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RICE AND RISK: ECONOMETRIC ESTIMATION OF PRODUCERS' RISK ATTITUDES IN FLOOD PRONE ENVIRONMENT OF BANGLADESH

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ABSTRACT

Present study developed a methodology to estimate risk attitudes of the producers operating under production risk. It analyzed risk aversion coefficients of the rice producers in flood prone environment of Bangladesh through econometric estimation of risk attitude distribution parameters incorporating the effect of subjective adjustment of human capital in the model. For this purpose, Generalized Method of Moment approximation of profit function was used to account for the stochastic technology with no restriction on preference structure. The results show that the population is characterized by Arrow-Pratt and downside risk aversion. The farmers were found to be moderately risk averse as indicated by smaller values of Arrow-Pratt risk aversion coefficients and relative risk premium.

1. INTRODUCTION

Risk is considered to be an important issue in crop production. There is a growing body of literature of applied research that focuses on producers' responses to environmental risk (Pratt 1964. Wiens 1976, Roumasset 1977, Roe and Nygard 1980, Smith 1985, Pope 1982. Just and Pope 1979, Binswanger and Siller 1983, Antle 1987, Pope and Just 1991, and Teague *et al* 1995). The farmers are usually facing different kinds of risk in crop production. They face production risk because natural phenomena occurring over time are detrimental to crop yield. They also facing economic risk because of market fluctuations.

The methodologies so far used to measure the risk attitudes of agricultural producers can be classified into three general categories- i) experimental approaches, ii) risk programming models and iii) econometric methods. In earlier works, the experimental approach developed by psychologists was used to directly illicit risk taking preferences through simulated .hypothetical gambling (Binswanger 1980, Siller 1980 and Grisley and Kellogg 1983). The experimental method has drawbacks in that the risks involved in hypothetical or experimental decisions do not necessarily correspond to the actual production decisions faced by the

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farmers. A risk programming model based on mean-variance is used for simulating producers' responses to risk (Hazel 1982). Modeling actual operators' behavior seemed to be difficult because of the need to specify the production structure, distribution of risk and farmers' risk preferences. The econometric method is attractive in that the risk attitudes estimates based on observations of farmers' actual production decisions correspond to the nature and degree of risk they actually face. However, there is a necessity for developing and testing a comprehensive model. A few studies estimated producers' risk aversion coefficients using utility function (Szpiro 1986, Antle 1987, Love and Buccola 1991 and Shaha *et al* 1994). In Antle and Love and Buccola's models the coefficients of risk aversion are estimated conditional upon a specific risk preference structure implied by the assumed form of the utility function. Chavas and Holt (1993) used structural form approach that allows data to reveal only the degree of risk aversion and not it's structure- the later was imposed by the functional form of the utility function. Shaha *et al* (1994) estimated degree of risk aversion through joint estimation of risk preference structure and technology using expo-power utility function. So, far none of the study dealt with the effect of subjective adjustment of human capital on risk aversion measures. To develop a behavioral model in an uncertain environment, it is necessary to reflect the farmers' perception about the random event they face. It was found that, the farmers' stock of information expands through experience and training, with the rise in his human capital stock, his errors in subjective probabilities declined and his input use moved toward the optimal level with perfect information (Crawford 1973, Huffman 1974, and Pingali and Carlson 1985). Roe and Nygard (1980) investigated the errors in input allocation of Tunisian wheat farmers by comparing the physical production functions with the farmers' perception of the same production functions at planting time. They determined that errors in input allocation decreased with the increase in years of experience in growing high yielding variety wheat. Several researchers have tried to relate socioeconomic characteristics to the degree of risk aversion (Dilllon and Scandizzo 1978, and Binswanger 1980). The purpose of this paper is to analyze producers' risk attitudes using a generalized method of moment approximation of profit function and incorporating the effect of subjective adjustment of human capital. The empirical model was applied to measure risk attitudes of rice producers in flood prone risky production environment in Bangladesh.

2. THE RISK ATTITUDES ESTIMATION MODEL

In order to simplify our model specification the underlying assumption is that the rice producers are facing a single period maximization problem based on the information available before production begins and is facing production risk from an uncertain environment. The economic output of the farm is rice yield in a season.

