The Role of Information Asymmetries, Asset Fixity and Farmer Perceptions in the Adoption of Improved Rice Varieties in Northern Ghana

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Abstract

Domestic rice production in Ghana meets only 30% of local demand. A number of new varieties have been released to farmers over the years to improve rice production but introduction alone does not guarantee widespread adoption by farmers. In order to identify determinants that impact the adoption of improved rice varieties in smallholder farming systems in northern Ghana, this paper uses a Tobit model to estimate the marginal impact of farm, farmer and technology specific characteristics in the adoption process. Identification of important determinants in the adoption of new rice varieties will improve technology targeting and development of subsequent technologies.

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1. Introduction

Rice is an important food crop in Ghana. Despite a vast expanse of suitable rice land, national production (nearly 70% in the lowland valleys of northern Ghana) is approximately 81,000 metric tons about 30% of national demand. Despite the development of improved varieties, adoption remains limited.

Strategies that can be pursued to increase the rate of adoption of improved varieties among small-scale farmers in Ghana are (i) targeting specific farmers directly by extension workers rather than broad varietal promotion strategies which requires greater information on local populations than often available; (ii) promoting varieties through more traditional channels such as research station field days or farmer association groups which may be less costly than the information intensive first alternative, but may not be sufficiently focused to induce experimentation with or adoption of, new varieties; and (iii) the development of varieties that are not only higher yielding, but also superior in terms of disease resistance and post-harvest transformation, however, breeding for multiple objectives is costly and known to increase disproportionately (Arnold and Innes, 1991).

This study determined the influence of (1) farmers' demographic characteristics and wealth; (2) institutional affiliation such as membership in agricultural associations or attendance at organized field day activities; and, (3) technology specific characteristics. On the adoption of new rice varieties, the speed at which varieties diffuse through the agricultural community in northern Ghana which are essential in designing individual targeting, group targeting or multi-attribute improvement strategies.

2. Literature Review

Three main paradigms explaining technology adoption decisions include (i) the innovation-diffusion model, (ii) the economic constraints model, and (iii) the adopters' perception model. The underlying assumption of the innovation-diffusion model is that the technology is appropriate and the problem of technology adoption is one of asymmetric information (Cameron, 1999; Feder and Slade, 1984; Shampine, 1998; Smale *et al.,* 1994.). This suggests that research has developed a "superior" agricultural technology but the information is not known to farmers and the search costs for this information is high, therefore, by emphasizing the use of extension, experiment station visits, on-farm trials and other vehicles to transmit technical information, the search costs of information on new varieties can be reduced.

The economic constraint model contends that input fixity in the short run, such as access to credit, land, labor or other critical inputs limit production flexibility and condition technology adoption decisions (Aikens et al., 1975; McGuirk and Mundlak; Smale et al., 1994; Foster and Rosensweig; Shampine, 1998). In the short-run, production patterns are less flexible than in the long-run as resources cannot be diverted to new activities without compensating effects on existing production patterns.

The "adopters' perception" paradigm (Kivlin and Fliegel 1967), assumes that the technical innovations are appropriate but subjective perceptions hamper the adoption process suggesting that even with full technical information about a new technology, farmers may subjectively evaluate the information differently than scientists. Therefore, adoption studies have included a variable attempting to measure farmers' perception of a problem (Gould et al., 1987; Norris and Batie, 1987; Ashby and Sperling, 1992; Ashby et al., 1989; Adesina and Zinnah (1992).

3. Data Collection Procedure and Econometric Approach

Data for the analysis were collected through a survey conducted in 1997/98 crop season in Tamale, Tolon and Savelugu districts in the northern region of Ghana. Five, four and three villages, respectively, were selected from Tamale, Tolon and Savelugu districts (the number selected per district was in proportion to the total number of rice producing villages in the district). A total of 240 farmers, 10 per village, were randomly selected and interviewed using structured questionnaires on: (1) socio-economic and institutional variables such as farmer's age, household size, farming experience (years since the farmer became a decision maker), labor usage, access to credit, land tenure status, extension contact, market access and infrastructure; (2) varietal adoption history, and (3) technology specific variables including a comparison of the best local variety to improved varieties of rice in terms of yield, tillering ability, lodging resistance, pest resistance, milling and cooking characteristics. A summary of farmer characteristics by district is presented in Table 1.

