Australian Journal of Basic and Applied Sciences, 6(12): 252-258, 2012
ISSN 1991-8178

Noise and Inefficiency augmented Production Risk Estimation for Rice Crops in Bangladesh

[1]KanisFatama Ferdushi, [1]Anton AbdulbasahKamil, [2]Adli Mustafa and [3]Md. Azizul Baten

[1]Mathematics Section, School of Distance Education, UniversitiSainsMalaysia ,11800 USM, Penang, Malaysia
[2]Mathematics Section, School ofMathmatics, UniversitiSainsMalaysia ,11800 USM, Penang, Malaysia
[3]Department of Decision Science,School of Quantitative Sciences,Universiti Utara Malaysia,06010 UUM Sintok, DarulAman,Malaysia.

Abstract: The aim of this paper was to estimate Production Risk with inefficiency on a stochastic frontier framework over the time period .This endeavor was carried out on the basis of stochastic production function, noise and inefficiency function. Panel data were taken for this framework from 1980-2008 in the agricultural field of Bangladesh concentrated on seasonal rice crop such like as Aus, Aman, and Boro. The noise with inefficiency had been checked for the production of Aus, Aman, and Boro production. In this study climate variables rainfall, temperature and humidity used in order to find out the impact of climate on the production risk. Seed and fertilizer urea have negative effect on production of Aus. Temperature and Humidity has a negative relation with noise model of Aus production i.e. are risk decreasing input. Wage rate for labor is statistically insignificant in Aman seasons as like Aus seasons which is a common scenario for Bnagladesh. In Boro production rainfall is robustly negatively significant with inefficiency model but temperature and humidity strongly creates inefficiency.

Key wrods:

INTRODUCTION

Aigner, Lovell and Schmidt (1977) and Meussen and van den Broeck (1977)have illustrated the stochastic frontier over the average production function. From the last two decades stochastic frontier model has been moderate in a wide era. Their model has been changed by Battese, Rambadi, and Wan (1997) with additively incorporate the structure of the conventional stochastic frontier production mode, into Just and Pope's (1978) model. At the very beginning, **r**isk analysis involves recovering the residuals and using them to investigate the marginal effects of inputs on production risk, or noise in a Just-Pope framework (1978 and 1979). Second, There have been a number of studies both regional and across the world that have focused on production risk in Stochastic frontier model.

A number of studies have been done in the context of inefficiency to estimate marginal effects of inputs on inefficiency Khumbhakar(1993), Villanoet. al(2005). Empirical application to estimate effects of inputs in this context of inefficiency are available in the literature by (Bernardo et. al (1995), Jaenicke *et al* (2003); He *et al* (2003),Walters et. Al(2004), Ligeon*et al* (2008) ,Edeh et.al (2011)).

Bangladesh has been divided into a number of growing period zones for both kharif (wet period from approx. March to October) and rabi (dry period from approx. November to February) seasons, As part of an FAO land resources appraisal FAO (1988). This kharif-rabi seasonal moisture regime has played an important role in shaping the diversity of rice varieties which are differentiated into three principal ecotypes in Bangladesh: aus, aman and boro. During the kharif season, the photoperiod-insensitive aus crop is grown. These varieties are usually sown in the pre-monsoon season (March/April) and harvested between July and August, a growing period of 80–120 days. Aus rice's are dwarf in stature, thermo sensitive, and perform best under summer conditions Alim (1974). They are grown under rain fed conditions and are prone to both drought and flooding. Aus crops have low yield and poor quality. Traditionally, aman varieties have been the main rice crop in Bangladesh. They are sown (broadcast) in March or transplanted following the aus harvest and mature throughout the kharif season. They are photoperiod-sensitive and flower in October/November. Since they have a longer growth duration (120–160 days), aman varieties are more productive than the ausrices and produce high quality, fine white grains. Bororices are photoperiod insensitive and are adapted to mild winter conditions showing some degree of cold toleranceZaman(1980). They are similar to transplanted aman both in their method of cultivation and crop habit. The boro crop is sown in October/November, transplanted around December/ January and harvested in the spring. Traditionally, they have only been grown-up on land which retains sufficient water throughout the rabi season to support crop growth. Among these cropping transplanted Aman is

Corresponding Author: KanisFatamaFerdushi, Mathematics Section, School of Distance Education, Universiti Sains Malaysia ,11800 USM, Penang, Malaysia
E-mail: ferdushi_nafia@yahoo.com

most important and occupies about 51% of the rice cultivated land According to FAO(2008) Report.The rest 10% and39% percent of the land is occupied by Aus and Boro respectively.

