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## **Decomposition of Economic Efficiency under Risk into Technical and Allocative Risks: A Study on Fish Production in South Tripura District, Tripura, India**

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### **Abstract**

The risk arises from inadequate knowledge about best practice techniques (technical risk) and markets/prices (allocative risk). On the basis of this assumption, the economic inefficiency has been decomposed into inefficiencies due to technical and allocative risks. The study, conducted during 2004-05, is based on the primary cross-sectional data collected from six villages from three rural development blocks of South Tripura district in the Tripura state of India, with 239 farms as the sample. More than 96 per cent of the difference between observed and frontier output has been found primarily due to factors which are under the control of farms, i.e. due to technical inefficiencies. The mean economic efficiency under risk has been estimated at the level of 34.11 per cent. The economic inefficiency due to technical risk and allocative risk has been found as 20.86 and 45.03 per cent, respectively of the existing economic inefficiency. The variations in  $EE_{ar}$  (allocative risks) have been found lower than those in  $EE_{tr}$  (technical risks). A negative correlation has been observed between  $EE_{tr}$  and  $EE_{ar}$ . The amount of  $EE_{tr}$  has been found to be lower than that of  $EE_{ar}$ .

### **Introduction**

Risk and uncertainty in agriculture can be directly related to variability in the production processes. There are normally three types of variabilities in the crop production process, viz. yield variability, price variability and income variability. When agriculture is commercialized, farmers are

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exposed, in addition to yield uncertainties, to price and technology uncertainties (Palanisami *et al.*, 2002). Risk is seen as an important and ever-present factor influencing the optimization behaviour of farms adjusting to disequilibria in agriculture (Schultz, 1975). It may be described as allocative (market) risk and technical (production) risk. Allocative risk affects the level of output by influencing the levels of inputs used. The technical risk constrains the firm from realizing the full potential of technology by influencing it not to follow the best method of application of inputs (Kalirajan and Shand, 1994). The literature on risk management has acknowledged these two manifestations of risk (Kislev and Shchori-Bachrach, 1973; Feder and Slade, 1985) and most of the studies have concentrated only on modeling the allocative risk (Hiebert, 1974; Zilberman and Just, 1984).

Kalirajan and Shand (1994) modeled and demonstrated empirically how to measure separately the influence of technical and allocative risks on production, using stochastic frontier production function (SFPP). In the present study, the methodology of Kalirajan and Shand (1994) has been used to decompose the economic efficiency under risk into economic efficiency foregone due to technical and allocative risks. The methodology has been applied to fish production in the South Tripura district of Tripura state (India) during the year 2004-05.

### Analytical Framework and Estimation Procedure

The economic efficiency for a firm at existing level of production under risk is defined as per Eq. (1):

$$EE_{ur} = \frac{Y_1}{Y_5} \quad \dots(1)$$

$EE_{ur}$  includes both technical and allocative risks, which are evident in technical and allocative inefficiencies, respectively.

A measure of economic efficiency foregone due to technical risk ( $EE_{tr}$ ) is defined by Eq. (2):

$$EE_{tr} = \frac{Y_2 - Y_1}{Y_5} \quad \dots(2)$$

A measure of economic inefficiency due to the perceived allocative risk ( $EE_{ar}$ ) is defined by Eq. (3):

$$EE_{ar} = 1 - \frac{Y_2}{Y_5} \quad \dots(3)$$

where,  $Y_1$  is the realized output level,  $Y_5$  is the output which is technically and allocatively risk-free, is technically and allocatively efficient, and maximizes net returns. It has been calculated by simultaneously solving Eqs (4) – (6), showing the potential frontier function and the profit maximizing marginal productivity conditions:

$$b_1 \ln X_1^* + b_2 \ln X_2^* + \dots + b_m \ln X_m^* - \ln y = -(b_{m+1} \ln X_{m+1}^* + \dots + b_k \ln X_k^* + b_0) \quad \dots(4)$$

$$\ln X_1 - \ln Y = \ln \beta_1 - \ln p_1 + \ln p_y \quad \dots(5)$$

$$\dots(6)$$

There are  $(m+1)$  equations in  $(m+1)$  unknowns,  $x_1, x_2, \dots, x_m$  and  $y$ ; the production parameters  $\beta_0, \beta_1, \dots, \beta_m, \beta_{m+1}, \dots, \beta_k$  are maximum likelihood estimates of the production frontier. The calculated inputs  $X_1^*, X_2^*, \dots, X_m^*, X_{m+1}^*, \dots, X_k^*$  represent the levels of inputs which the farm would have chosen, had there not been any perceived risk.