Characterization of survey villages

Table 1. Descriptive variables of farm households

	Tamale (n = 100)		Tolon (n = 80)		Savelugu (n = 60)		Total sample (n = 240)	
	Mean	SD*	Mean	SD	Mean	SD	Mean	SD

Age of respondent	42.14	13.26	41.64	10.77	39.10	12.10	41.21	12.20
Family size (no.)	9.32	6.94	19.06	12.82	5.22	6.87	11.54	10.82
Adults (%)	43	-	52	-	49	-	48	-
Farm size (ha)	12.43	9.83	19.45	22.12	34.54	93.86	20.30	49.53
Rice field (%)	44	-	32	-	9	-	25	-
Fallow period (yrs)**	3.99	3.08	2.10	1.96	1.50	2.25	2.74	2.76
Labor equivalents-Land ratio	0.94	0.87	1.67	2.03	0.51	0.67	1.08	1.41

Note: * SD = Standard deviation

** Fallow period for rice fields

Specification of the model

Table 2. Definitions of variables in empirical model

Variable	Mean	Std. Deviation	Description
Dependent variable			
PROPN	0.52	0.42	Proportion of rice area planted with an improved variety.
Independent variables			
GENDER	0.94	0.22	Binary variable, assumes a value of 1 if male and 0 otherwise.
AGE	41.00	12.00	Age of farmer in years.
ASSOC	0.30	0.46	Membership of a farmers' association. Measured as a binary variable: 1 if farmer is a member of a farmer's association, 0 otherwise.
FARMSIZE	5.20	6.50	Size of rice farm in hectares.
FIELDAYS	0.36	0.48	Participation in farmer field days. Measured as a binary variable: 1 if farmer participated in recent farmer field days, 0 otherwise.
YIELD	0.70	0.46	Yield. Measured as a binary variable: 1 if farmer thought improved varieties were superior in yield compared to the best local variety, 0 otherwise.
LODGE	0.54	0.50	Lodge. Measured as a binary variable: 1 if farmer thought improved varieties were more resistant to lodging than the best local variety, 0 otherwise.
DISEASE	0.32	0.47	Disease resistance. Measured as a binary variable: 1 if farmer thought improved varieties were more resistant to diseases than the best local variety, 0 otherwise.
THRESH	0.53	0.50	Ease of threshing. Measured as a binary variable: 1 if farmer thought improved varieties were easier to thresh than the local variety, 0 otherwise.
BIRDS	0.44	0.50	Resistance to birds attack. Measured as a binary variable: 1 if farmer thought improved varieties were more resistant to bird attack than the best local variety, 0 otherwise.

Results

Table 4. Tobit model regression estimates and standard errors

Independent Variable	Asymptotic Normalized Coefficients and Standard Errors: Information and Asset Fixity Model	Farmer Perceptions Model	Combined Model	Marginal effects for Combined Model
GENDER	-0.566***		-0.748***	-0.3276
	(0.302)		(0.313)	(0.1230)
AGE	0.001		0.001	0.0008
	(0.006)		(0.006)	(0.0025)
ASSOC	0.329*		0.321*	0.1340
	(0.176)		(0.178)	(0.0729)
FARMSIZE	0.028**		0.037**	0.0130
	(0.011)		(0.011)	(0.0048)
FIELDAY	0.592***		0.449***	0.1753
	(0.166)		(0.170)	(0.0693)
YIELD		0.156	-0.027	0.0090
		(0.194)	(0.200)	(0.0818)
LODGE		0.229	0.283	0.0988
		(0.164)	(0.169)	(0.0688)
DISEASE		-0.404**	-0.500***	-0.1646
		(0.173)	(0.179)	(0.0733)
THRESH		0.240	0.069	0.0371
		(0.165)	(0.170)	(0.0697)
BIRDS		-0.496**	-0.360**	-0.1524
		(0.166)	(0.171)	(0.0700)
CONSTANT	0.894**	0.718***	1.173***	0.4818
	(0.393)	(0.146)	(0.422)	(0.1712)
Dependent Variable				
PROPN	1.857	1.804	1.705	
	(0.114)	(0.095)	(0.103)	
Log-Likelihood function	-196.0	-201.1	-185.5	
LRT (combined spec.)	21.02	31.13		
Mean-square error	0.148	0.158	0.140	
No. observations	235	235	235	

Note: In parenthesis are the standard errors
* Significant at 10%
** Significant at 5%
*** Significant at 1%

<TABLE 1 goes about here>

The mean age of the 240 farmers interviewed was 41 years. Over 50% of the sample were household heads and the primary farm decision maker. An average household consists of 12 members and these members supply the majority of farm labor. Approximately 79% of the farmers are illiterate, 10% have some form of structured education in English and 11% a Koranic education. Agriculture is the main source of family income. Small scale trading and artisanal activities[3] are sources of off-farm income for 56% and 44% of households, respectively.