Following Antle (1987) the stochastic technology can be approximated by the probability distribution of output or by the corresponding distribution of profit. The profit of the jth farmer can be defined as return to fixed factor as:

$$\pi_j = P_jY_j - W_jX_j \qquad (1)$$

where π represent profit, j stands for number of farm, Y is a vector of output, X is a vector of input, P and W are vectors of output and input prices, respectively.

Defining Z_j as fixed factor-input vector, the conditional distribution of profit can be expressed as:

$$F(\pi|x_j, Z_j, \alpha_j), j = 1,2,....,N \qquad (2)$$

where α represents the parameter vector. Following Arrow-Pratt, risk attitudes are defined in this study in terms of the derivatives of the utility function. The jth farmer's utility function is specified as:

$$U_j = U(\pi_j, \Omega_j) \qquad (3)$$

where Ω_j represents the jth farmer's risk attitude parameters vector. Following the results of Pratt (1964), Ω_j can be interpreted as measuring Arrow-Pratt and downside risk aversion:

$$U(\pi_j, \Omega_j) = e^c \int \exp\{ \int (DS_j - AP^2_j)\}$$

where c is a constant of integration; $AP_j = -U_j^2/U_j^1$, U_j^i is the ith derivatives of U with respect to π_j and $DS_j = U_j^3/Uj^1$. AP represents the Arrow-Pratt measure of absolute risk aversion and DS is a measure of downside risk aversion (Menzes *et al* 1980). From (1) and (2), the expected utility of the jth farmer can be expressed as:

$$EU_j = \int U(\pi_j, \Omega_j)\, dF(\pi_j | X_j, Z_j, \Omega_j, \alpha) \qquad (4)$$
$$\equiv \phi(X_j, Z_j, \Omega_j, \alpha)$$

.Assuming U is globally concave in X_j and has a unique interior solution, the first order condition for maximizing the value function will give the optimal variable input quantities as:

$$\delta U(X_j, Z_j, \Omega_j, \alpha)/\delta X_j = \varphi(X_j, Z_j, \Omega_j, \alpha) = 0 \qquad (5)$$

Now interpreting Ω_j as a random variable in the population, X_j is also random variable because it depends on Ω_j . Similarly, the firm's vector of fixed input can be viewed as distributed in the population of producers and may be correlated with Ω_j. We can define the joint distribution of X_j, Z_j, and Ω_j in the population as:

$$G(X_j, Z_j, \Omega_j|X, Z, \theta) \qquad (6)$$

where X and Z are the mean input vectors in the population and θ is the parameter vector. Using equations (5) and (6), the population mean of the implicit factor demand equation can be expressed as:

$$\int \delta(X, Z, \Omega, \alpha)\, dG(X, Z, \Omega | X, Z, \theta) \equiv \delta(X, Z, \theta, \alpha) = 0 \qquad (7)$$

Replacing X and Z in (7) with their observed values gives $\delta(X_j, Z_j, \theta, \alpha)$ and general

$$\delta(X_j, Z_j, \theta, \alpha) \equiv E\ \delta(X_j, Z_j, \theta, \alpha) \neq 0 \qquad (8)$$

Defining the function δ^* such that

$$\delta^*(X_j, Z_j, X, Z, \theta, \alpha) = \delta(X_j, Z_j, \theta, \alpha) - \delta(X, Z, \theta, \alpha) = e_j \quad (9)$$

where e_j is a random variable with zero expectation. Equation (9) can be interpreted as the first order condition for expected utility maximization defined in terms of population parameter vector θ. Defining the econometric model as the system of equations (2) and (9), the problem is to identify the parameter α and θ.

The empirical model has been developed on the basis of approximation of the stochastic technology and utility function following a four step procedure- (i) approximation of the profit distribution in terms of its moments, (ii) derivation of the first order conditions from expected utility maximization, (iii) imposition of a statistical structure on the risk attitudes of the producers' population, (iv) derivation of the Generalized Method of Moment (GMM) estimator based on the statistical structure of first order conditions.