An annual shortage of about 1.5 million tons of cereals Hossain&Shahabuddin(1999) is reported due to the increase of population at 1.8 percent per annum. With this rate of population growth, the country's total rice requirement will be 35.5 million tones to feed 173 million people by 2020 BARC (1994). Since there is no scope for horizontal expansion of the rice area, it is the greatest challenge to the policy makers, administrators and rice scientists of the country to produce more food from the limited land available.

In addition changing climate conditions and unfavorable weather events causes great hamper in production. The impacts of climate change on agriculture food production are global concerns and Bangladesh is exposed a great danger country. Rice yield can be increased by only 0.3 t/ha (1.5 million tonnes/5 million ha = 0.3 t/ha clean rice or 0.46 t/ha rough rice) and the present level of modern variety (MV) adoption from 51 to 55 percent, providing supplemental irrigation, using balanced fertilizers and adopting better plant production measures Sattar(2000).Efficiency measurement gives us idea about how to use variable to increase productivity by simply increasing its efficiency. This research is on agricultural field of Bangladesh involves increasing efficiency identifying the cause of noise and inefficiency on production process. An increase in efficiency could reduce production costs and maximize production. These savings could be passed on to consumers in the form of reduced rice prices, which could then potentially increase access among poor people. From efficiency analysis positive steps can be taken to encourage use of balanced input (Fertilizer, Area etc.) by the farmer.

Objectives:

The main objectives of this paper are to estimate Production Risk with inefficiency of rice production over the time period in Bangladesh. The specific objectives are to

i) Estimate and identify the cause of noise or production risk over the study area.

ii) Ascertain which types of inputs is risk increasing (or decreasing).

This paper has made an intense on the field of rice crop of Bangladesh which has never been met such type of analysis of production risk. Every year production of rice faces many problems such as disasters, pesticides, drought etc. In this paper, we attempts to shed light about what factors are most relevant in explaining inefficiency. From this analysis we shall be able to make a good policy for the production of rice in Bangladesh.

Materials:

The data on principal three crops such as Aus, Aman, and Boro in Bangladesh were taken from the year book of agricultural statistics of Bangladesh published by the Bangladesh Bureau of Statistics (BBS) every year. For this study 29 time periods of data set from 1980 -2008 is considered.The dependent variableis rice production and other independent variables such as area, the amount of seed, the amount of fertilizer urea, Labor wage, Bullock wage and the climate variable such as rainfall, temperature and humidity for each crop .Summary statistics of output and input variable is given in table 1. The average level of labor wage is 52 to 55 taka and Bullock wage is from 82 -101 taka in Aus, Aman and Boro season. Average temperature is from 28^0C-32^0C and Humidity 74%-84%.

Dependent Variable:

Productionis measured as metric tons of rice harvested in seasons.

Independent Variable:

Inputs*:* The input variables are defined as follows:

Arearepresents planted land (ha) to rice by the farmer.

Laborrepresents the amount of both own and hired labor (person-days) used.

Fertilizerincludes the amount of fertiliser (kg) (Urea) applied to the crop.

Seed represents the amount of seed (kg) used to the crop.

Bullock wageis charges for hired bullock pair (Taka/day) used for rice production (imputed for family supplied animal power).

LabourWageis amount of payment to agricultural labour by taka per day .

Climate Variable:

Rainfall:

Rainfall is calculated by millimeter .The annual rainfall is about 1600 mm, Most parts of the country receive at least 2000 mm per year. Most of the rainfalls (often over 60 inches per year) occurs during the rainy monsoon season (June to Sep.). Very little rain falls in the cooler month (Nov-Feb).