The average farm size per farm household is 20 hectares, of which approximately 25% is under rice. Nearly all farmers (91%) cultivate rice as a monocrop and those who do practice intercropping plant maize on ridges or yams on mounds and rice in the furrows. The choice of field for the farmer's choice of variety is sometimes influenced by extension staffs of the Ghanaian Ministry of Food and Agriculture (MoFA). MoFA staffs are also instrumental in organizing farmers into associations and groups to bargain for better services. The formation of associations is also motivated by the fact that financial and other credit institutions advance credit/loans to farmers only when they belong to an association. In this case the loan is contracted in the name of the association rather than individual farmers.

Farmers spread yield risk by planting more than one variety on their fields. Fifty three percent of farmers indicated that they cultivate more than one variety. Of this percentage, 35% cultivate two varieties and 18% cultivate more than 2. The remaining

[3] Craftsmanship includes fitting mechanic work, artisan work (masonry and carpentry) and basketry.

47% are not diversified and cultivate only one variety. Nine varieties are grown on a wide scale, six of which are improved including GR18, GR19, GR21 Faro15, and ROK3 and Afefe. Local varieties include Glaberimma, Mendi, and Anyufula which are all upland types. In general, the proportion of farmers growing any improved variety increased from less than 25% in 1988 to nearly 60% in 1997. In terms of area cultivated, approximately 53% of northern Ghana (40% for Tamale district, 53% for Tolon, and 76% for Savelug) is planted to improved varieties.

In order to improve the efficiency of varietal development and target end-users with more accuracy, this study evaluates three distinct sets of factors conditioning adoption decisions: (1) farm and farmer attributes; (2) organizational affiliation; and, (3) technology specific characteristics. The farm and farmer characteristics in the model include age of farmer, gender, and the size of the rice field. These characteristics can be used to evaluate whether fixed human capital (age), fixed social bias (gender) and land constraints are important in the adoption process. Organizational affiliation include participation in farmer field days on rice production and membership in a farmer's group. These variables are hypothesized to reduce information asymmetries. Regarding the technology specific attributes, farmers compared the improved varieties with the best local variety (in this case, *Mendi*) in terms of yield, lodging resistance, disease resistance, ease of threshing and resistance to bird damage. These variables are used to test whether farmers' perceptions of technology characteristics are significant in the decision to adopt new seed technologies.

Farmers are risk averse and therefore are very cautious in their willingness to devote some portion of their field to an untried new variety. Consequently the proportion of area devoted to the new varieties would be positively related to farm size. Ghanaian society is highly patriarchal and females are not directly addressed, in many circumstances, by extension or other information sources. It is therefore hypothesized that males would have better information to new technologies and hence adopt new varieties at higher rates than their female counterparts. As farmers grow older, they are less amenable to change and therefore may be unwilling to change from their old practices to new ones, hence age is expected to be negatively related to adoption. Others have argued that age is positively related to adoption especially prior to the consolidation period in the producer's life cycle. Therefore it will be determined empirically in the applied model.

Demonstration is a very important tool in technology transfer. During the growing season extension staff organize farmer field days for farmers to observe the performance of new technologies in the field. Exposing farmers to new technologies is known to stimulate communication and adoption. Hence participation in farmer field days is postulated to be positively related to adoption. Membership in farmers' associations is expected to have a positive impact on technology adoption by providing a forum for information exchange and discussion.

<TABLE 2 goes about here>

Farmers grow rice mainly for cash income and they know that higher yields inevitably lead to higher revenues. Therefore the perceived superior yield performance of improved varieties is expected to be positively related to adoption and use intensity. Flooding usually leads to lodging and consequently poor yields. Even if the variety were superior to the local ones, but prone to lodging, the yield advantage would be reduced through reduced harvestability. Therefore farmer perception of lodging resistance is postulated to be positively related to adoption. Disease resistance is hypothesized to be positively related to adoption due in part to its yield effect and impact upon grain quality. The definitions of these variables and their descriptive statistics are presented in Table 2 and Table 3.

<TABLE 3 goes about here>

Three models were estimated: the first used only the farm and farmer specific factors plus organizational affiliation, the second farmers' perceptions of the technology specific factors and third, both the farm and farmer specific factors and the technology specific attributes were used.

Some farmers did not adopt improved varieties and therefore the dependent variable, the proportion of area under improved varieties, is censored at zero. As a result, censored regression models were estimated using the Tobit procedure. The Tobit model decomposes the dependent variable into two groups: one which has a positive percentage of rice land allocated to improved varieties and the second that does not. The Tobit procedure maximizes a two part log-likelihood function which is continuous, for those that have adopted new varieties, and a second part which is discrete, for those farmers who have not adopted improved varieties. As a result, the Tobit model, when estimated as the proportion of land under improved varieties, measures two decisions simultaneously: the decision to adopt and the intensity of usage[4].