The assumption of the moment based model is same as in Antle (1987). To outline the procedure suppose that the technology can be represented in terms of the distribution of profit as:

$$\mu_{ij} = \mu_i(X_j, Z_j, \beta_i)$$

where μ_{ij} represents ith moment of profit (i = 1, 2,..,m and j = 1,2,..., n observations). Suppose that the k = 1, 2,..., n first order conditions for expected utility maximization can be expressed as:

$$D_{1jk} + D_{2jk}r_{2j} + \ldots\ldots + D_{mjk}r_{mj} = e_{ojk} \quad (10)$$

where $D_{1jk} = \delta\mu_{ij}/\delta X_{kj}$, r_{ij} represents the jth farmers risk attitudes in terms of the ith derivatives of expected utility function, $E(e_{ojk}) = \theta^0 1k$ and $E(e_{ojk} \cdot e_{ojk'}) = \theta^0_{kk}$, for $k = k'$, otherwise it is zero.

The error term e_{ojk} in the model account for the fact that the first order condition is approximate and to allow both systematic and random errors in maximization. If $\theta^0_{ik} \neq 0$, there is systematic deviation from kth first-order conditions; and if $\theta_{0kk} \neq 0$, there is random deviation from it. These errors are used to be distributed independently of the explanatory variables in the model. These deviations from first order conditions could be caused by mainly sub-optimal behavior of the farmer.

Let the distribution of the risk attitudes in the population be defined as:

$$r_{ij} = \theta_1^i + e_{ij}, \quad E(e_{ij}) = 0 \qquad (11)$$

$$E(e_{ij}.\ e_{gh}) = \theta_{igjh} \text{ for } j \neq h,$$
$$= \theta_{ig}, \text{ for } j = h$$

For θ_{igjh}, the first two subscript i, g = 1,2,....,m index the risk attitudes characteristics and j, h = 1,2,.....,N index the observation. Substituting (11) into (10) we get:

$$D_{1jk} + D_{2jk}\,\theta_1^{\,2} + \ldots + D_{mjk}\,\theta_1^{\,m} = W_{jk} \qquad (12)$$

$$\text{where } W_{jk} \approx e_{ojk} - D_{2jk}\,e_{2j} - \ldots - D_{mjk}\,e_{mj}$$

The left hand side of (12) represents the jth farmer's first order condition evaluated at the population mean risk attitude and w_{jk} represents the jth farmer's deviation from the population mean.

The parameter vector θ_1 in (12) can be identified and consistently estimated, following the GMM estimation technique (Antle, 1987). Let t_j be a vector of instruments satisfying the condition that $E(W_{jk}, t_j) = 0$ for all k and let T be a matrix of t_j. Defining D_1 as the stacked vector of D_{1k} and D_2 as the stacked matrix of D_{2k}, the instrumental variable estimator

$$\hat{\theta} = (T'D_2)^{-1}S'D_2 \qquad (13)$$

provide a consistent estimate of parameter vector, $\theta = [\theta_1^{\,i}]$. The two stage least square version of the instrumental variable estimator is obtained by defining

$$T = S(S'S)^{-1}S'D_2$$

where S is a matrix of exogenous variables uncorrelated with risk attitudes but correlated with D_2.

The other risk attitudes distribution parameters θ_{0kk}, θ_{22} and θ_{33} can be obtained by computing instrumental variable estimates of the equation

$$(U_{jk})^2 = \theta_{0kk} + \theta_{22}\,(D_{2kj})^2 + \theta_{33}(D_{3jk})^2 + 2\theta_{23}D_{2jk}D_{3jk} + V_j \qquad (14)$$

where U_{jk} is the residual from the instrumental variable estimate of θ_1 in equation (13) and V_j is an error term.

In above risk attitudes estimation model, the same profit (or revenue) distribution function and the same parameter vector applies to each farmers in the population because all farmers are assumed to produce with the same stochastic technology, to face the same price distribution, and to form rational expectation based on those prices and output distributions. However, Schultz (1975) has emphasized, farmers may not be in this kind of rational expectation equilibrium. When events such as rapid technological changes occur, farmers will acquire information at different rates as a function of their human capital endowment, thus all farms will not have the same subjective expectations. The existing evidence on this issue suggests that the assumption of rational expectation depend on the degree of equilibrium or disequilibrium experienced by farmers. Grisley and Kellogg (1983) found evidence that farmers subjective expectations were accurate estimations of objective distribution in a case of relative economic equilibrium, whereas, evidence from the study of Pingali and Carlson (1985) suggest that human capital plays an important role in the accuracy of subjective expectation in the presence of technological change. It follows that the assumption that all the farmers face the same profit distribution may have to be modified in the case where the population under the investigation is experiencing information disequilibrium. Pingali and Carlson (1985) found that the absolute error in the subjective probability estimates of a random event (for example,