Temperature:

Maximum summer temperatures range between 30^0C to 40^0C.April is the warmest month in most parts of the country 34^0C. January is the coldest month, when the average temperature for most of the country is about 10^0C.

Humidity:

A hot humid summer from March to June and vary from 78%-84%.

Method:

A production function with input and error specification is as follows

$$y_{it} = f\left(x_{it}, \beta\right) + e_{it} \tag{1}$$

Where y_{it} is a scalar output of production in different types i, $i = 1, 2, .., I$, at time $t = 1, 2, ..., T$;

x_{it} is a vector of N inputs used for production process such as area ,seed, urea ,wage rate for labor and wage rate for bullock and some climate variable rainfall, temperature and humidity;

$f\left(x_{it}, \beta\right)$ is the deterministic part of the production frontier ; β is a vector of unknown parameters to be estimated; e_{it} is a residual component ;

In the stochastic frontier framework, the residual component can take the form

$$e_{it} = g\left(z_{it}, \delta\right) v_{it} - h\left(p_{it}, \theta\right) u_{it} \tag{2}$$

Where $g\left(z_{it}, \delta\right)$ is a noise or variance function and $h\left(p_{it}, \theta\right)$ is an inefficiency function;

z_{it} and p_{it} are input vectors that may or may not equal each other or x_{it}; δ and θ are parameters vector ; v_{it} is a two-sided exogenous production shock associated with noise and u_{it} is a one-sided exogenous inefficiency term.The v_{it} is distributed independently and identically normally distributed with zero mean, i.e. $v_{it} \sim i.i.d.N(o, \sigma_v^2)$ .The u_{it} is assumed to be distributed according to a one-sided distribution, $i.i.d.$ non-negative half normal with zero mean. i.e. $u_{it} \approx i.i.d.N(o, \sigma_u^2)$;The u_{it} and v_{it} distributed independently of each other, and of regresses.Assuming that $f\left(x_{it}, \beta\right)$, $g\left(z_{it}, \delta\right)$ and $h\left(p_{it}, \theta\right)$ are all linear functions.

Then using equation (1) and (2) Jaenicke and Larson (2001) provides some different model which can be written as like follows:

$$y_{it} = \beta_o + \beta' x_{it} + v_{it} - u_{it} \tag{3}$$

$$\ln(v_{it}^2) = \delta_o + \delta' z_{it} + \upsilon_i \tag{4}$$

$$\ln(u_{it}^2) = \theta_o + \theta' p_{it} + \mu_i \tag{5}$$

Where υ_i and μ_i are random disturbances with zero mean and constant variance.

The equations (3),(4) and (5) is known as respectively Production, Noise and Inefficiency equations where production equation is to be estimated with inefficiency effects model Batteseand Coelli(1992) and maximum likelihood techniques using software FRONTIER version (4.1). The Noise and inefficiency equations can be estimated using OLS techniques. The flexible representation in (2) allows inputs to have separate marginal effects on noise and inefficiency.

RESULTS AND DISCUSSION

The estimation results are reported by the particular rice crop in specific time throughout year Aus (April-August), Aman (June-December) and Boro (January-June) respectively in tables 2.1,2.2 and 2.3.

Noise and Inefficiency in Aus Production:

In the production process of rice crop Aus, Area and fertilizer urea becomes significant at 1% level of significance respectively positively and negatively under frontier model. The fertilizer urea has a very positive impact on increase of Aus production. Wage rate for Bullock is negatively significant at 5% level of significance. Time is also a significant factor at 1% level of significance. The coefficient of seed and wage rate for labor fails the significance test (t-test) under frontier model. That's means that it is essential be more concern about the seed; without a good amount of seed higher production is impossible. In Bangladesh labor wage is very dominating and this fact is also true in this case of the Aus season.

