Determinants of Adoption Decision of Hybrid Paddy in Rangpur District of Bangladesh: An Econometric Analysis

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Abstract

The study aims at investigating the determinants of farm-level adoption pattern of hybrid rice varieties. Empirical data were collected from 200 farmers via questionnaires. Among the respondent farmers, the majority (56.50%) have adopted hybrid rice variety. In this paper a Logistic Regression Model is employed to explain the contribution of the determinants of HYRV adoption decision in Bangladesh. The effects of variables on the adoption decision are determined within the model. Results from our final model indicate that variables- age, education level, experience, training, farm size, family income, fertilizer cost and extension service are significantly associated with the decision of the farmers to adopt hybrid rice variety. Findings show that education level, experience, training, farm size, extension service have positive effect and age, fertilizer cost and family income have negative effect on adoption rate. Hybrid paddy increases the productivity of agriculture sector and meets-up the additional demand for rice. So, the government and non-government organization should come forward to provide agriculture extension services and training to the farmer.

Introduction

Bangladesh is an agriculture dependent country in South Asia with a population of around 150 millions. The major source of livelihood of the people of Bangladesh is agriculture. It employs nearly 60% of labour force and contributes one third of gross national product of the country. Rice is the principle crop of Bangladesh and staple food of the people. Rice production dominates the farming system of Bangladesh, accounting for 75% of gross cropped area (BBS, 2001). It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country. Rice sector contributes one-half of the agricultural GDP and

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one-sixth of the national income in Bangladesh. Almost all of the 13 million farm related families of the country grow rice. Rice is grown on about 10.5 million hectares which has remained almost stable over the past three decades. About 80% of the total irrigated area is cultivated for rice production. Thus, rice plays a vital role in the livelihood of the people of Bangladesh. Total rice production in Bangladesh was about 10.59 million tons in the year 1971 when the country's population was only about 70.9 millions. However, the country is now producing about 25.0 million tons rice to feed her 150 million people. This indicates that the growth of rice production was much faster than the growth of population.

Table 1: Hybrid Rice Adoption Rate in Bangladesh by Division in 2011

Division	Adoption Rate (%)
Barisal	0.00
Chittagong	6.02
Dhaka	5.35
Khulna	9.74
Rajshahi	16.08
Rangpur	15.34
Sylhet	5.62

Source: IFPRI (2012).

This increase in rice production has been possible largely due to the adoption of hybrid and modern rice varieties on around 66% of the rice land which contributes to about 73% of the country's total rice production. Adoption of hybrid rice varieties is higher in Rajshahi and Rangpur divisions. Hybrid rice adoption rate is shown division-wise in Table-1 above. However, there is no reason to be satisfied. The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020 (MoA & BRRI, 2012). During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased from the present 2.74 tonnes/ha to 3.74 tonnes/ha (MoA & BRRI, 2012).

Rapid population growth, increased food demand, and urbanization are the main reasons which have created tremendous pressure on agricultural land, making it an increasingly scarce resource. As a result agricultural land per capita is decreasing over the years in Bangladesh. Food security, therefore, remained as an important concern since the independence of Bangladesh. The government of Bangladesh imports a large amount of rice from abroad every year to meet up the domestic demand. Research and development (R&D) and crop management with adoption of hybrid variety of rice is the logical way to raise the gross production of food using the limited land resources. In Bangladesh introduction of using modern high-yielding varieties (HYV) of rice date backs from 1968, but the rate of adoption remained low until 1975-76. The major sources of growth of food grain production in the 1970s were the expansion of crop area and increased yield of wheat. Rapid distribution of rice HYVs took place only after mid-1980s with the liberalization of policies regarding the procurement and distribution of agricultural inputs, and reduction of import duties on agricultural equipment (Hossain and Akash, 1994).

