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Access to Information and the Adoption of Hybrid Maize : Evidence from China's Poor Areas

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This paper investigated the role of farmers' access to information in a farm household's decisions of whether or not to adopt hybrid maize and the amount to adopt using data collected in a poor region of China. The empirical results suggest that increased availability of medium and more frequent extension visits would lead more farmers to adopt the hybrid maize. It is also found that, once adoption is realized, more frequent extension visits to the adopters will be vital to influence farmers to allocate more of their maize area to hybrid maize. The paper also demonstrate the adoption of new technology in the poor areas may well be different from that in the rich areas.

Key words : access to Information, adoption of new technology, hybrid maize, double hurdle adoption model, China.

1. Introduction

The rapid diffusion of suitable agricultural technology is considered to be one of the fundamental measures to alleviate poverty in poor areas. However, the introduction of many new technologies in poor areas has met with only partial success. Maize, for example, is one of the most important crops in China's southwest poor area (Liu [14]).[1)] The development of hybrid maize in the 1960s gave China a great hope that the introduction of hybrid maize to the southwest poor areas would help solving the food shortage problem.[2)] However, after almost thirty-five years, the adoption rate of hybrid maize in some poor areas such as Puding County in Guizhou Province and Luquan County in Yunan Province was still only about 50%, well below the national adoption rate of 86%.

Why is the diffusion of hybrid maize much slower in poor areas? There is little research within or outside China available to answer the question. Some research has been done on the adoption of hybrid rice in southeast China (Lin [12], Huang and Rozelle [11]). As the Southeast is China's most wealthy region, it raises concerns about the relevance of findings from the adoption of hybrid rice to adoption of hybrid maize in a poor area. Zhu and Zhao [20] examined the determinants of farmers' adoption of hybrid maize in poor area using a probit model. They found that the most important factor to effect adoption is output increase when adopting hybrid maize. Meanwhile frequency of contact with extension service and distance to town have positively significant effect. However farm size and frequency to use centain kinds of media are not significant. In the literature on the diffusion of innovation, many constraints to the rapid diffusion of a new technology have been identified, such as farm size, risk and credit, information, labor availability, education and so on (Feder, Just, and Zilberman [4]). This paper focuses on the role of better access to information in a farmer's decision regarding adoption of hybrid maize. This focus is chosen because most poor areas are located in mountainous regions. Due to geographic isolation from outside and lack of modern communication systems, farmers' access to information is very limited. Increasing farmers' access to information is considered by many to be a key measure in the rapid diffusion of hybrid maize in poor areas (Liu [14]). Aiming at speeding up the diffusion of hybrid maize in poor areas, the main component of China's large scale

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'WenBao' project initiated in early 1980s was to provide more extension services and to increase farmers' access to information. Such efforts met with only limited success, as measured by observed rates of adoption of hybrid maize in poor areas (Liu [14]). This raises concerns regarding the value and delivery of public information provided by government.

For the purpose of this study, cross-sectional data collected in 1994 from a sample of 194 farmers are used to determine the role of better access to information in a farmer's decision regarding adoption of hybrid maize in southwest China's poor areas. The adoption process is broken down into two stages. The first stage is the decision of a farmer either to adopt or not adopt the new technology, sometimes termed the tendency of adoption. Once the decision to adopt is made, the second stage consists of the decision on the amount of area allocated to the hybrid maize, termed the intensity of adoption. Recognizing the two-stage nature of the adoption decision process, a double hurdle adoption model of new technology, similar to Cragg's demand model for durable goods, is developed. In particular, we are interested in knowing whether or not better access to information influences the decision to adopt and the decision of how much to adopt differently.