The noise equation is presented in table 2.1. Area is highly negatively significant at 1 % level of significance. The results indicates that Area is a noise decreasing (i.e., risk decreasing) input. In the case of climate input rainfall has very limited support as a noise increasing performed. Temperature and Humidity has a negative relation with noise model i.e. are risk decreasing input. Jaenicke and Larson(2001) showed nitrogen has a limited support that is nitrogen is a noise increasing on cotton grown with a cover crop but in case of Aus production fertilizer urea has a negative relation with noise model i.e. risk decreasing variable.

The inefficiency equations results in table 2.1 show that Increase in urea application rates has a very few support about in increasing inefficiency. Application of Area and seed has a decrease rate in inefficiency. Wage rate labor increases inefficiency. Temperature and Humidity has slightly effect on increasing inefficiency. On the other hand increasing amount of rainfall decreases inefficiency.

Noise and Inefficiency inAman Production:

The estimation results for another kind of rice Aman is presented in table 2.2. The results are show that very few estimated coefficients are statistically significant. Area and Fertilizer urea is statistically significant at 1 % level of significance. Wage rate for labor is statistically insignificant in Aman seasons as like Aus seasons. Wage rate for bullock in negatively significant at 5% level of significance.

In case noise model area and wage rate for bullock is statistically significant respectively at 10% and 5% level of significance. In this analysis area is negatively i.e. noise decreasing but wage rate for bullock is positively related with noise model i.e. increasing noise. Seed and Fertilizer urea has also very few positive relation with noise model. Wage rate for labor is negatively related by way of noise model. Bangladesh is densely populated country. About 90% of the population engaged with the agricultural sector. That's why though wage rate is not in satisfactory level but it's not making a bad impact on production.Though rainfall and temperature has a negative significantly strong relation with noise decreasing but humidity is strongly positive effect on production of Aman.

Inefficiency model for Aman rice crops is presented in table 2.2. Fertilizer urea decreases inefficiency .According to Coelli *et al*(2002) in Aman season surplus labor is more of a problem, suggesting population pressure which is similar of this result.

Table 1: Summary of statistics of output and input.

	Aus				Aman				Boro			
Variables Output and Inputs	Mean	Std.	Min	Max	Mean	Std.	Min	Max	Mean	Std	Min	Max
Production	2220.81	610.52	1500	3289.0	8421.30	1.66 E3	5574.00	11613.	8402.0	4.51 E3	2630	17809
Area	1912.97	791.26	906	3158.1	5671.85	276.00	5047.86	6052.4	2846.6	1.07 E3	1160	4716.2
Seed	505.96	273.04	207	1580.0	4364.83	3.17 E3	629.00	13619.	7730.5	1.00 E4	453	35089
Urea	1656.16	695.27	519	2762.8	1656.17	695.27	519.00	2762.7	1656.1	695.275	519	2762.7
Labor Wage	51.94	34.654	10	150.00	55.79	35.64	15	150	65.96	49.24	16	190
Bullock Wage	82.62	38.987	15	145.00	94.03	49.71	23	200	101.10	47.95	30	190
Rainfall	56829.03	6891.18	42155	66908	60210.1	7638.06	44271	73988	28882	5276.13	20378	39532
Temperature	31.95	.389	31.18	32.50	30.95	.35	30.20	31.91	28.93	.59	27.92	30.41
Humidity	84.79	1.003	82.85	86.78	82.54	2.29	76.12	85.47	74.45	2.62	69.77	78.15

Total No. of Observation, N=87

Table 2.1: Production, Noise and Inefficiency Estimation for the production of Aus.

