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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

Kehar Singh

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

[1] Department of Veterinary and Animal Husbandry Extension, College of Veterinary Sciences and Animal Husbandry, Central Agricultural University, Selesh - 796 014 (Aizwal), Mizoram

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 (SFPF). 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):

$$EE_{ur} = \frac{Y_1}{Y_5} \qquad \ldots(1)$$

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):

$$EE_{tr} = \frac{Y_2 - Y_1}{Y_5} \qquad \ldots(2)$$

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

$$EE_{ar} = 1 - \frac{Y_2}{Y_5} \qquad \ldots(3)$$

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:

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

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

$$\ln X_m - \ln Y = \ln \beta_m - \ln p_m + \ln p_y \quad \ldots(6)$$

There are (m+1) equations in (m+1) unknowns, x_1, x_2,…, x_m and y; the production parameters β_0, β_1, …, β_m, β_{m+1}, …, β_k are maximum likelihood estimates of the production frontier. The calculated inputs X_1^*, X_2^*, …, X_m^*, X_{m+1}^*,…, 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)]:

$$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \left(\nu_i - \mu_i\right) \quad \ldots(7)$$

where,

Y = production (kg); α, β_1, β_2, β_3, β_4 and β_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_4 = feed expenditure, v_1 = 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, σ^2_v) random variable, independent of μ_i's. U_i's were assumed to be non-negative truncations of the N (0, σ^2_u) distribution (i.e., half normal distribution).

The model has been estimated using Limdep 7.0 software, which gives the estimates of parameters λ (= $\sigma^2_u \div \sigma^2_v$), σ^2_u, σ^2_v, and σ. γ has been estimated from the estimates of σ^2_u, σ^2_v.

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 γ 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	α	0.8969	0.0185
		(0.3807)	
Pond area (acre) (X_1)	β_1	0.6120	0.0000
		(0.0373)	
Seed expenditure (INR) (X_2)	β_2	0.0155	0.0515
		(0.0080)	
Labor expenditure (INR) (X_3)	β_3	0.7022	0.0000
		(0.0464)	
Fertilizer expenditure (INR) (X_4)	β_4	0.0125	0.0019
		(0.0040)	
Feed expenditure (INR) (X_5)	β_5	0.0112	0.0000
		(0.0026)	
	Lambda (λ) =	5.0990	
		(1.4876)	0.0006
	Sigma (σ) =	0.6484	
		(0.0296)	0.0000
	Gamma (γ) =	0.9630	
	Sigma-squared (v) = σ^2_v	0.0156	
	Sigma-squared (u) = σ^2_u	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 σ^2_u and σ^2_v 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 γ 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: No.	Number of farms: % to total No.	Farmer identification number									
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_{tr}) = 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: No.	Number of farms: % to total No.	Farmer identification number									
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}) = 45.03per 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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