_s^2 = \sigma_v^2 + \sigma^2 \text{ and} \tag{7}$$

$$\gamma = \sigma^2/\sigma_s^2 \tag{8}$$

Where the γ- parameter has a value between zero and one. The parameters of the stochastic frontier function are estimated by the method of maximum likelihood, using the computer program FRONTIER version 4.1 (COELLI, 1994)

4 Results and Discussions

The estimated stochastic frontier production function is presented in Table 1. All the coefficients in the model have the expected *a priori* signs and are mostly significant.

The estimated coefficient for land is positive, which conform to *a priori* expectation, and significant at 1-percent level. The magnitude of the coefficient of land, which is 0.07, indicates that the output in food crop production is inelastic to changes in the

Table 1: Maximum likelihood estimates of the parameters of the stochastic frontier function.

Variable	*Parameter*	*Coefficient*	*Standard error*
Production factors			
Constant	β_0	8.282	0.159**
Farm size (X_1)	β_1	0.073	0.033 **
Fertiliser (X_2)	β_2	0.204	0.012**
Hired labour (X_3)	β_3	0.063	0.003**
Family labor (X_4)	β_4	0.001	0.014
Seeds (X_5)	β_5	0.0009	0.008
Inefficiency effects			
Constant	δ_0	-9.904	2.581**
Age (Z_1)	δ_1	-2.042	0.417**
Education (Z_2)	δ_3	-0.221	0.059**
Credit (D_1)	δ_4	-0.380	0.092**
Extension (D_2)	δ_5	-0.24	0.050**
Crop diversification (Z_3)	δ_6	0.076	0.041*
Diagnostic Statistics			
Likelihood ratio $=$ 161.42			
Sigma-squared (σ^2)	7.059	1.022**	
Gamma (γ)	0.897	0.015**	

**,* significant at the 1% and 5% level respectively

level of cultivated land area. The 0.07 elasticity of land implies that a 1-percent increase in cultivated land area, *ceteris paribus*, would lead to an increase of 0.07 percent in the output of food crops, and vice versa. This suggests that land is a significant factor associated with changes in crop output.

The production elasticity with respect to inorganic or chemical fertilizer is positive as expected and statistically significant at 1-percent level. The significance of the fertilizer variable derives from the fact that fertilizer is a major land fertilizing input and improves the productivity of existing land by increasing crop yields per hectare.

The magnitude of the coefficient of hired labour, which is 0.06, indicates that output in crop production is highly inelastic to changes in the amount of hired labour used. Thus, a 1-percent increase in hired labour would induce an increase of only 0.06 per cent in the output of crops, and vice versa. Farmers who have the main objective of income maximisation in food crop production would tend to allocate resources more efficiently, including the allocation of hired labour (Amaza and Gwary, 2000). On the other hand, farmers whose main objective is household food security would be more concerned with maximising their output per unit of resource used, especially family labour; that is, they tend to emphasize technical efficiency.

The inefficiency parameters are specified as those relating to farmers' specific socio-economic characteristics. These include the age, educational levels, access to credit, access to extension advice and their degree of crop diversification. The coefficient of age variable is estimated to be negative and statistically significant at 1-percent level. This indicates that farmers who are older are relatively less efficient in food crop production and vice versa. Thus, because food crop production in the study area is relatively labour intensive, especially weeding and harvesting operations, younger farmers tend to be more productive. Also, the younger farmers are likely to be more progressive and, hence more willing to adapt new practices, thus leading to higher efficiencies in food crop production.

The coefficient of education variable is estimated to be negative as expected and statistically significant at the 1-percent level. This finding agrees with comparable findings by Battese *et al.* (1996), Coelli and Battese (1996) and Seyoum *et al.* (1998). The implication is that farmers with formal schooling tend to be more efficient in food crop production, presumably due to their enhanced ability to acquire technical knowledge, which makes them move close to the frontier output. It is very plausible that the farmers with education respond readily to the use of improved technology, such as the application of fertilizers, use of pesticides and so on, thus producing closer to the frontier.