Variable	Parameters Pdn Noise Inef	Frontier Panel Production Coe	t-ratio	Noise Coe	t-ratio	Inefficiency Coe	t-ratio
Constant	$\beta_0\delta_0\theta_0$	.946**	1.537	276.687***	1.524	-9.738***	-839.338
Area	$\beta_1\,\delta_1\theta_1$	1.087*	15.371	-0.378	-0.246	-0.002	-0.523
Seed	$\beta_2\,\delta_2\;\theta_2$	-0.008	-0.219	-.012	-0.043	-0.001	-0.843
Urea	$\beta_3\delta_3\theta_3$	-.234*	-2.514	-1.094	-0.875	0.001	0.165
Labor Wage	$\beta_4\delta_4\theta_4$	0.075	0.918	-1.964***	-1.297	0.005	1.034
Bullock wage	$\beta_5\delta_5\theta_5$	-0.125**	-1.525	1.099	0.880	-0.001	-0.286
Time	$\beta_6\delta_6\theta_6$	0.0401*	4.662	2.279	1.023	0.992	144.731
Rainfall	$\delta_7\;\;\theta_7$			.089	0.305	-0.001	-1.047
Temperature	$\delta_8\;\;\theta_8$			-0.731	-1.265	0.001	0.622
Humidity	$\delta_9\,\theta_9$			0-.568***	-1.331	0.002	1.561
F(9,19)Statistics				.601		286864**	
γ				.345E-07	.001		
σ^2				0.023*	5.902		
σ_v^2				.0237			
σ_u^2				7.14E-09			
λ				5.48E-04			

*, **, *** are significant at 1%, 5% and 10% respectively

Table 2.2: Production ,Noise and Inefficiency Estimation for the Production of Aman.

Variable	Parameters Pdn Noise Inef	Frontier Panel Production Coe	t-ratio	Noise Coe	t-ratio	Inefficiency Coe	t-ratio
Constant	$\beta_0\delta_0\theta_0$	-12.961*	-13.022	9.442***	1.145	-9.782	-23.097
Area	$\beta_1\,\delta_1\theta_1$	2.271*	5.195	-0.152***	-1.318	0.001	0.020
Seed	$\beta_2\,\delta_2\;\theta_2$	-0.105	-0.193	0.032	0.107	0.005	0.047
Urea	$\beta_3\delta_3\theta_3$	0.154	0.177	0.092	0.307	-0.030	-0.286
Labor Wage	$\beta_4\delta_4\theta_4$	0.453	0.475	-0.151	-0.219	0.096	0.405
Bullock wage	$\beta_5\delta_5\theta_5$	0.118	0.127	1.213**	1.726	0.194	0.800
Time	$\beta_6\delta_6\theta_6$	-.011	-0.224	-0.333	-0.735	0.770	4.918
Rainfall	$\delta_7\;\;\theta_7$			-0.161**	-1.497	-0.002	-0.060
Temperature	$\delta_8\;\;\theta_8$			-0.228**	-2.164	0.016	0.445
Humidity	$\delta_9\,\theta_9$			0.199***	1.284	-0.060	-1.119
F(9,19)Statistics				25.021**		225.525**	
γ				0.00002	0.0098		
σ^2				0.0267*	3.579		
σ_v^2				0.0267			
σ_u^2				5.713E-07			
λ				0.0046			

*, **, *** are significant at 1%, 5 % and 10% respectively

Table 2.3: Production, Noise and Inefficiency Estimation Result for the Production of Boro

Variable	Parameters Pdn Noise Inef	Frontier Panel Production Coe	t-ratio	Noise Coe	t-ratio	Inefficiency Coe	t-ratio
Constant	$\beta_0\delta_0\theta_0$	1.858	1.866	-75.552***	-1.365	-9.880	-245.771
Area	$\beta_1\,\delta_1\theta_1$	1.174***	1.552	1.150	0.791	0.057	0.894
Seed	$\beta_2\,\delta_2\;\theta_2$	.018	0.274	0.180	0.209	0.035	0.936
Urea	$\beta_3\delta_3\theta_3$	-0.434	-0.627	-1.005	-0.842	0.049	0.931
Labor Wage	$\beta_4\delta_4\theta_4$	0.040	0.156	-0.239	-0.196	0.145*	2.704
Bullock wage	$\beta_5\delta_5\theta_5$	0.0631	0.0675	-0.714	-0.421	-0.034	-0.453
Time	$\beta_6\delta_6\theta_6$	0.024	0.579	0.312	0.179	0.731*	9.537
Rainfall	$\delta_7\;\;\theta_7$			0.017	0.073	-0.015***	-1.392
Temperature	$\delta_8\;\;\theta_8$			0.214	0.906	0.021*	2.039
Humidity	$\delta_9\,\theta_9$			0.504***	1.473	.025***	1.633
F(9,19)Statistics				0.612		1398.221**	
γ				0.000057	0.021		
σ^2				.0106*	3.553		
σ_v^2				.0105			
σ_u^2				6.042E-07			
λ				7.558E-03			