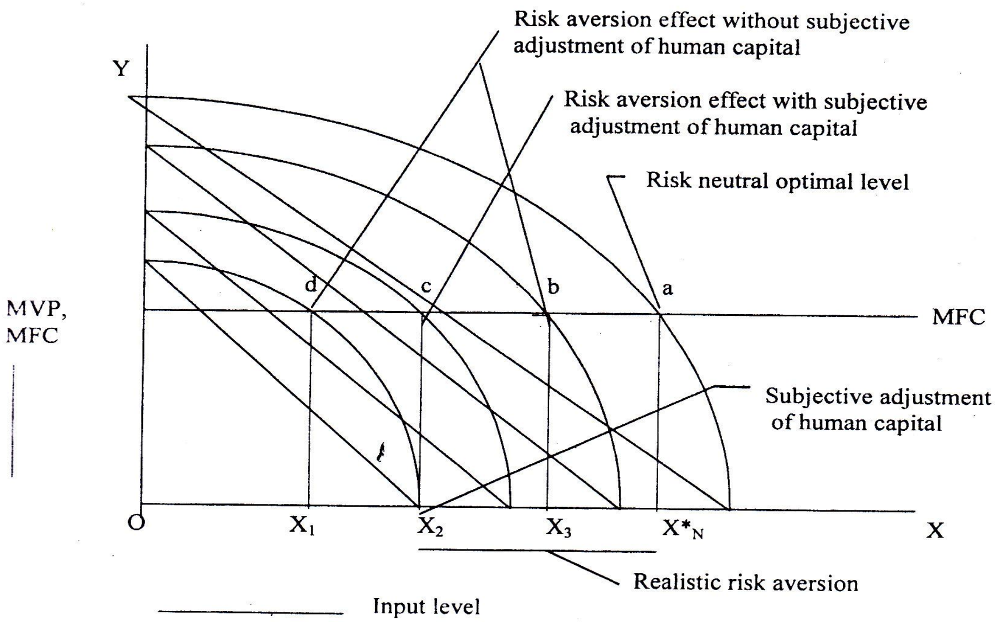

Figure 1: Effect of subjective adjustment of human capital on risk aversion.

pest damage) diminishes with a rise in the human capital stock of the farmers. With other things constant, absolute errors in the subjective probability estimates of pest damage have a positive effect on the demand for risk reducing inputs (for example, pesticides) and a negative effect on a demand for risk increasing inputs (for example, fertilizer and labor). Therefore, to construct input demand function under uncertainty, errors in probability assessment or alternatively human capital might be incorporated as an independent variable. The present study incorporated human capital component in revenue distribution function to adjust risk aversion effects to the realistic level as illustrated in Figure 1. It shows the effect of subjective adjustment of human capital of the rice producers on their risk aversion measures. In this figure, risk neutral farmer's optimal input level is X^*_N at the point a. However, if the farmers are risk averse, the model without incorporation of human capital would result either in an over estimation of risk aversion at point d with input level X_1 or an under estimation of risk aversion at point b with input level X_3. On the other hand, if the advantages associated with experience is to acquire and process information, the farm with more experience and education or alternatively with more human capital are more efficient in processing information and making decision regarding input use. So, incorporation of human capital in the model will capture this effect and would provide realistic measure at point c with input level X_2.

Therefore, considering above empirical wisdom the moment of revenue function can be specified as quadratic functions of following forms:

$$\mu_i = \beta_0 + \beta_1 N + \beta_2 N^2 + \beta_3 LAB + \beta_4 LAB^2 + \beta_5 INS + \beta_6 HCAP + (\beta_7 N + \beta_8 LAB + \beta_9 INS)*HCAP \quad (15)$$

where μ_i represents ith moment of revenue from rice production (in local currency of Taka per hectare). N represents nitrogen applied (kg per hectare), LAB stands for labor used (man-day per hectare), INS is number of dose of insecticides applied and HCAP is index of human capital. The variables within the parenthesis are interaction term of respective input with human capital. Human capital was measured by giving weights on age and education of the farmers as in Huffman (1974). The coefficients of human capital with material inputs are included in the model to capture farmers' adjustment of actual input use to the optimal quantity. Considering the fact that allocative ability has a comparative advantage over "rule of thumb" decision-making procedures when it becomes necessary to learn and adjust to new technology. If the advantages associated with additional experience and education refers to differential ability to acquire and process information, the farmers with more experience and education presumably are more efficient at processing information and making decisions. Holding other things constant, the hypothesis is that the farmer with more experience and education adjusts faster to disequilibrium than the farmers with less experience and education.