$Y_2$  is the potential frontier output level. In this study, the SFPF model has been used for cross-sectional data. The specific SFPF model estimated was [Equation (7)]:

$$\ln X_{\bar{m}} = \alpha + \ln \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + (v_i - \mu_i) \quad \dots(7)$$

where,

$Y$  = production (kg);  $\alpha, \beta_1, \beta_2, \beta_3, \beta_4$  and  $\beta_5$  = parameters to be estimated;  $X_1$  = pond area (acre);  $X_2$  = seed expenditure (INR);  $X_3$  = labour expenditure (INR);  $X_4$  = fertilizer expenditure (INR);  $X_5$  = feed expenditure,  $v_i$  = random error having zero mean which is associated with random factors;  $v_i$  = one-sided inefficiency component;  $\ln$  = natural logarithmic value; INR = Indian Rupee.

The random errors ( $v_i$ ) were assumed to be independently and identically distributed as  $N(0, \sigma_v^2)$  random variable, independent of  $\mu_i$ 's.  $U_i$ 's were assumed to be non-negative truncations of the  $N(0, \sigma_u^2)$  distribution (i.e., half normal distribution).

The model has been estimated using Limdep 7.0 software, which gives the estimates of parameters  $\lambda (= \sigma_u^2 \div \sigma_v^2)$ ,  $\sigma_u^2$ ,  $\sigma_v^2$ , and  $\sigma$ .  $\gamma$  has been estimated from the estimates of  $\sigma_u^2, \sigma_v^2$ .

## Data and Sampling Design

The present study was based on the primary cross-sectional data collected from six villages (two villages each from Matarbari, Amarpur and Bagafa rural development blocks) of South Tripura district of Tripura

state of India during the year 2004-05. South Tripura district contributed about 35 per cent of total culture fish production in Tripura during 2002-03. The rural development blocks and villages within the blocks were selected on the basis of water area under fish culture, i.e. top three blocks within the district and top two villages within the block. A sample of 250 fish farms proportionately allocated to selected villages was drawn. Due to non-availability of adequate information, 11 farms were dropped; hence the final sample was of 239 farms.

### Empirical Results

The ML estimates of SFPF have been shown in Table 1. The estimates concerning  $\gamma$  statistics indicate the existence of inefficiencies in the production activities of the pisci-culturists in the study area.

**Table 1. Maximum likelihood estimates of the stochastic frontier production function, Tripura (India): 2004-05**

Variables	Parameters	Overall	
		Coefficients	p-value
Constant	$\alpha$	0.8969 (0.3807)	0.0185
Pond area (acre) ( $X_1$ )	$\beta_1$	0.6120 (0.0373)	0.0000
Seed expenditure (INR) ( $X_2$ )	$\beta_2$	0.0155 (0.0080)	0.0515
Labor expenditure (INR) ( $X_3$ )	$\beta_3$	0.7022 (0.0464)	0.0000
Fertilizer expenditure (INR) ( $X_4$ )	$\beta_4$	0.0125 (0.0040)	0.0019
Feed expenditure (INR) ( $X_5$ )	$\beta_5$	0.0112 (0.0026)	0.0000
	Lambda ( $\lambda$ ) =	5.0990 (1.4876)	0.0006
	Sigma ( $\sigma$ ) =	0.6484 (0.0296)	0.0000
	Gamma ( $\gamma$ ) =	0.9630	
	Sigma-squared (v) = $\sigma_v^2$	0.0156	
	Sigma-squared (u) = $\sigma_u^2$	0.4048	
	log likelihood function =	-101.6158	
Model: $\ln Y = a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + (V_i - U_i)$			

*Notes:* Figures within the parentheses are the standard errors, ln = Natural logarithmic value, INR = Indian Rupee, 1 acre = 0.4 hectare, p-value is the probability of significance.

