

## DOES AN IRRIGATORS' ASSOCIATION AFFECT PRODUCTIVITY OF RICE? A PRELIMINARY PRODUCTION FUNCTION ANALYSIS

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*The estimation of production function for groups of rice farmers with and without an irrigators' association (IA) reveals that the availability of irrigation water is a critical determinant of the technical efficiency of individual farmers. It is found that the mean level of technical efficiency of farmers located in the irrigation system with an IA is higher than that of farmers located in the system without an IA. Likewise, the variation of technical efficiency of farmers located in the system with an IA is lower than without an IA. These results suggest the critical role played by an IA in the O&M of irrigation systems and in ensuring the efficient and equitable distribution of water among farmers. Efficient and equitable distribution of scarce water in irrigation systems might be enhanced if IA implemented rational water rotation as well as better maintenance activities. Our study supports the hypothesis that the existence of an IA does affect the productivity of rice farming positively. Certainly, there could be many factors that are not included in this study that possibly affect the technical efficiency of farmers. In this sense, our evidence is circumstantial. Further study is necessary to single out the impact of an IA on the technical efficiency of farmers.*

Keywords distribution of water, irrigators' association, irrigation water, production function, rice, technical efficiency

### INTRODUCTION

Worldwide, particularly in rice-producing areas in monsoon Asia, a strong drive has been ongoing in the past two decades to transfer the responsibility of managing irrigation systems from the state agencies to the groups of water-users (Ostrom 1992). Underlying such a trend has been the recognition that the participation of water-users in the management of irrigation systems is a prerequisite for sustaining the performance of these systems, which were mostly constructed during the last few decades of the Green Revolution but have been deteriorating due to poor operation and maintenance (O&M). The Philippines is not an exception in this respect: as a national policy, the National Irrigation Administration (NIA) has been trying to create an irrigators' association (IA) with farmer beneficiaries and

hand over to them the responsibility of O&M of irrigation systems (Kikuchi et al 2001).

It has been expected that an IA, if built, will produce positive impacts on the performance of irrigation systems, indirectly through improving the quality of system maintenance, directly through improving the quality of system operation while enhancing equitable water distribution among water users. As a result, the productivity of rice production is expected to be higher in irrigation systems with an IA than those without an IA. The purpose of this paper is to examine if this contention is tenable. Specifically, we examine if the existence of an IA indeed improves the technical efficiency in rice production by estimating frontier production functions based on the data collected in irrigation systems with and without an IA.

## SAMPLE IRRIGATION SYSTEMS & SAMPLE CHARACTERISTICS

For this study, we selected two irrigation systems, one with an IA and the other without an IA. The former system is the Pula River Irrigation System in Mindoro Oriental with the command area of 2,800 ha. This system has been operated and managed by NIA since its construction in 1960 and IAs have been active since their formation in the 1980s practicing group maintenance activities and

two kinds of water rotation are implemented by NIA: between MC and Lateral A and between upper and lower reaches along MC and Lateral A. The former rotation has been enforced reasonably well, but the latter rotation has not been successful because of farmers' opportunistic behavior.

In these irrigation systems, we conducted a field survey to collect data on rice production in August-September 2000. The cropping seasons for which data were obtained were the 1999 wet season and the 1999/2000 dry

**Table 1. Sample characteristics, Cavite and Mindoro 2000**

	C a v i t e	M i n d o r o
<b>Number of Samples</b>	9 1	1 0 3
Downstream farmers	(5 4 % )	(5 3 % )
Upstream farmers	(4 6 % )	(4 7 % )
<b>Family Size (No.)</b>		
Male	3 . 4	3 . 6
Female	4 . 0	3 . 9
Total	7 . 4	7 . 5
<b>Farm size (ha)</b>	1 . 5 3	1 . 6 8
<b>Age of operators</b>	5 4 . 5	5 1 . 6
<b>Educational level of operators</b> (years of schooling)	6 . 2	7 . 4
<b>Tenure Status (%)</b>		
Owner-operator	3 6	4 8
Leaseholder	4 6	2 4
Share-tenancy	1 2	2 7
Sub-tenancy	5	1
<b>Household Income (Peso/yr)</b>		
Rice	2 2 , 8 8 9	4 8 , 5 1 0
Non-rice farming	1 6 , 8 5 3	1 0 , 4 4 1
Non-farm	4 3 , 9 6 7	4 1 , 5 6 6
Total	8 3 , 7 0 9	1 0 0 , 5 1 7
<b>Wage (Peso/day)</b>		
Agriculture	1 5 0	1 2 0
Construction	1 8 0 - 2 0 0	1 2 0 - 1 5 0