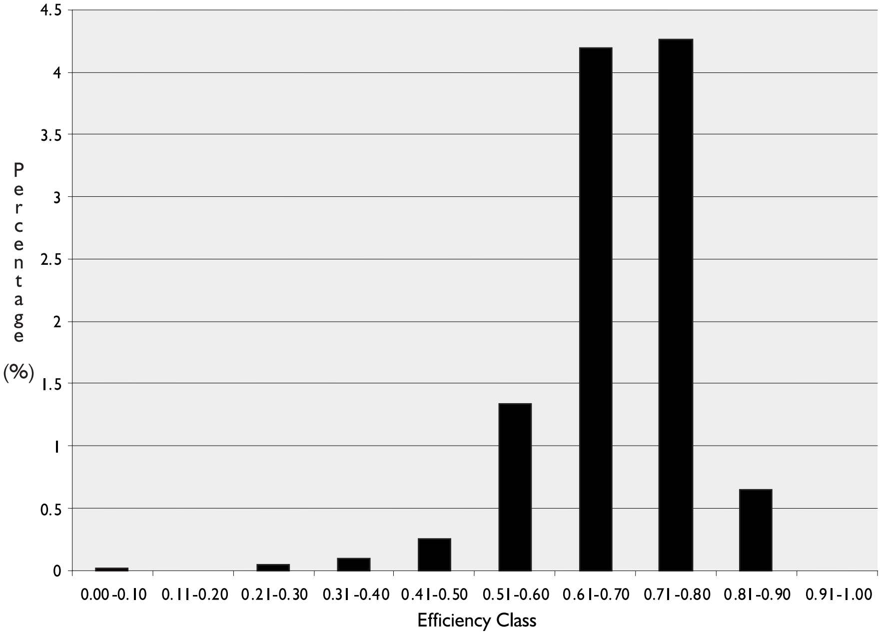
The coefficient of credit variable is estimated to be negative as expected and statistically significant at 1-percent level. This suggests that farmers who have greater access to credit tend to be more efficient in food crop production. Because food crop production is heavily labour-intensive, substantial part of the credit is used to hire labour, especially for weeding and harvesting operations. Also, the availability of credit helps to finance purchased inputs, especially fertilizer, which has positive effect on the productivity of farmers.

The coefficient of the extension variable is estimated to be negative and statistically significant at the 1-percent level. This indicates that increased extension services to farmers tend to increase technical efficiency in food crop production. The significance of extension in this study corroborates the findings of Seyoum *et al.* (1998) who reported positive influence of extension contact on efficiency in their study of technical efficiency and productivity of maize farmers in eastern Ethiopia.

The crop diversification variable in the model is negative and statistically significant at 5 percent level. As diversification decreases and fewer crops are grown, efficiency increases. The implication is that lesser diversification is associated with higher relative efficiency. The consideration for risk minimization is a major factor accounting for the practice of mixed-cropping (Norman, 1974; Just and Candler, 1985). A study by Abalu (1976) on crop mixtures in Northern Nigeria contends that crop mixtures are employed by farmers primarily as risk-minimizing precautions and that the immediate objective of farmers is not only one of profit maximization but also of stability of income.

A significant characteristic of the stochastic frontier production model is its ability to provide farm-specific measures of technical efficiencies. The distribution of farmers' technical efficiency indices derived from the analysis of the stochastic production function is provided in Figure 1.

Figure 1: Distribution of farmers' technical efficiency indices.



The technical efficiency of the sampled farmers is less than 1 (or 100 %), indicating that all the farmers are producing below the maximum efficiency frontier. A range of technical efficiency is observed across the sample farms where the spread is large. The best farm has a technical efficiency of 0.90 (90 %), while the worst farm has a technical efficiency of 0.02 (2 %). The mean technical efficiency is 0.68 (68%). This implies that, on the average, the respondents were able to obtain a little over 68 percent of optimal output from a given mix of production inputs.

The distribution of technical efficiency of the farmers reveals that only 7 farmers representing 0.64 percent had a technical efficiency of less than 30 percent, while 491 farmers, representing approximately 45.3 percent had a technical efficiency of above 70 per cent.

The picture that emerges from this analysis is one of generally average technical efficiency in food crop production in the study area. The magnitude of the mean technical efficiency of the farmers is a reflection of the fact that most of the sample farmers carry out food crop production under technical conditions, involving the use of inefficient tools, unimproved seed varieties and so on. The low production technology adopted by the majority of the farmers and their low levels of formal education are major factors that have influenced the level of their technical efficiency.

The distribution of the technical efficiency suggests that potential gain in technical efficiency among the sample farmers is large. The mean technical efficiency of approximately 68 per cent implies that, in the short-run, there is the scope for increasing technical efficiency in food crop production in the study area by 32 per cent. This can be achieved through improved farmer-specific efficiency factors, which include improved farmer education, access to credit, access to improved extension services and less crop diversification

5 Conclusion and Policy Implication

The study reveals that farm size; fertilizer and hired labour are the major factors that are associated with changes in the output of food crops. The effect of land area on output is positive and the coefficient found to be statistically significant ($p = 0.01$). Chemical fertilizer and Hired labour have positive effects on output and their coefficients are statistically significant ($p = 0.01$).

The model for the inefficiency effects in the frontier function includes age, education, access to credit, access to extension and crop diversification. All the farmer-specific variables were significant in accounting for the observed variation in efficiency among the farmers. The policy implication of the study is that technical efficiency in food crop production could be increased by 32 percent through improved use of available resources, given the current state of technology. This can be achieved through improved farmer-specific efficiency factors, which include improved farmer education, access to credit, access to improved extension services and less crop diversification.

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