Moreover, specification of revenue function in this form allows us to reflect the effect of human capital in the derived input demand functions that would adjust risk aversion to a realistic level. For instance, the input demand functions for nitrogen in risk neutral case can be derived as:

$$N = 1/2B_2 (B_1 - P_N^* + B_6 HCAP)$$

where P_N^* is normalized input price.

We can interpret the term r_{ij} in terms of Arrow-Pratt and downside risk aversion and relate measures of risk aversion behavior as in Antle (1987). The term r_{ij} are closely related to the

Arrow-Pratt risk aversion measures, $AP = -U^2/U^1$ and downside risk aversion measure, $DS = U^3/U^1$.Using $E(U_j^1)$ as a second order approximation to $U^1(\mu_1)$, it follows that $-2r_{2j} \approx AP_j$ and $6r_{3j} \approx DS_j$. So at the population mean, $-2\theta_1^2 \approx AP$ and $6\theta_1^3 \approx DS$. Thus $4\theta_{22}$ and $36\theta_{33}$ measure the variance of AP and DS in the population, while $-12\theta_{23}$ is their covariance.

The magnitude and range of risk attitudes in the population also can be interpreted in terms of the risk premium (p) by the estimates of AP and DS. The risk premium as a proportion of expected net returns, or the relative risk premium is approximately:

$$p/\mu_1 \approx \mu_2 AP/2\mu_1 - \mu_3 DS/6\mu_1$$

3. ESTIMATION PROCEDURE

The estimation procedure of risk attitudes parameters is illustrated in Figure 2. Several steps were followed for estimation. SAS software was used to estimate first three moments - based revenue

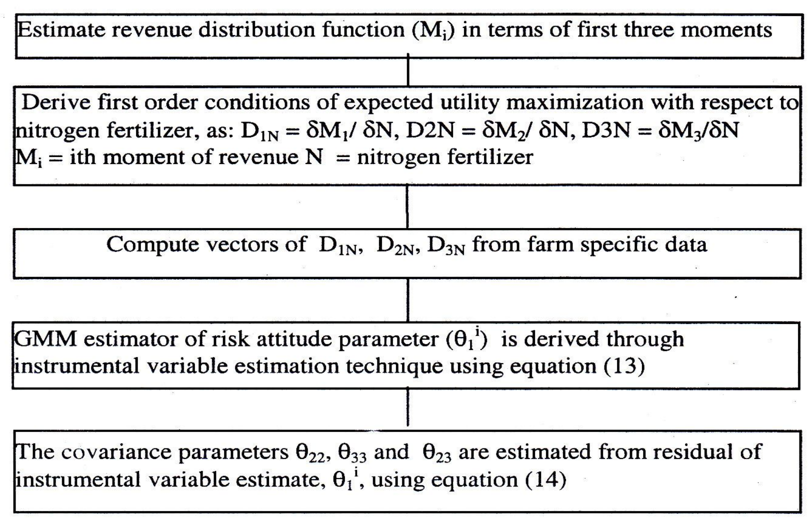

Figure2. Flow chart illustrating the estimation procedures of risk attitudes distribution paramerers.

distribution function. Then first order conditions of expected utility maximization with respect to nitrogen was derived from the first three moments of revenue distribution. The vectors of D_{1N}, D_{2N} and D_{3N} were computed from farm specific data in the third step. Then GMM estimators of risk attitudes parameters were derived through an instrumental variable estimation technique using equation (13).

4. SOURCES OF DATA

The study area consists of Kamalgange Thana selected from flood prone agro-ecological zone, which is representative of the vast area in the Northeast and eastern region of Bangladesh. The data represents rice production of individual farm fields in the flood prone environment for the production period 1991-1993. A total of 450 observations were used. This observation represents rainfed field cultivated by rice growing subset of the 78 farmers from flood prone environment selected using stratified random sampling technique.