water rotation between Divisions as well as between upper and lower reaches within Laterals.

The other system, without an IA, is the Culong-Culong System in Cavite with a command area of 610 ha. This system is one of sub-systems of Cavite Friar Land Irrigation System, the construction of which dates back to the Spanish period. NIA has been trying to form an IA in this system since the 1980s, but so far has met with no success. Without an IA,

season. The number of sample farmers and basic sample characteristics are summarized in Table 1. On average, sample rice farmers share similar characteristics between the two systems in terms of family size, farm size, age of operators, educational attainment of operators and tenure status. The difference in the total household income is not so large as well, though income from rice farming in Mindoro is twice as high as in Cavite. Reflecting the proximity to the Metro-Manila,

the wage rates are significantly higher in Cavite than in Mindoro. It may be worth noting that, though the impacts of urbanization are far more distinct in Cavite, the non-farm income in Mindoro is as large as in Cavite. This is mainly because there is no

farmers in the systems. It is nearly the rule that farmers in the head-end of the systems have an inherent tendency to use water more lavishly than farmers in the tail-end of the systems and that when water is scarce the tail-enders suffer more seriously than head-

**Table 2. Average rice yield (mt/ha) by season and location, Cavite and Mindoro 1999/2000**

		Cavite			Mindoro		
		Wet	Dry	Average	Wet	Dry	Average
<b>Total</b>		3.4 27%	3.4 30%	3.4 28%	4.3 26%	4.3 26%	4.3 26%
<b>Upstream</b>	(1)	3.6 24%	3.7 27%	3.7 25%	4.6 20%	4.8 20%	4.7 20%
<b>Downstream</b>	(2)	3.1 28%	3.1 30%	3.1 29%	3.9 29%	3.7 26%	3.8 28%
<b>(1) - (2)</b>	**	0.5	0.6	0.6	0.7	1.1	0.9
<b>(2)/(1)</b>		0.85	0.84	0.84	0.85	0.77	0.81

\* Percentage figures are the coefficient of variation of rice yield.

\*\* Yield difference between upstream and downstream is statistically significant at 1% level for both systems for both seasons.

significant difference between Cavite and Mindoro in the amount of remittances from abroad by overseas workers belonging to local families.

## RICE PRODUCTION IN THE SYSTEMS

### *Rice yield by location in the system*

First, we summarize rice yield/ha in the systems in Table 2 by season and by location in the systems. For the systems as a whole, rice yield in the Cavite system (without an IA) is 3.4 mt/ha, while it is 4.3 mt/ha in the Mindoro system (with an IA); the yield difference between these two systems are statistically significant at the 1% significance level. Such yield differences are what we expect to find in irrigation systems with and without an IA. Within each system, the yield differences between the wet and the dry seasons are nil.

The most common problem in gravity irrigation systems is the difficulty of distributing irrigation water equitably among

enders. A result of this is higher yield in the head-end than in the tail-end. This is exactly the case in the systems; farmers in upstream attain significantly higher yields than those in downstream in both systems. The yield differences between upstream and downstream are, however, smaller in Cavite than in Mindoro. One may expect that irrigation systems with an IA attain more equitable water distribution within their systems through implementing water rotation and other measures that improve system performance. If so, yield differences between upstream and downstream are expected to be smaller in irrigation systems with an IA than in those without an IA. In this respect, our systems do not satisfy the expectation.