*, **, *** are significant at 1%, 5 % and 10% respectively

Noise and Inefficiency in Boro Production:

During the season of Boro production only area has a positively significant effect at 10% level of significance. The noise result indicates that humidity is substantially positive relation. Climate variable rainfall, temperature has also a very limited support in noise. Input Urea, Wage rate for labor and wage rate for Bullock is negatively related; i.e. make positive effect on production. Noise model for Boro production is presented in table 2.3 shows that increase in urea application decreases inefficiency. According to Coelli *et al* (2002) in Boro season is less labor intensive.

Inefficiency model of Boro season states that area, seed, urea has a very limited support on inefficiency and wage rate for labor and time is statistically significant at 1% level of significance. Rainfall is robustly negatively significant with inefficiency model but temperature and humidity strongly creates inefficiency.Table2.1-2.3 presented the estimate results for λ, which indicates the relative contribution of the inefficiency component to the noise component. γwere statistically significant at 5% level so these indicated the justification of using a stochastic frontier production model in this case because of the presence of technical inefficiencies in different rice crops of Bangladesh. Here $\gamma < 1$ indicates that one-sided error cannot dominate the symmetry error. γ is statistically significant at 10% level of significance only for total production intensity , which indicates that the technical inefficiency effect has an impact on outputand this result is consistent with Sharma *et al.* (1997), Coelli and Battese (1996), Kalirajan (1981), Ali and Flinn (1989).the estimated value of sigma squared is significant at 1% level of significance which is similar with Sharma *et al.* (1997), this suggests that a conventional production function is not an adequate representation of the data.The estimated gamma parameter (g) of 0.71 in total production indicates that 71% of the total variation in rice output is due to the technical inefficiencies in the study. In the case ofAus,Aman and Boroproduction, the estimate for the g (gamma)parameter in the stochastic frontier productionfunction is quite small, which means that theinefficiency effects aren't significant in theanalysis of the value of output of that production.

Conclusion:

This paper investigates production risk and inefficiency in a stochastic frontier framework using seasonal rice crop in Bangladesh due to find out marginal effects of input on noise.Aus and Aman crops are exposed to produce the least amount of noise as compared with Boro seasonal crop. Rainfall, temperature and humidity have positively significant effects on inefficiency of total production. Bangladesh consistsvariation of seasons that's why intensity, duration of rainfall temperature and humidity depends on weather condition. From this background sometimes heavy rainfall, excessive temperature hampers production every year.The comparatively few empirical investigations on riskiness of seasonal rice in Bangladesh has commenced and provide that seasonal rice may reduce yield variability .These results will give a hand to make bigger amount of production by producers. Future research on this background is to proper use of risk increasing inputs.

REFERENCES

Alim, A., 1974. An introduction to Bangladesh agriculture, (Dacca:Ministry of Agriculture).

Ali, M., and J.C. Flinn, 1989. Profit efficiency among Basmati rice producers in Pakistan Punjab.American Journal ofAgricultural Economics, 71: 303 -10.

Aigner, D.J., C.A.K. Lovell and P. Schmidt, 1977. Formulation and Estimation of Stochastic Frontier Production Function Models.Journal of Economics, 6: 21-37.

Battese, G.E., and T.J. Coelli, 1992. Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India.The Journal of Productivity Analysis, 3: 153-169.

Battese, G.E., A.N. Rambaldi, G.H. Wan, 1997. A Stochastic Frontier Production Function with Flexible Risk Properties".J. of Productivity Anal. August, 8: 269-280.

Council, B.A.R.C., 1994. Strategic plan for national agricultural research system to the year 2010. Dhaka, BARC.

Coelli, T.J., G.E. Battese, 1996. Identification of factors which influence the technical inefficiency of Indian farmers.Australian Journal of Agricultural Economics, 40: 103- 28.