5. RESULTS AND DISCUSSION

5.1. The Estimates of the Revenue Distribution Function

The parameter estimates of the quadratic revenue distribution moment function (equation 15) of modern variety (MV) rice in flood prone environment with subjective adjustment of human capital are presented in Table 1. These estimates were obtained by using the three stage-Generalized Method of Moment procedure in order to account for sequential decision-making in resource use. All three functions are statistically significant, as judged by the F-statistics. The coefficients of most of independent variables have zero standard errors, thus they were precisely estimated and are highly significant.

In order to interpret the parameter estimates with regard to the effect of input use on revenue distribution, it is important to compute the marginal effects of the input on each moment, which is the first derivative of moment equation with respect to the input being considered. Thus the elasticity of the moments with respect to input can be expressed as functions of parameters of the model. These elasticities are useful in interpreting the results and are presented in Table 2.

The coefficients of nitrogen, insecticide, labor, animal labor, human capital and season are significant in the estimated revenue distribution moments. All the variable inputs except season, have positive elasticities in the first moments. This implies that nitrogen, insecticides, labor, animal labor, and human capital are positively contributing to mean revenue.

Labor contributes the most in mean revenue followed by human capital, while nitrogen is the third contributor. It was hypothesized that human capital contributes positively in the revenue distribution by reducing errors in subjective probability estimates of random events and improving farmer's ability to use modern technology in a timely and effective manner, thus, adjusting farmers risks aversion effects to the realistic levels. One can see that this hypothesis could be accepted in flood prone environment at 1% level as the coefficient of human capital and its interaction with other inputs are significant in the first three moment equations. This is also evidenced in the results by the positive and negative coefficient of first and second moment of

Table 1. Estimated revenue distribution function of modern variety rice production with subjective adjustment of human capital of sample farms in flood prone environment of Bangladesh, 1991-93.

Parameters	Moments		
	1st	2nd	3rd
Constant	-55.526**	0.02	0.040
	(0)	(0.87)	(307.88)
Log nitrogen (N)	1.671**	0.017**	0.002**
	(0)	(0)	(0)
Log nitrogen^2	0.008**	.00002**	.0000001**
	(0)	(0)	(0)
Insecticide dosage (INS)	0.238*	0.005**	-0.001**
	(0)	(0)	(0)
Log labor (LB)	2.182**	0.012*	-0.029**
	(0)	(0)	(0)
Log labor^2	- 0.004**	.00005**	.000002**
	(0)	(0)	(0)
Log animal labor (ALB)	0.156**	0.010**	0.033**
	(0)	(0)	(0)
Log animal labor^2	0.005**	.00009**	-.000003**
	(0)	(0)	(0)
Human capital (HC)	0.440**	-0.003	0.001**
	(0)	(91.02)	(0)
Season	- 0.060**	0.012*	-0.010**
	(0)	(0)	(0)
Log (N x HC)	- 0.001**	0.007**	0.001**
	(0)	(0)	(0)
Log (INS x HC)	-0.0115**	0.002**	0.00001**
	(0)	(0)	(0)
Log (LB x HC)	0.001**	0.001**	0.0002**
	(0)	(0)	(0)
Log (ALB x HC)	0.0200*	0.001**	0.0003
	(0)	(0)	(4.62)
F-value	25320**	92*	49**

** t-value and F-value significant at 1% level

Figures in parentheses are standard errors of estimates

revenue with respect to human capital, respectively. The negative elasticities of second moment of revenue implies that human capital playing as risk reducing input by interacting with other inputs. On the other hand, nitrogen, labor and animal labor are risks increasing inputs in flood prone environments as evidenced by the positive sign in the second moment equation. However, insecticide was found to be risk neutral. The season dummy is negative in the first moment equation, which implies that flood could lower revenue.

Table 2. Mean elasticity of revenue distribution moments of modern variety rice in flood prone environment.

Parameters	Moments		
	1st	2nd	3rd
Nitrogen	0.146	0.003	0.210
Insecticide dosage	0.021	0	0.009
Labor	0.729	0.016	0.578
Animal labor	0.068	0.004	1.02
Human capital	0.241	-0.005	0.488
Season	-0.015	0.002	0.270

5.2. Estimates of the Risk Attitudes Distribution Parameters

The parameters of the risk attitudes distribution were estimated by the use of the econometric method involving instrumental variable approach. The instruments were specified as rice acreage, variety, season and output price. These variables are assumed to be exogenous to risk attitudes of the rice producers were estimated in flood prone environment with subjective adjustment of human capital.