More equitable water distribution due to a well-functioning IA may reveal its positive impact in smaller variations in rice yields within an irrigation system. Table 2 shows that the yield variations, as measured by the coefficient of variation, are larger in Cavite than in Mindoro. It is suggestive that the

variation was relatively large in the dry season in Cavite. However, the differences between Cavite and Mindoro are so small that it is hardly possible to conclude that the differences are a gauge to the positive impact of an IA.

Simple statistical analyses of rice yield/ha thus deny an easy conclusion as to the impacts of an IA on the productivity in rice production. Rice yield/ha depends not only on irrigation activities but more heavily on various other factors, such as the levels of production inputs and of farmers' technology.

### *Production inputs and factor shares in rice production*

Before proceeding to estimate production functions to control these various factors, let

Mindoro for the average of upstream and downstream, while it is only 67 kg/ha in Cavite. It is also observed that the levels of current inputs are less in downstream than in upstream in each system. The differences in the intensity of current inputs are thus consistent with the differences in rice yield/ha, and should therefore explain to a certain extent the yield gaps between the Cavite system and the Mindoro system and between upstream and downstream in each system.

Table 4 presents labor intensity in rice production. Labor person-days/ha is larger in Cavite than in Mindoro. It is interesting to see, however, that the labor item for which labor input is significantly different between the two systems is irrigation control; labor requirement for irrigation control is much

**Table 3. Current inputs for rice production per ha, Cavite and Mindoro, wet and dry average 1999/2000**

	Cavite			Mindoro		
	Up-stream	Down-stream	Average	Up-stream	Down-stream	Average
<b>Seeds (cavan)</b>	2.4	2.0	2.2	2.2	2.3	2.3
<b>Fertilizer (bag)</b>						
Urea (46-0-0)	2.3	2.2	2.3	2.8	1.9	2.3
Ammonium Sulfate (21-0-0)	0.0	0.0	0.0	2.2	2.0	2.1
Ammonium Phosphate (16-20-0)	0.2	0.7	0.5	1.2	2.4	1.8
Complete (14-14-14)	1.6	1.5	1.5	1.8	1.8	1.8
<b>Insecticide (liter)</b>	1.4	1.5	1.4	1.6	1.7	1.6
<b>Weedicide (liter)</b>	0.8	0.9	0.8	1.1	0.9	1.0
<b>Control of Snail (liter)</b>	0.7	0.5	0.6	0.9	0.8	0.8

us observe rice farming in the systems in terms of the levels of production inputs and factor shares. Since the differences between wet and dry seasons are insignificant in both the systems, we show the averages of the two seasons in what follows.

The levels of current inputs, such as seeds, fertilizers and chemicals, are summarized in Table 3. Comparing the two systems, the levels of current inputs are higher in Mindoro than in Cavite. In the case of fertilizer, for example, the applied level of total nitrogen in terms of nutrient content is 102 kg/ha in

larger in Cavite (without an IA) than in Mindoro (with an IA). Excluding labor inputs for irrigation control, the total work-days/ha are nearly the same for the two systems. In any case, the differences in labor intensity are not very consistent with the yield differences between the two systems. Comparing between upstream and downstream in each system, labor intensity is generally higher in upstream than in downstream, which is consistent with the yield differences.

Table 5 summarizes the structure of rice production in terms of factor payment and

factor share. Production inputs are grouped into four categories: (1) current inputs, (2) fixed capital services, (3) labor, and (4) land. A distinct difference between the two systems is found in the return to land, which is computed as the residual after deducting the non-land costs from the gross output; it is far more in Mindoro than in Cavite. This results from two facts. The first fact is that non-land costs (the sum of factor payments for current inputs, capital and labor)/ha is higher in Cavite, and the second fact is that, in spite of higher non-land costs, yield/ha is lower in Cavite. As

factor payments are consistently larger in upstream than in downstream, and so is rice output/ha. Accordingly, the factor shares are slightly different between the two locations in each system. But, it should be noted that the intra-system differences in factor shares are not as distinct as the inter-system differences.