2. Double Hurdle Adoption Model of New Technology

Several discrete choice models, in particular the probit, the tobit, and the logit models, have been developed to conduct adoption analysis (e.g., Griliches [7], Feder, Just, and Zilberman [4]). When the interest is to identify the factors that influence both the tendencies of adoption and the intensity of adoption the tobit model is preferred (e.g., Lin [12], Adesina and Zinnah [1]). The tobit model assumes that no adoption represents corner solutions and thus allows the same stochastic process to represent both the decisions to adopt and the decision of how much to adopt. As noted in Nichola [15], in developing countries modern agricultural technologies or the inputs needed to apply the technology are often in short supply. It is possible that farmers who have decided to use the technology may be hindered from using it because of supply restrictions. In such cases, the identification of the variables that motivate adoption using a tobit model may not be reliable. As the decision to adopt may involve processes that are different from the decision of how much to adopt, one needs to model the two adoption decision processes separately. The double hurdle model is more appropriate. The double hurdle model can be specified as follows :

$$\begin{aligned} y_i &= y_i^*, \text{ if } y_i^* > 0 \text{ and } D_i > 0 \\ y_i &= 0, \text{ otherwise} \end{aligned} \tag{1}$$

$$\begin{aligned} y_i^* &= x_i\alpha + \varepsilon_i, \\ D_i &= z_i\beta + v_i \end{aligned} \tag{2}$$

where y_i is the i_{th} farmer's recorded amount of hybrid maize area as proportion of his or her total area, y_i^* is the corresponding latent variable that embodies the decision of how much to adopt, D_i is a latent variable that characterizes the decision of whether to adopt, x_i and z_i represent vectors of socioeconomic and demographic variables that are expected to influence the respective decisions of whether to adopt and how much to adopt. These two vectors of independent variables need not be different, and the error terms (ε_i, v_i) are assumed to be independently normally distributed with zero means and constant variances $N\sim(0, \sigma^2)$.

3. Data and Empirical Specification

The data come from a cross-sectional survey of 289 households in Puding County in the province of Guizhou and Luquan County in the province of Yunan, which was carried out during September 1994. There are many similarities between these two counties. Both of the sample counties belong to the so-called Southwest poor region and are located inside of the Hengduan and Wumen mountain ranges. Average elevation of these two counties is over 2,000 meters. These two counties are among the poorest in China. In 1993, per capita disposable income was 347 yuan per year for Luquan and 358 per year for Puding. Maize is the most important crop in these two counties. Close to half of the total sown area is allocated to maize production in these two counties. As such, the introduction of hybrid maize to the southwest poor areas was seen as a viable strategy to solve the food

shortage problem. However, the adoption rate of hybrid maize in some poor areas was felt by many to be below the target level, though there is little systematic information on the actual diffusion process of hybrid maize in these remote poor counties. This called for a better account of the diffusion process of hybrid maize in these poor counties. The 289 households were randomly selected from six townships in these two counties and the survey was conducted by a research team from the Agricultural Economics Research Institute at the Chinese Academy of Agricultural Science. Though the original survey was not designed to the study of the adoption of hybrid maize per se, it contained rich information for such investigation.

Information on the household's allocation of land among crops, including hybrid maize and conventional maize, was collected. The proportion of hybrid maize area to total maize area can be readily calculated. To measure the impact of access to information on the adoption of hybrid maize, three variables are constructed from the survey : distance from a household to the extension center (DISTANCE), the availability of mass media in the household (MEDIUM), and the farmer's contact frequency with the extension technician (CONTACT). DISTANCE is measured in kilometers. It is expected that the greater the distance between the household and extension center, the more costly for the farmer to get information. DISTANCE should have a negative effect on the adoption of hybrid maize. MEDIUM takes a value of one if there is any kind of medium in the household including television, radio, and newspaper and zero otherwise. CONTACT takes a value of one if the household had contact with an extension technician regarding the hybrid maize and is zero otherwise. The availability of medium and contact with extension technician would help farmers get more information and are expected to have positive effects on a farmer's adoption of hybrid maize. It is also logical that MEDIUM may have more effect on the decision to adopt but have much less effect on the decision of how much to adopt.