The parameter estimates of the risk attitude distribution allowing subjective adjustment of human capital of the rice producers in flood prone environment is presented in Table 3. The parameter estimates of all the equations show systematic deviations from the first order condition at the population mean, as θ^0_{1N} is significantly different from zero, indicating evidence of random deviations from the first order conditions.

The remarkable finding regarding the behavior of risk attitudes distribution parameters was that the estimate of θ_1^2 is negative and the estimate θ_1^3 is positive, indicating that expected utility is decreasing in the variance and increasing in the third moment of the net returns. This finding implies that the population in flood prone risky environment is characterized by Arrow-Pratt and downside risk aversion. Furthermore, the estimates of the variance of parameters θ_{22} and θ_{33} are small and significant which implies that there is no evidence of highly heterogeneous risk attitudes of the producers in flood prone environment. This is also consistent with the results of Antle (1987).Our analysis showed that the behavior of risk attitudes parameters remained same when they were estimated without subjective estimates of human capital. Only the notable difference was that the magnitude of θ_1^2 and θ_1^3 differ in two estimation procedures of with and without subjective adjustment of human capital. The possible reason for such a variation is that inclusion of subjective adjustment of human capital in the model facilitates to adjust risk aversion effect to the realistic level. Thus the result supports the hypothesis that subjective adjustment of human capital contributes positively to the adjustment of risk aversion effect to the realistic level.

Table 3. Estimates of risk attitudes distribution parameters with subjective adjustment of human capital of the rice producers in flood prone environment, Bangladesh.

Parameters	Flood prone environment equations			
	Small farm	Medium farm	Large farm	All farm
Mean risk attitudes:				
θ^0_{IN}				
θ^2_1	8.96**	7.7176**	5.300**	6.022**
	(0.126)	(0.007)	(0.012)	(0.011)
	-0.131**	-0.151**	-0.139**	-0.125**
θ^3_1	(0.01)	(0.004)	(0.003)	(0.002)
	1.41**	1.249**	1.139**	1.124
R^2	(0.012)	(0.004)	(0.003)	(0.003)
	0.995	0.999	0.999	0.999
Covariance parameter:				
θ_{0NN}				
θ_{22}	8.974**	6.0001	10.44**	2.886**
	(0)	(0)	(0)	(0)
θ_{33}	0.0017**	0.0001**	0.041**	0.224**
	(0)	(0)	(0)	(0)
θ_{23}	0.09**	0.040**	0.059**	0.115**
	(0)	(0)	(0)	(0)
	-0.040**	- 0.002**	0.044**	0.237
	(0)	(0)	(0)	(0)

** t-value and F-value significant at 1% level

Figures in parentheses are standard errors of estimates

In order to interpret the implications of risk attitudes parameters in Table 3 various risk aversion coefficients were computed. Table 4 and 5 presents the risk aversion coefficients estimated with and without subjective adjustment of human capital in flood prone environment. Our analysis show that inclusion of subjective adjustment of human capital in the model allowed adjustment of risk aversion effect to the more realistic level as we hypothesized. As a result of subjective adjustment of human capital, the small, medium and large farmers were found to be "moderately" risk averse. On the other hand, exclusion of subjective adjustment of human capital in the model could result higher value risk aversion coefficient for the small and medium and lower value coefficient for the large farmers (Table 5). The possible reason is that the absolute error in the subjective probability estimates of the random events of yield reduction by flood decreased with the inclusion of the human capital stock of the farmers in the model. With other things constant, absolute errors in the subjective probability estimates of the random events have a positive effect on the demand for risk reducing input and negative effect on the demand for risk increasing inputs. Therefore, as a result of the reduction of the absolute error in the subjective

Table 4. Risk attitudes characteristics estimated with subjective adjustment of human capital of the rice producers in flood prone environment of Bangladesh.

Parameters	Flood prone environment coefficients			
	Small farm	Medium Farm	Large Farm	All Farm
Absolute Arrow-Pratt (AP):				
Mean	0.262	0.250	0.278	0.267
Standard deviation	0.261	1.159	0.405	0.063
Coefficient of variation	-	-	-	23.60
F-value*	-	-	-	0.072
Absolute downside (DS):				
Mean	8.460	6.774	6.834	7.494
Standard deviation	1.800	2.035	2.124	1.200
Coefficient of variation	-	-	-	16.01
Correlation of AP and DS	1.021	1.205	-0.613	0.317
Relative risk premium	0.143	0.145	0.162	0.176

F-value was computed to test whether mean risk aversion coefficients of the three groups of farmers differ significantly. F- value is insignificant.