### *Estimation of Rice Production Function*

The overview above of rice farming in the two systems reveals that the production structures observed in terms of factor share

**Table 4. Labor use (person-days) in rice production per ha, Cavite and Mindoro, wet and dry average 1999/2000**

	Cavite			Mindoro		
	Up-stream	Down-stream	Average	Up-stream	Down-stream	Average
Land Preparation	10.6	7.9	8.9	8.2	8.5	8.5
Transplanting	10.7	10.2	10.5	12.3	12.8	12.4
Weeding	13.6	13.3	13.5	10.7	7.8	9.7
Irrigation Control	7.9	7.0	7.4	2.6	2.7	2.7
Harvesting and Threshing	19.8	21.9	21.0	19.7	18.4	18.9
Others	3.7	3.6	3.6	7.3	5.3	6.6
Total	66.3	63.9	64.9	60.8	55.4	58.7
% hired	61%	73%	67%	83%	81%	82%
Total (excluding irrigation control)	58.4	56.9	57.4	58.2	52.7	56.0

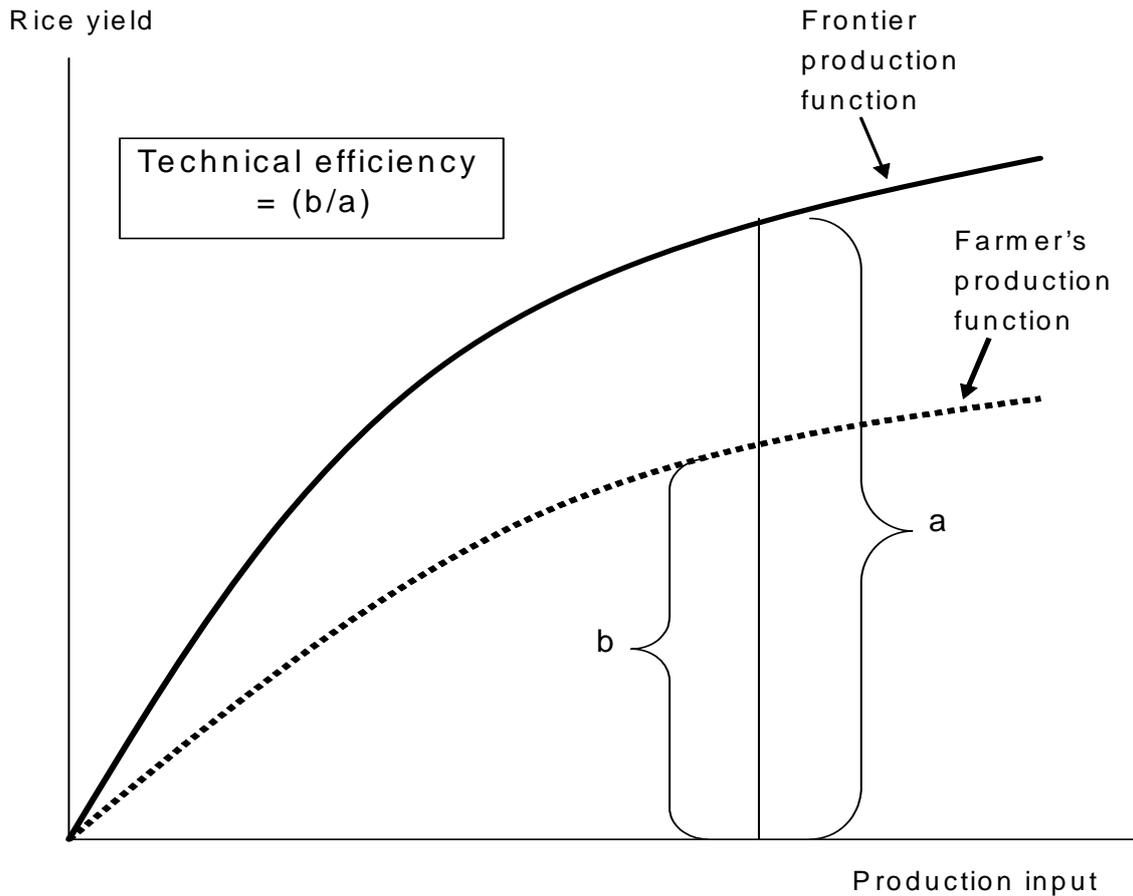
shown in Table 3, farmers in the Cavite system use less current inputs than their counterparts in the Mindoro system, but they use more labor and capital. The cost of labor is higher in Cavite partly because of the higher labor intensity (Table 4), but more because of the higher wage rate (Table 1). The higher capital cost may indicate that with the higher wage rate farmers in Cavite try to substitute labor for fixed capital. As a result, the factor shares in rice production differ significantly between the two systems. In Cavite, the share of labor is as high as 43%, followed by the shares of land (21%) and capital (17%). In contrast, the share of land is as high as 44% in Mindoro, followed by the share of labor (27%). The share of capital takes only 9% in Mindoro.