The potential and optimal yield of hybrid paddy depends on the inputs usages during paddy production and requires suitable production environments and proper knowledge of inputs application like amount of fertilizers, pesticides and irrigation. As most of the farmers of Bangladesh are illiterate and poor, they are not able to follow the input using techniques and timing of input use for paddy production. As a result farmers do not get optimal amount of production from adoption of hybrid variety. Since the ending of the 1960s, Bangladesh has pursued a policy of rapid technological progress in agriculture, leading to the diffusion of a rice-based Green-Revolution technology package. As a result, farmers have concentrated on producing hybrid varieties of rice all year round covering three production seasons- namely, Aus(pre-monsoon), Aman (monsoon) and Boro (dry winter) particularly in areas that are endowed with supplemental irrigation facilities. Several studies were conducted on the household income, labor demand, per unit yield, institutional change of land tenure system, land degradation, and other socio economic constraints of hybrid variety paddy farming in Bangladesh in last three decades. However, study on the determinants of adoption decision of hybrid variety paddy production is quite in sufficient in Bangladesh. Therefore, a comprehensive study is required

to see the influences of various determinants of adoption decision of hybrid varieties in paddy production of Bangladesh. The objective of this study is to explore and estimate the determinants of adoption decision of hybrid varieties in paddy production in Rangpur district of Bangladesh and to draw the implication of the results and findings and also to draw the forward policy suggestions.

Literature Review

Extended studies have been done on different aspects and issues of hybrid paddy. Some literatures are synthesized in the following sections.

Barmon et. al (2009) found that potential yield of hybrid paddy is comparatively higher than modern variety of paddy that mainly influences the farmers to adopt hybrid paddy. Education of the farmers, family size, land ownership and lack of proper information of hybrid production has significant impact on adaption decision of hybrid paddy in Chanchara village of Jessore District. Hossain et. al. (2001) studied the adoption pattern, differential performances, relative profitability and constraints to adoption of two hybrid rice varieties-Alok-6201 and Sonar Bangla (CNSGC 6) introduced during 1999 Boro season in Bangladesh. Findings showed that farm size had negative but education had positive effect on adoption rate. Grain yield of hybrids were 14% higher than that of HYVs though Sonar Bangla did much better than Alok-6201. Input costs of hybrids were 23% higher. Profitability of Sonar Bangla was higher but that of Alok 6201-was lower than that of HYVs. Constraints to hybrid rice adoption included external dependence and higher seed cost, better management skill, input intensity, higher incidence of pests and diseases, inadequate yield gain and lower head-rice recovery.

Vien and Nga (2009) analyzed the adoption decision of hybrid rice production in the red river delta area of China. The study used Logit model to estimate the effect of determinants of adaption decision of hybrid paddy. The estimated result found that chemical fertilizer was generally used more on Chinese hybrid rice and this rice had the highest yield. The study also found that there were a number of factors which determined the adaption decision of hybrid rice by farmers. They include the level of experience and education of household heads, the socio-economic condition of the farmers, the number of labors in a household, the time of the year and the amount of hybrid rice yields. Hybrid rice seemed to be concentrated in households

who had less experience, education and socio-economic condition classified as poor. Li, Xin, and Yuan (2010) found that hybrid rice cultivation were more than half of all area under rice cultivation in China. It has contributed significantly to increasing national rice yields and output. These contributions have, in turn, contributed to improve food security by feeding an estimated 60 million additional people per year in China. Hybrid rice in China is heralded by many as one of the nations' great agricultural successes. Janaiah and Hossain, (2003) showed that that hybrid rice adoption is moving slowly in Asia, particularly in South Asia, where the overall growth in rice yields has been slow in recent decades. A range of technical challenges, market failures, and policy constraints have limited the development.

Methodology

Selection of the Study Area and Data Collection

Five Upazilas of Rangpur District were selected for the present study. The selected Upazilas are Rangpur Sadar, Gangachara, Badarganj, Kaunia, and Pirgachha. Then from each Upazila, five Unions were selected taking one from each Upazila. After selecting the unions, two villages were selected from each union and thus ten villages were selected for the analysis. In the next, list of farmers was collected from the union office and 200 farmers were selected randomly. The empirical data were collected by personal interviews conducted with the respondent. The authors and five trained data collectors conducted the interviews. The population analyzed in this study consisted of farmers from the ten villages who grew rice, wheat etc.