All independent variables considered have positive significant coefficients up to 5 per cent level of significance, which indicates that there is a scope for increasing production of fish by increasing the level of these inputs. The estimated values of  $\sigma_u^2$  and  $\sigma_v^2$  indicate that the difference between the observed output and frontier output is not due to the statistical variability alone, but also due to TE of farms. The estimates of  $\gamma$  indicate the presence as well as the dominance of inefficiency effect over random error. This implies that more than 96 per cent of the difference between observed and frontier output is primarily due to factors which are under the control of farms, i.e. due to technical inefficiencies.

**Table 2. Farm-specific economic efficiency under risk**

Economic efficiency (per cent)	Number of farms		Farmer identification number											
	No.	% to total No.												
0-10	8	3.35	228	232	164	137	9	161	149	215				
10-20	35	14.64	16	60	37	25	64	28	118	66	39	211		
			130	235	2	8	213	131	214	46	31	121		
			136	155	216	138	19	34	56	234	217	65		
			144	51	233	110	11							
20-30	50	20.92	13	140	152	139	74	226	68	165	224	205		
			72	57	40	238	197	58	24	125	223	82		
			3	132	207	81	45	123	173	222	36	97		
			201	32	160	6	151	41	79	239	14	196		
			230	99	109	113	48	108	59	198	202	225		
30-40	67	28.03	87	53	107	227	229	128	192	143	15	169		
			75	85	162	47	73	122	168	88	114	218		
			171	182	163	221	98	54	191	141	63	172		
			127	43	17	190	105	179	175	103	236	174		
			90	4	212	55	180	178	111	12	199	50		
			67	30	112	142	38	95	209	29	193	219		
			84	124	150	22	159	208	89					
40-50	49	20.50	27	71	166	117	145	189	126	10	62	1		
			135	21	61	176	170	35	92	77	148	194		
			94	154	184	70	18	206	210	147	200	86		
			185	44	23	104	237	204	231	146	220	102		
			183	195	96	181	78	76	157	167	5			
50-60	23	9.62	52	20	153	134	83	69	7	106	26	133		
			116	119	156	91	49	101	33	42	129	80		
			100	115	120									
60-70	7	2.93	177	186	93	188	187	203	158					
Total	239	100												

Mean economic efficiency under risk ( $EE_r$ ) = 34.11 per cent

Coefficient of variation = 39.44 per cent

The farm-specific economic efficiency under risk ( $EE_{ur}$ ) has been depicted in Table 2. It is evident from this table that the majority of farmers (69.45 %) were realizing only 20-50 per cent economic efficiency. About 18 per cent farmers attained economic efficiency of less than 20 per cent, whereas 12.55 per cent farmers experienced economic efficiency between 50-70 per cent. No one was found at economic efficiency level equal to or higher than 70 per cent.

The economic inefficiencies due to risk are composed of inefficiencies due to technical and allocative risks. Table 3 discerns the pattern of technical

**Table 3. Farm-specific economic efficiency foregone due to technical risk**

Economic efficiency (per cent)	Number of farms		Farmer identification number											
	No.	% to total No.												
0-10	50	20.92	129	177	62	207	133	206	70	186	102	187		
			151	1	220	29	18	231	113	215	118	146		
			91	49	71	185	194	149	235	218	142	104		
			85	87	66	8	233	229	55	101	210	167		
			46	162	52	228	169	221	237	69	93	145		
10-20	79	33.05	219	225	230	116	209	158	227	204	80	168		
			175	147	61	201	78	50	24	76	74	183		
			165	222	40	17	114	32	86	136	191	121		
			166	112	178	148	163	44	106	141	197	88		
			217	205	170	95	58	67	188	157	43	184		
			173	212	4	189	171	223	224	238	135	203		
			181	53	172	115	111	176	131	39	199	30		
			14	89	48	119	193	19	56	42	21			
20-30	56	23.43	100	96	154	109	3	232	124	180	5	200		
			226	84	174	9	23	107	120	33	59	153		
			99	54	92	179	123	214	182	192	126	159		
			94	77	12	196	27	108	105	13	152	155		
			51	83	26	132	143	211	122	150	190	41		
			75	63	195	10	57	47						
30-40	27	11.30	73	117	31	60	72	160	198	98	208	128		
			38	28	6	156	97	15	134	103	20	7		
			81	16	45	125	22	202	140					
40-50	19	7.95	127	110	234	25	138	164	35	239	213	68		
			36	90	137	144	236	79	161	216	82			
50-60	5	2.09	139	130	37	64	2							
60-70	3	1.26	11	34	65									
Total	239	100												

Mean economic efficiency foregone due to technical risk ( $EE_{ur}$ ) = 20.86 per cent

Coefficient of variation = 64.77 per cent

inefficiencies existed in the study area. The mainstream of sampled farms demonstrated  $EE_{tr}$  to be less than 30 per cent, whereas 11.30 per cent demonstrated it as greater than or equal to 40 per cent. The economic inefficiencies due to farmers' perceived allocative risk were between 30 and 60 per cent for 68.20 per cent of farmers (Table 3).