Comparing upstream and downstream in each system, it should be remarked that the

are significantly different between the two. But it gives nearly no clue as to the question of how far the existence of an IA in irrigation systems affects the productivity of rice production. In this section, we try to obtain some clues as to the answer to this question through estimating frontier production functions and examining the technical efficiency of farmers in the two systems.

### **Model**

The representative way to measure the technical efficiency of individual farmers is to estimate a frontier production function. Numerous refinements have been made on the frontier function methodology since it was introduced by Farrel (1957). Some earlier studies tried to estimate inefficiency effects by adopting a two-stage approach; first, estimate



**Figure 1. Frontier production function, farmer's (average) production function and farmer-specific technical efficiency**

the stochastic frontier production function and then regress the technical inefficiency index, which is derived from the density function obtained in the first stage, on the set of explanatory variables that causes technical inefficiency (Kalirajan 1981). Battese and Coelli (1995) developed a one-stage estimation procedure wherein potentially influential variables are simultaneously estimated along with the variables that describe the production technology. This is the model we adopt in this paper.

In this inefficiency effect model by Battese and Coelli (1995), the stochastic frontier production function can be written as

$$Y_i = \beta'X_i + V_i - U_i \quad (1)$$

where  $Y_i$  is the logarithm of rice production of the  $i$ -th farmer;  $X_i$  is a column vector ( $k \times 1$ ) of input variables of the  $i$ -th farm;  $\beta$  is a column vector ( $k \times 1$ ) of unknown parameters;  $V_i$  is the random error that captures statistical noise, measurement error, and exogenous shocks beyond the control of farmers, assumed to be independently and identically normally

distributed  $N(0, \sigma_v^2)$ ; and  $U_i$  is non-negative random variables that represent the departure from the frontier due to technical inefficiency of individual farmers and assumed to be non-negative truncated distribution of  $N(\mu_i, \sigma_u^2)$  at zero.

The mean of  $U_i$  is defined as

$$\mu_i = \delta'Z_i \quad (2)$$

where  $\delta$  is a column vector ( $m \times 1$ ) of parameters to be estimated,  $Z_i$  is a column vector ( $m \times 1$ ) of explanatory variables that causes the technical inefficiency of farmers.

The parameter  $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$  defines the share in the total output variation ( $\sigma^2 = \sigma_v^2 + \sigma_u^2$ ) of the variation attributable to technical inefficiency, and as such must lie between 0 and 1. If  $\gamma = 1$ , all the composed errors are attributable to technical inefficiency.

The technical efficiency of production for the  $i$ -th farm is given by

$$TE_i = \exp(-U_i) \quad (3)$$

which is the ratio of observed production to the corresponding frontier production

associated with no technical inefficiency (Figure 1).