Other relevant information collected in the survey are education level, the value of total family assets, total arable land, total dry land, and the household head's age. Education is considered to be an important variable in determining the adoption behavior of small farmers in a developing country as education enhances one's ability to receive, decode, and understand information (Schultz [18], [19]). Lin [12] showed the empirical importance of the household head's education on the adoption of hybrid rice in the Chinese farm households. A household head's years of formal schooling is used to capture the impact of education (EDU). It is expected that the variable EDU has a positive effect on the adoption of hybrid maize. To measure the impact of the household's income on the adoption of hybrid maize, total family assets are used (ASSET). The reason for selecting the total asset value over the current income is because total assets value is a better measure of the farmer's economic condition in the long run and because annual cash income tends to be low and unstable in poor areas. It is expected that ASSET has a positive effect on the adoption of hybrid maize.

Farm size is a variable that has received considerable attention in the diffusion of agricultural technology. Many found a positive relationship between farm size and adoption (e. g., Feder and O'Mara [6]). In this study the effect of farm size is captured by *per capita* total arable land area (PLAND), total arable land area (TLAND), and total dry land (DRYLAND). To fully realize the benefits of hybrid maize farmers need to invest more time and need to purchase more fertilizer and more expensive seeds. It is unlikely that many poor farmers in the surveyed townships can meet the extra costs involved. The availability of and access to credit (CREDIT) are likely to influence adoption positively. Total indebtedness in *yuan* from official organizations was used to measure the availability of credit. The household's age is a demographic variable that has also received some attention in the diffusion studies of agricultural technology. It is hypothesized that older farmers are less likely to adopt.

Excluding those who do not have dry land, those who do not grow maize and those do not give complete information on the abovementioned variables results in a complete sample of 194 farming households. Table 1

Table 1. Variable definitions, means, and standard deviations

Variable	Explanation	Mean	Standard deviation
The tendency of adoption	1 for adopters and 0 for non-adopters	0.579	
The intensity of adoption	The ratio of hybrid maize to the total maize area for adopters	0.871	
DISTANCE	Distance from household to extension center measured in kilometers	6.711	5.815
EDU	The number of years in school	4.982	3.578
MEDIUM	1 if there is any kind of medium and 0 otherwise	0.537	0.501
CONTACT	1 if household has contact with technician and 0 otherwise	0.527	0.501
AGE	The household head's age	42.797	12.490
SIZE 1	*per capita* arable land, measured in *mu*	1.500	1.910
SIZE 2	Total dry land, measured in *mu*	3.317	2.711
SIZE 3	Total arable land, measured in *mu*	4.601	2.708
ASSET	Total assets measured in hundreds of *yuan*	64.659	77.289
CREDIT	Total indebtedness to official organizations, measured in *yuan*	384.207	634.420
DUM	1 if coming from Puding and 0 otherwise	0.489	

presents variable definitions, means, and standard deviations. Fifty-seven percent of the 194 farmers under the survey adopted hybrid maize. The hybrid maize represents about 87% of the total maize area for adopters, while the ratio of hybrid maize to the total maize area for all farmers is about 50%. The average distance from farmers' houses to the extension center is 6.7 km with a standard deviation of 5.8. About 50% of households have access to some forms of media and have contact with extension technicians. The average age of the household head is about 42. Per capita land is about 1.5 *mu*. The average dry land per farm is about 3.3 *mu* and the average arable land is about 4.6 *mu*. The average value of household assets is about 6,465 yuan and total indebtedness is about 384 yuan.

Following Lin [12], the same sets of explanatory variables are used in the first and second stage of the adoption. The resulting empirical specification of the double hurdle adoption model (1) is as follows :

$$\begin{aligned} A = {} & \alpha_{0A} + \alpha_{1A}Distance + \alpha_{2A}Medium \\ & + \alpha_{3A}Contact + \alpha_{4A}Education \\ & + \alpha_{5A}(Education)^2 + \alpha_{6A}Asset \\ & + \alpha_{7A}Credit + \alpha_{8A}Dryland + \alpha_{9A}Perland \\ & + \alpha_{10A}Age + \alpha_{11A}(Age)^2 + \alpha_{12A}Size \\ & + \sum_{i=13}^{18} \alpha_i DUM_i + \varepsilon_A \end{aligned} \quad (3)$$

where A is dependent variable that, in the first hurdle, has a value of one for the adopters and zero for non-adopters and, in the second hurdle, is the ratio of hybrid maize area to total area for the adopters.