Table 2: Selected Upazilas, Unions and Villages

Upazilas	Unions	Sample	Villages	Sample
Rangpur Sadar	Uttam	40	Hazipara	20
			Kutialpara	20
Badarganj	Damadurpur	40	Shapur	20
			sterpara	20
Gangachara	Gangachara,	40	Nobonidus	20
			Gutaka	20
Kaunia	Balapara	40	Balapara	20
			Vutsara	20
Pirgachha	Parul	40	Shaorifsundor	20
			Chakla	20
Total = 5	5	200	10	200

Conceptual Model: The Logistic Regression Model

Previous empirical and theoretical research indicated that the logistic curve or the S-shaped diffusion path characterizes fairly well the adoption pattern of new agricultural technologies [Griliches (1957), Feder and O'Mara (1982), Jarvis (1982) and Rogers (1983)]. According to the hypothesis, when new technology is introduced firstly diffusion is slow. Through the process of "demonstration effects"generated by the early adopters (the most progressive), diffusion increases rapidly as information and experience spreads to other producers. Eventually, after all of the potential adopters have been exposed to and adopted the new technology, a long-run equilibrium is reached. The logistic function traces out this path and defines the rate of adoption and the long-run equilibrium.

Logistic regression analysis is a unit/multivariate technique which allows for estimating the probability that an event occurs or not, by predicting a binary dependent outcome from a set of dependent variable. A Logit model was used to estimate the effects of various quantitative and qualitative factors on the adoption decision of modern variety of paddy production in Rangpur District. When the dependent variable is binary, the linear probability model (LPM), Logit and Probit model can be used (Ramnathan 1998; Green 2000). Logit and Probit model are quite comparable; however the logistic has slightly flatter tails. Thus the choice between the two is one of the conveniences and ready availability of computer programs. On this score, the Logit model is usually used in preference to the probit (Gujirati 1995). However, Logit model have been widely used in order to explore the factors affecting farmers' decision in adoption studies (Jarvis, 1981; Feder and O'Mara 1992; Rogers, 1983; Adsena et al., 2000; and Vanderveer, 2001).

The Linear Probability Model can be written as

$$Pi = E(Y=1/ Xi) = \beta 1 + \beta 2\ Xi$$

Where, Xi is the independent variables and Y=1 means that the farmers adopt hybrid variety of rice. Let us consider the following representation of the adoption decision of the farmer.

$$P_1 = E(Y = \frac{1}{X_1}) = \frac{1}{1 + exp^{-(\beta_1 + \beta_2 X_1)}} = \frac{1}{1 + exp^{(-Z_1)}} \quad .....(1)$$

Where,

$Zi = \beta 1 + \beta 2\ Xi$

This equation (1) is known as the (cumulative) logistic distribution function. Here Zi ranges from $-\infty$ to $+\infty$; Pi ranges between 0 and 1; Pi is non-linearly related to Zi (i.e. Xi), thus satisfying the two conditions required for a probability model. In satisfying this requirement, an estimation problem has been created because Pi is non-linear not only in Xi but also in the β's. This means that one can't use OLS procedure to estimate the parameters.

Here Pi is the probability of adopting hybrid variety of rice and is given by

$$P_1 = \frac{1}{1 + exp^{(-Z_1)}}$$

Then (1-Pi), the probability of not adopting hybrid variety, is

$$1 - P_1 = \frac{1}{1 + exp^{(-Z_1)}}$$

Therefore, it can be written,

$$= \frac{1 + exp^{(Z_1)}}{1 + exp^{(-Z_1)}} \quad .....(2)$$

Where, $\frac{P}{1 - P_1}$ is the odds ratio in favor of adopting a modern rice variety i.e. the ratio of the probability that a farmer will adopt modern variety to the probability that he will not adopt a modern variety.