The mean economic efficiency under risk has been estimated at the level of 34.11 per cent (Table 2). The economic inefficiency (65.89 %) is composed of economic efficiency foregone due to technical risk (20.86 %)

**Table 4. Farm-specific economic efficiency foregone due to allocative risk**

Economic efficiency (per cent)	Number of farms		Farmer identification number											
	No.	% to total No.												
10-20	11	4.60	7	156	20	65	134	35	236	90	120	11		
			26											
20-30	26	10.88	34	83	33	203	100	42	195	22	188	115		
			79	127	153	82	119	158	2	139	10	208		
			5	117	36	38	103	64						
30-40	54	22.59	93	239	80	130	106	96	94	77	150	202		
			23	15	216	144	200	92	181	37	98	116		
			27	126	157	101	128	63	154	68	190	73		
			159	47	187	45	12	69	81	21	75	186		
			125	76	122	105	49	198	177	6	84	124		
			176	78	52	97								
40-50	59	24.69	44	184	183	110	143	91	234	140	135	89		
			179	138	213	193	189	174	129	170	180	160		
			86	167	54	204	148	182	30	41	199	147		
			192	133	111	237	108	61	166	95	161	67		
			4	72	212	25	196	172	107	210	132	57		
			59	112	104	99	145	178	43	137	171			
50-60	50	20.92	146	50	141	109	123	209	219	185	231	88		
			220	53	163	102	48	191	31	17	194	175		
			14	28	114	152	3	16	18	13	51	206		
			168	70	164	55	71	155	1	221	142	226		
			227	173	62	211	169	223	162	60	29	225		
60-70	26	10.88	214	32	238	85	230	222	224	58	229	201		
			218	56	19	197	205	87	24	40	131	165		
			217	74	39	113	121	136						
70-80	9	3.77	151	207	233	9	46	232	8	66	235			
80-90	4	1.67	118	215	228	149								
Total	239	100												

Mean economic efficiency foregone due to allocative risk ( $EE_{ar}$ ) = 45.03 per cent

Coefficient of variation = 33.36 per cent



and economic inefficiency due to allocative risk (45.03%), as shown in Tables 3 and 4.

The variations in  $EE_{ar}$  (33.36 %) were found lower than those in  $EE_{tr}$  (64.77%) as given by the coefficient of variation. This is consistent with the findings of Kalirajan and Shand (1994). High (low)  $EE_{tr}$  was found associated with low (high)  $EE_{ar}$  (correlation coefficient = -0.5597). Also, the magnitude of  $EE_{tr}$  was lower than that of  $EE_{ar}$  as given by mean levels. These observations are against the conclusions drawn by Kalirajan and Shand (1994). The high levels of economic efficiency foregone due to allocative risk imply the non-optimal behaviour of the farmers. The net gains foregone owing to risk are significantly large and vary among the sample farmers.

## Conclusions

'Risk' arises from inadequate knowledge about best practice techniques (technical risk) and markets/prices (allocative risk). On the basis of this assumption, the economic inefficiency has been decomposed into inefficiencies due to technical and allocative risks.

More than 96 per cent of the difference between observed and frontier output has been found primarily due to the factors which are under the control of farms, i.e. due to technical inefficiencies. The mean economic efficiency under risk has been estimated at the level of 34.11 per cent. The economic inefficiency due to technical risk and allocative risk has respectively represented 20.86 and 45.03 per cent of the existing economic inefficiency. The variations in  $EE_{ar}$  have been found lower than those in  $EE_{tr}$ . A negative correlation has been observed between  $EE_{tr}$  and  $EE_{ar}$ . The amount of  $EE_{tr}$  has been found to be lower than that of  $EE_{ar}$ .

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