Coelli, T., S. Rahman and C. Thirtle, 2002. Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: A non-parametric approach. *Journal of Agricultural Economics*, 53: 607-626.

Edeh, H.O., E.C. Eboh, B.N. Mbam, 2011. Analysis of Environmental Risk Factors Affecting Rice Farming in Ebonyi State. Southeastern Nigeria. World Journal of Agricultural Sciences, 7(1): 100-103.

F.A.O., 1988. Land resources appraisal of Bangladesh for agricultural development. Report 4 Hydro-climatic resources, (Rome: FAO).

FAO/WFPCFSAM., 2008. FAO/WFP crop and food supply assessment mission to Bangladesh.Food and Agricultural Organization of the United Nations,World Food Program,Rome.

Hossain, M.Q., Shahabuddin, 1999. Sustainable agricultural development in Bangladesh. Challenges and issues, Pages 65-78 in Bhuiyan, S.I. ,A. M.R. Karim (ed), Increasing Rice Production in Bangladesh: Challenges and Strategies. Dhaka (Bangladesh): Bangladesh Rice Research Institute and Manila (Philippines): International Rice Research Institute.

He, S., F.C. White, S. Fletcher, 2003. The Effects of Research on Wheat Yields and Yield Variances**.**The Southern Agricultural Economics Association Annual Meeting, Mobile, Alabama, February, pp: 1-5.

Just, R.E., R.D. Pope, 1978. Stochastic Specification of Production Functions and Economic Implications,J. of Econometrics, 7: 67-86.

Just, R.E., R.D. Pope, 1979. Production FunctionEstimation and Related Risk Considerations..Amer. J. Agr. Econ., 61: 276-284.

Jaenicke, E.C., J.A. Larson, 2001. Production Risk Revisited in a Stochastic Frontier Framework: Evaluating Noise and Inefficiency in Cover Crop Systems,American Agricultural Economics Association, Annual Meeting, Chicago, IL, Aug. 5-8: 2201.

Jaenicke, E.C., D.L. Frechette, J.A. Larson, 2003. Estimating Production Risk and Inefficiency Simultaneously: An Application to Cotton Cropping Systems **.**Journal of Agricultural and Resource Economics, 28(3): 540-557.

Kalirajan, K., 1981. An econometric analysis of yield variability in paddy production ,Canadian Journal of AgriculturalEconomics, 29: 167- 80.

Kumbhakar, S.C., 1993. Production Risk, Technical Efficiency, and Panel Data.Economic Letters, 41: 11-16.

Ligeon, C., C. Jolly, N. Bencheva, 2008.Production risks in Bulgarian peanut production. Agricultural Economics Review, 9(1): 103-110.

Meeusen, W., J.V.D. Broeck, 1977. Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error.International Economic Review, 18: 435–444.

Statistics, B.B., 1989.Agricultural sample survey of Bangladesh.1989-2008. Statistics Division Bangladesh Secretarait Dhaka.

Sattar, A.S., 2000. Bridging the Rice Yield Gap in Bangladesh.

Sharma, K.R., P. Leung and H.M. Zaleski, 1997. Productiveefficiency of the swine industry in Hawaii: stochastic frontier vs data envelopment analysis, Journal of ProductivityAnalysis, 8: 447- 59.

Wadud, A., B. White, 2000. Farm household efficiency in Bangladesh: a comparison ofstochastic frontier and DEA methods. Applied Economics, 32(13): 1665-1673.

Walters, J.T., R.T. Roberts and J.A. Larson, 2004. Effects of Risk, Disease, and Nitrogen Source on Optimal Nitrogen Fertilization Rates in Winter WheatProduction. The Southern Agricultural Economics Association Annual Meeting, Tulsa, Oklahoma, February, pp: 14-18.

Zaman, S.M.H., 1980. Ecology of transplant aman rice. In: Proceedings of the International seminar on photoperiod-sensitive transplantrice 1977, (Dacca, Bangladesh Rice Research Institute), pp: 1-7.