4. Estimation and Empirical Results

The estimation of the double hurdle model as in equation (3) requires the joint use of the probit and the truncated regression models, which was estimated using maximum likelihood procedure of LIMDEP version 7.0 (Greene [9]). Several models with different specifications of the independent variables were analyzed. It was found that the models appeared to be rather unstable. Unstable model results were related to the inclusion of the variable DUM in the model. The variable DUM is closely correlated with the variables such as DISTANCE, CONTACT, and three measures of farm size. DUM is therefore dropped from the further analysis to avoid the potential multi-collinearity problem that makes the models unstable. A formal test was also carried out to see whether to reject the null hypothesis that the tobit estimation can be used to analyze the adoption of hybrid maize for the data under consideration. The null hypothesis is rejected at the .05 level of significance in all three estimates with different measures of farm size (Table 2). This result indicated that the tobit model imposes

Table 2. Chi-squared test results of tobit v.s. double hurdle specifications

	Chi-square	Critical value of Chi-square with df = 9 and $\alpha = 0.05$
Model with SIZE 1	129.43	
Model with SIZE 2	129.99	19.68
Model with SIZE 3	129.47	

invalid restrictions on the decision of how much to adopt and provides strong evidence of two separate but related adoption decisions. As such the farmers' adoption behavior for hybrid maize should based on the double hurdle model that treats the decision to adopt and the decision of how much to adopt as different processes. The empirical results of the probit and the truncated regression models under three measures of farm size are presented in Table 3. All three models perform well in terms of the percentage of correct prediction, which is about 70%.

The estimation results are robust across three measures of farm size. In the probit estimation (the tendency of adoption), coefficients of the two information variables, MEDIUM and CONTACT, are positively significant at the 5% level, while the coefficient of the variable AGE, is negatively significant at the 10% level. The tendency of adoption would increase if farmers are exposed to more media and have more contact with the technicians. The tendency of adoption would decrease if farmers were older. In the truncated regression results (the intensity of adoption), only the coefficient of one information variable, CONTACT, is statistically significant. Exposure to more media and closeness to an extension center are not significant factors in determining the intensity of adoption. The results are intuitive as farmers will normally have more practical questions related with new technology when adoption is realized. More frequent extension visits would help to prevent farmers from quitting new technology, and to become stable new technology users. The coefficient of AGE remains negative and significant. The young farmers are likely to allocate more areas to hybrid maize. The above results indicate the importance of farmers' access to information on the adoption of hybrid maize in poor areas. In particular, the access to information has different impacts on the decision to adopt and the decision of how much to adopt.

Coefficients of another information variable, DISTANCE, have negative signs as expected but are not significant in either the probit or truncated models. In other words, the distance from the extension center would not increase or decrease the tendency or intensity of adoption in the studied region. A possible explanation is that the opportunity cost of farmers' time in these two regions may be very low, if not close to zero. None of coefficients of SIZE are statistically significant in either the probit on truncated models. This result does not lend support to the previous empirical results in which larger farmers tend to adopt a new technology more readily. A possible explanation is that the farm size is usually proportional to the number of family members in rural areas because of the institutional arrangements. As such the measures of farm size may not be considered as a determining factor in the adoption of new technology. Coefficient of CREDIT is insignificant, which indicates that the availability and access to credit are unlikely to influence adoption in the studied regions.

Moreover, unlike the findings in Lin [12] and Huang and Rozelle [11] on the adoption of hybrid rice in south-east China, neither income nor education is a significant factor in determining either the tendency or intensity of adoption of hybrid maize. One possible explanation may be the differing research areas. Data in Lin [12] and Huang and Rozelle [11] were collected in China's most wealthy provinces, such as Jiangsu, Fujian and Guangdong Provinces. Yet, in the poor counties surveyed in this study the majority of income is used for surviving rather than investing.