Table 5. Risk attitudes characteristics estimated without subjective adjustment of human capital of the rice producers in flood prone environment of Bangladesh.

Parameters	Flood prone environment coefficients			
	Small farm	Medium farm	Large farm	All farm
Absolute Arrow-Pratt (AP):				
Mean	4.924	3.914	0.048	2.962
Standard deviation	0.289	5.311	2.00	2.533
Coefficient of variation	-	-	-	85.517
Absolute downside (DS):				
Mean	8.766	4.866	0.084	4.572
Standard deviation	1.200	14.356	1.200	5.585
Coefficient of variation	-	-	-	122.16
Correlation of AP and DS	1.38	-0.088	0.25	0.57

* F-value was computed to test whether mean risk aversion coefficients of the three groups of farmers differ significantly. F- value is significant.

probability estimates of the random events due to incorporation of subjective adjustment of human capital in the model made a positive effect on the demand for risk increasing input (e.g., fertilizer) of the small and medium farmers while it has a negative effect on the demand for risk increasing input of large farmers in flood prone environment. Thus subjective adjustment of human capital in the model gave better estimates of risk aversion coefficients of the farmers. The implications of these risk aversion measures are discussed below.

The first notable result about the risk aversion measures is that in flood prone environment the estimates from all categories of farm indicate that the population is characterized by Arrow-Pratt and downside risk aversions. The absolute Arrow-Pratt risk aversion coefficients for all sample farms are almost similar in flood prone environment. The values of these coefficients were 0.262, 0.250 and 0.278, respectively, for the small, medium and large farms. It was hypothesized that there is significant difference in degree of risk aversion in different farm sizes. One can see that this hypothesis can be rejected at 1% probability level as indicated by the insignificant F-value which implies that there is no difference in degree of risk aversion among the three farm size groups in flood prone environments. The considerable homogeneity of risk attitudes in the population is also evidenced by low standard deviation and coefficient of variation of risk aversion coefficients. The rice producers in flood prone environment is "moderately" risk averse as indicated by risk aversion coefficients and relative risk premium. The average relative risk premium is about 17.6% in flood prone environment of all farms suggests that the growers represented in the study may be interpreted as being "moderately" risk averse. It implies that the farmers in flood prone environment would be willing to pay at most about 17.6% of expected returns to insure against risk. The correlation between ArrowPratt and downside risk aversions is positive which implies that if the farmers are risk averse in Arrow-Pratt measures are also risk averse in downside measures.

6. CONCLUSIONS

The present study could contribute to the economic theory, in that it proposes an improved methodology of producers' risk attitudes estimation using iii:ormation on their actual investment behavior rather than using a hypothetical gambling. It added evidence to the existing economic thoughts that risk attitude estimation of the producers without subjective adjustment of human capital would result inappropriate biased estimates.

In order to estimate farmers' risk attitudes behavior it is necessary to consider the effect of subjective adjustment of human capital. The estimates of farmers' risk attitudes behavior given here support the conclusion that human capital variables can act as catalyst to adjust risk aversion effect to more realistic levels due to correcting an upward bias in the farmer's estimate of probability of random events of yield reduction by flood. This objective was achieved by using Generalized Method of Moment based approximation of revenue distribution function with incorporation of human capital variable.

The estimates of risk attitudes distribution of the rice producers in flood prone environment show that the population is characterized by Arrow-Pratt and downside risk aversion. The farmers were found to be moderately risk averse as indicated by smaller values of Arrow-Pratt risk aversion coefficients and relative risk premium. There is considerable homogeneity in the degree of risk in the producers' population and no significant difference in the degree of risk aversion in different farm sizes.

The present study provided evidence of support for the policy makers for increased public investment on human capital development with a view to improve the farmers' information processing and risk assessing capacity in the uncertain environment, thus, reducing their perceived risk due to efficient use of information.

The econometric methodology developed for estimation of producers' risk attitudes can be used for policy study. Given imperial estimates of risk attitudes, the empirical analysis of productivity and welfare under uncertainty can be used for developing policy options.

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