To find an appropriate adoption curve, it is natural to start with our earlier logistic function and modify it. Taking natural log the logistic function (2) can be written as

$Li = \ln [Pi / 1-Pi\ ] = \beta 1 + \beta 2\ Xi$ .....(3)

That is, the log of the odds ratio is not only linear in Xi but also linear in the parameters. L is called the Logit.

Empirical Model

The empirical relationship between dependent variable and a set of explanatory variables on the adoption of hybrid variety of paddy is specified using the following relationship

$$Li = \ln [Pi /1-Pi] = \beta 1 + \beta 2\ AGE + \beta 3\ EXP + \beta 4\ EXT + \beta 5\ FEC + \beta 6\ EDU + \beta 7\ FAS + \beta 8 TFI + \beta 9\ TFM + \beta 10\ TRA + ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, the dependent variable L is the log odds ratio in favor of adopting hybrid rice variety. AGE = age of the farmer, EXP = experience of the farmer, EXT = agriculture extension service, FEC = Fertilizer and chemical cost, EDU = education level of farmer, FAS = farm size, TFI =total family income, TFM = total family member, TRA = training of the farmer

$\beta 1$ is constant, $\beta 2$, $\beta 3$,..... $\beta 10$ .are regression coefficients and ui is the random error which is normally distributed. The coefficients of the regression model were estimated by applying the maximum likelihood estimation (MLE) technique.

Measurement of Dependent and Explanatory Variables

The dependent variable was dichotomized with a value of 1 if the farmer was an adopter of hybrid paddy and 0 otherwise. The explanatory variables were the age, education level, experience, training, extension service, farm size, fertilizer cost, total family income, and total family member. Table 3 lists definitions of the variables and measurement methods.

Table 3: Description of the Variables Used in the Logit Model

Variable	Type	Measurement
Dependent variable (Yi)	Dummy	1 if farmer has adopt modern variety, 0 otherwise
Age of household head	Continuous	Age of the household head (years)
Education of house-hold head	Continuous	Formal education of the household head (years of schooling)
Farming experience of household head	Continuous	Farming experience of household head (years)

Variable	Type	Measurement
Farm size	Continuous	Amount of land under cultivation (decimal)
Household income	Continuous	Amount of money earned by the family members in a year (000 BDT)
Extension services	Dummy	1 if farmer receive agriculture extension services, 0 otherwise
Training	Dummy	1 if farmer get training , 0 otherwise
Fertilizer cost	Continuous	Total fertilizer cost (tk.)
Total family member	Continuous	Total number of persons in the family

Result and Discussion

Descriptive Statistics of the Variables

The characteristics of respondent farmers are listed in Table 4. The average age of the farmers was 44.21 years whereas the average education was 6.62 years of schooling and average farming experience was around 23.38 years. The average farm size was small was 145.93 decimal. There was an average of 6.075 members in each household.

Table 4: Descriptive Statistics of Explanatory Variables by Adopter and Non-adopter Groups

Variable (units)	Mean			SD (all farmers)
	All farmers (200)	Adopters (113)	Non- adopters (97)	
Age of farmers (yrs)	44.21	44.73	43.53	12.79
Education of household head(yrs)	6.62	6.27	7.06	4.68
Family member	6.08	6.32	5.76	2.81
Farming experience of household head(yrs)	23.38	23.70	22.97	12.37
Extension services	0.44	0.53	0.32	0.50
Farm size (decimal)	145.93	167.23	118.28	183.05
Household income (000 BDT/yrs)	61219.75	69897.79	49948.28	65454.86
Fertilizer cost (tk.)	3284.57	3194.15	3402.02	4551.54
Training of the farmer	0.33	0.37	0.28	0.47

Source: Authors' own calculation

It is also found from the table that average household income was around 61219 BDT (Bangladeshi currency). The average household's access to agriculture extension service was 0.44 and average training of the respondent farmers was 0.33. There are significant differences between adopter and non-adopter farmers of hybrid paddy farming in terms of all socio-economic factors.