5. Concluding Comments

This paper has focused on the role of farmers' access to information in a farm household's decisions of whether or not to adopt hybrid maize and the amount to adopt using data collected in a poor region of China. The paper demonstrates the importance of model-

Table 3. The double hurdle estimates for adoption of hybrid maize (standard error is in bracket)

Variable	SIZE 1		SIZE 2		SIZE 3	
	The probit	The truncated regression	The probit	The truncated regression	The probit	The truncated regression
Constant	.4581 (.5565)	1.0539** (0.1309)	.4581 (.5565)	1.0041** (0.1319)	.4071 (.5541)	1.0383** (0.1345)
MEDIUM	0.4937** (.2146)	−.0483 (.0506)	0.4792** (.2171)	−.0513 (.0510)	0.4877** (.2170)	−.0491 (.0516)
CONTACT	0.6702** (.2104)	0.0957* (.0522)	0.5543** (.2107)	0.0857* (.0520)	0.5876** (.2087)	0.0937* (.0524)
DISTANCE	−.0246 (.0185)	−.0047 (.0048)	−.0286 (.0199)	−.0066 (.0052)	−.0218 (.0187)	−.0037 (.0049)
AGE	−0.0175* (.0090)	−0.0042* (.0022)	−0.0147* (.0091)	−0.0037* (.0022)	−0.0152* (.0091)	−0.0040* (.0022)
EDU	−.0170 (.0334)	−0.0079 (.0076)	−.0105 (.0332)	−0.0092 (.0076)	−.0111 (.0332)	−0.0091 (.0077)
SIZE 1	0.0272 (.0518)	0.0009 (.0112)				
SIZE 2			0.0398 (.0392)	0.0150 (.0099)		
SIZE 3					−0.0016 (.0372)	0.0004 (.0097)
ASSET	0.0009 (.0016)	0.0003 (.0003)	0.0006 (.0016)	0.0002 (.0003)	0.0009 (.0016)	0.0004 (.0003)
CREDIT	.0002 (.0002)	.0000 (.0000)	.0002 (.0002)	.0000 (.0000)	.0002 (.0002)	.0000 (.0000)
Log-likelihood function	−111.1131	3.0526	−108.7124	3.07256	−109.2245	1.9500
% of Correct prediction	69%		70%		69%	
Number of observations	194	111	194	111	194	111

*Level of significance at 90% and ** level of significance at 95%.

ing the adoption of maize in poor areas as a two-stage process. As such the double hurdle adoption model was developed in which explanatory variables are allowed to affect the decision to adopt and the decision of how much to adopt differently. The model was tested with data collected from a sample of 194 households from two of the poorest counties in China, Puding County in the province of Guizhou and Luquan County in the province of Yunan. The empirical results suggest that increased availability of media and more frequent extension visits would lead more farmers to adopt the hybrid maize. Once adoption is realized, frequent extension visits will be vital to influence farmers to allocate more of their maize area to hybrid maize. The paper also demonstrates the adoption of new technology in poor areas may well be different from that in rich areas. This calls for more research on the adoption of new technology in the poor areas of China in the future.

The findings also have important policy

implications. The evidence in the paper indicates that increasing state investment in better access to information for poor farmers is effective to achieve and accelerate adoption of hybrid maize in the poor areas. Compared with a national average adoption rate of 86%, only 57% of farmers have adopted hybrid maize in these two poor counties. This appears to suggest that, to speed up diffusion of hybrid maize in these two poor counties, more attention needs to be paid to increasing farmers' access to media and extension services. China's large scale 'WenBao' project initiated in the early 1980s is in the right direction to promote the adoption of new technology through providing more extension services and increasing farmers' access to information. However, the efforts were apparently not sufficient to bring the adoption rate up to the national average level. It would be interesting to examine the actual diffusion process of hybrid maize after 1994 in the regions. Unfortunately, this information is not readily available.

1) In China a county is classified as either a provincial or national level poverty area, depending on the county's annual per capita income. In 1994, if the county' annual per capita income was less than 440 yuan, it was classified as a national level poverty area.

2) Hybrid maize can increase yield by 25% (Liu [14]).

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