[4] A full mathematical treatment of the Tobit model is not included in this paper as its usage is common in applied economics research. Thorough treatments of the model may be found in Greene (2000), chapter 20, pp. 896-951.

4. Empirical results

In the first model, including only the farm and farmer specific regressors, all variables had expected signs except gender, which had an opposite sign (column 1 of Table 4). The negative sign of the gender coefficient implies that females are more inclined to adopt new rice varieties compared to their male counterparts. One possible explanation for this result is that female rice farmers have access to relatively smaller plots but adopt higher yielding varieties to compensate for the small plot size.

Membership in a farm association is significant in explaining adoption decisions by farmers. Periodic meetings of association members tend to promote interaction among farmers and between MofA staff. Consequently adoption decisions are improved compared to non-members and hence better opportunity to procure seed and related inputs, and potentially reduces input fixity constraints. Participation in farmers' field days is significant in explaining adoption indicating that observing the performance of improved varieties on fields of their fellow farmers or experimental stations reduces information asymmetries.

<TABLE 4 goes about here>

The second column of Table 4 presents the influence of technology specific characteristics on adoption decisions. Resistance to lodging, disease and birds attack as well as ease of threshing are significant in influencing adoption decisions. Farmers allocate a higher percentage of their land to improved varieties that they perceive are more resistant to lodging and easier to thresh compared with their local variety. On the contrary, improved varieties are perceived to be less resistant to diseases and more prone to birds attack and hence their negative impact upon adoption decisions. These signs are contrary to the expected. One unobserved trait that could be important in the adoption process is the cycle length of improved varieties. Traditional rice varieties are harvested approximately five months after seeding. One major achievement in rice breeding has been to reduce the time from seeding to harvest by thirty days without yield loss. As a result, improved varieties my be seen as more susceptible to pest, including bird attack as they are mature and seed before local varieties. At the same time, they may be more susceptible to disease outbreaks that are correlated with moisture since they are maturing earlier while there is some rainfall.

When both technology specific farm and farmer specific characteristics are pooled, all the variables had expected signs except gender as the case was in model 1. In terms of degree of influencing adoption decisions, variables found significant in the previous two models were also significant except field days and threshing (Table 7). The variable measuring farm size became significant when technology specific characteristics were included indicating that the new varieties introduced in Northern Ghana are not size neutral.

All measures of regression fit increased for the combined specification of the model over the farm and farmer characteristics model and the technology perceptions model. Likelihood ratio tests were calculated comparing the full specification against a restricted version in which either the technology specific characteristics were not significant (model 1) or the farm and farmer characteristics (model 2). Both hypotheses were rejected at a significance level less than one percent indicating that adoption decisions and intensity of use at the farm level can be better predicted using information on farm, farmers, institutional affiliation as well as farmers' perception of technology attributes.

5. Conclusions and Research Policy Implications

This study examined and analyzed the impact of selected technical and socio-economic factors on the adoption and use intensity of improved rice varieties in smallholder farming systems in northern Ghana. Two hundred and forty farmers were interviewed in 1997/98. The estimated adoption rates in terms of area planted to improved varieties GR 18, GR 19, GR21, Farro 15, Rok 3 and Afefe were 40% in Tamale district, 53% in Tolon-Kumbungu district, and 76% in Savelugu-Nanton district. In terms of proportion of farmers growing improved varieties, adoption rates increased from 24% in 1988 to about 58% in 1997. The cumulative adoption curve showed the traditional S-shape and an adoption ceiling of 73% was estimated.

The impact of selected farmer specific and technology specific attributes on adoption decision by farmers was examined using a Tobit model. The results showed that gender, membership of farmer's association, participation in farmer field days, resistance to lodging, diseases and birds as well as ease of threshing are important in explaining adoption decisions. These model results differ from those found by Adesina and Forson (1995) in which only farmer perception variables were determined significant. This means that there are dividends in extension education of women and should be emphasized. Farmers should be encouraged to form groups and participate in field-days as they are important in promoting group discussions and subsequent technology adoption. This is an important difference from previous findings and it may signal that alternative institution settings found throughout West Africa may affect the adoption process differentially.

Breeding work should emphasize lodging resistance, resistance to bird attack through the incorporation of awns or other similar characteristics. Because rice is threshed manually, it should be easy to thresh. This means that education on the timeliness of harvesting should be stressed to reduce losses due to shattering.

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