Regression Result of Hybrid Farming Adaption

An important purpose of this study was to explore the important factors that influence farmers' decisions to adopt hybrid farming. To this end, we performed Logistic regression analysis (Table 5). The obtained log likelihood ratio is 49.37 and chi-square statistic for the goodness of fit of the model is 168.03, significant at the 1% level. The pseudo R2 value of the model is 0.59. Thus, the overall model is significant and the explanatory variables used in the model are collectively able to explain the farmers' decisions regarding the adoption of hybrid farming. It is appeared from Table 5 that all the coefficients of the variables in the Logit model are statistically significant except farmers' total family member (TFM) for adoption of hybrid paddy in Rangpur District of Bangladesh.

The age of a farmer can be either generate or erode confidence in crop production. It is also evident that a farmer with more experience can become more or less risk averse when taking decision regarding input use in hybrid paddy production. Some studies found that younger farmers are more informative about farm production and they easily bear production risk (Kebede et al., 1990; Polson and Spencer, 1991). The contradictory results were also found (Adesina and Baidu-Forson, 1995). Thus, the expected sign on farmer's age and experience may positive or negative in the empirical model. The coefficient of farmers' age has negative impact on adaption decision and the coefficient of farmers' experience has positive impact on adoption decision. The coefficient of age (-0.1354) and experience (0.3387) reflects that farmers with higher age are less likely to adopt hybrid rice and farmer with higher experience are more likely to adopt hybrid paddy compared with those with a low experience. Agriculture extension service is another important factor in terms of adoption decisions. The regression result shows that higher extension service influences the farmers to adopt hybrid variety.

Table 5: Logit Regression Results of Hybrid Farming Adaption

Variable	Coefficient	z-statistic	Prob.
C	-0.8986**	-1.98568	0.0471
AGE	-0.1354*	-1.954361	0.0507
EXP	0.3387**	2.213068	0.0269
EXT	0.2864***	2.672466	0.0075
FEC	-0.1215**	-1.986233	0.0470
EDU	0.2357***	-2.594377	0.0095
FAS	0.1565**	1.998408	0.0457
TFI	-0.1666**	1.976204	0.0481
TFM	0.2809	1.457265	0.1450
TRA	0.1280**	2.376466	0.0175
	X2 statistic with 14df 168.03(p < 0.000)	Pseudo R2 0.59 ratio 49.37	Log likelihood

Source: Authors' own calculation. Note. * Significant at 1% level; ** Significant at 5% level; * Significant at 10% level**

Education increases farmer's ability and knowledge for crop production. An educated farmer is more informative and bears all types of production risk. The coefficient of education (0.2357) has significant positive impact on adoption decision of cultivating hybrid paddy indicating that comparatively educated farmers are more likely to adopt hybrid paddy. Training of the farmer increases their knowledge about cultivation. The coefficient of training of farmer (0.1280) indicating that trained farmers are more likely to cultivate hybrid paddy. Large families are able to provide the necessary labor for timely land preparation, weeding, and harvest. Moreover, large family needs more rice to feed the family members. Therefore, they adopt more hybrid paddy. The coefficient total family member (0.2809) has positive impact on adoption decision but it is not statistically significant. The coefficient of farm size is statistical significant in the logit model for adaption decision

of hybrid paddy in Rangpur District of Bangladesh. The coefficient of farm size (0.1565) indicates that the owner of the large farm is more likely to adopt hybrid paddy. But the sign of fertilizer and chemical cost and family income are negative. Therefore they have negative effect on the adoption decision.

Conclusion and Recommendations

Hybrid paddy has significant impact on productivity. It is a high yielding variety and hence hybrid farming lead to improved income of the farmers and it increased the supply of food. Therefore, it is essential to make farmers aware of the benefits of hybrid farming via extensive education campaigns. Both public and NGO extension services are important in terms of farmers' decisions regarding the adoption of hybrid paddy farming. Hybrid paddy increases the productivity of agriculture sector and meet-up the additional demand for rice. So, to rapidly increase the rate of adoption of hybrid paddy farming in Bangladesh, government and non-government organizations should come forward to provide agriculture extension services and training to the farmers.

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