### Regression model

**Average production function:**  
Assuming the Cobb-Douglas, the production function for *i*-th farmer can be expressed as follows:

tractor used in land preparation (peso); Labor is the number of person-hours applied excluding the postharvest activities such as hauling of paddy and threshing operations; WATER is the dummy variable representing farmers' perception as to the availability of water throughout the cropping season (sufficient = 1, not sufficient = 0); LOCATION

**Table 5. Factor payments and factor shares of rice production, Cavite and Mindoro, wet and dry average 1999/2000**

	Factor Payments (kg*/ha)			Factor Share (%)		
	Up-stream	Down-stream	Average	Up-stream	Down-stream	Average
<b>Cavite:</b>						
Total output	3,652	3,085	3,362	100	100	100
Current Input	621	615	618	17	20	18
Capital	572	560	566	16	18	17
Owned	112	90	101	3	3	3
Hired	460	470	465	13	15	14
Labor	1,609	1,320	1,462	44	43	43
Family	659	418	536	18	14	16
Hired	950	902	926	26	29	27
Return to Land**	850	590	716	23	19	21
<b>Mindoro:</b>						
Total output	4,728	3,835	4,278	100	100	100
Current Input	879	827	862	18	21	20
Capital	417	375	396	9	10	9
Owned	93	122	107	2	3	2
Hired	324	253	289	7	7	7
Labor	1,219	1,081	1,149	26	28	27
Family	195	241	218	4	6	5
Hired	1,024	840	931	22	22	22
Return to Land**	2,213	1,552	1,871	47	41	44

\* In rough rice equivalent.

\*\* Residual.

$$\ln Y_i = \beta_0 + \beta_1 \ln \text{Land}_i + \beta_2 \ln \text{Current}_i + \beta_3 \ln \text{Capital}_i + \beta_4 \ln \text{Labor}_i + \beta_5 \text{WATER}_i + \beta_6 \text{LOCATION}_i + \beta_7 \text{OWNER}_i + \beta_8 \text{SEASON}_i + \beta_9 \text{SYSTEM}_i + E_i$$

where the subscript *i* refers to farmers; ln denotes logarithms; Y is the rice output (kg); Land is the area planted to rice (ha); Current is the sum of paid and/or imputed cost of current inputs (peso); Capital is the sum of paid and/or imputed rentals of carabao and

is the dummy variable representing the rice field's location in the irrigation system (upstream = 1, downstream = 0); OWNER is the dummy variable representing the tenure status of farmers (landowner-operator = 1, otherwise = 0); SEASON is the dummy variable representing the cropping season (Dry = 1; Wet = 0); SYSTEM is the dummy variable for village location (Mindoro = 1; Cavite = 0); and E is the random error term.

**Stochastic frontier production function:** Following the average production

field location within each irrigation system in the estimation of rice production.

**Table 6. Average Cobb-Douglas production function, Cavite and Mindoro 1999/2000**

		Cavite		Mindoro		Total	
		Coefficient	SE	Coefficient	SE	Coefficient	SE
Ln Land	$\beta_1$	0.310 ***	0.093	0.440 ***	0.076	0.396 ***	0.058
Ln Current input	$\beta_2$	0.197 ***	0.075	0.146 **	0.068	0.185 ***	0.050
Ln Capital	$\beta_3$	0.125 *	0.072	0.073 *	0.053	0.080 *	0.042
Ln Labor	$\beta_4$	0.337 ***	0.121	0.269 ***	0.088	0.271 ***	0.069
WATER	$\beta_5$	0.177 ***	0.051	0.120 ***	0.046	0.134 ***	0.033
LOCATION	$\beta_6$	0.110 **	0.047	0.162 ***	0.036	0.137 ***	0.028
OWNER	$\beta_7$	- 0.132 ***	0.043	-0.059 *	0.034	- 0.086 ***	0.026
SEASON	$\beta_8$	0.117 ***	0.044	0.026	0.032	0.057 **	0.026
SYSTEM	$\beta_9$					- 0.118	0.089
Constant	$\beta_0$	0.431	0.475	0.396	0.264	0.517 **	0.250
Adjusted R <sup>2</sup>		0.776		0.887		0.858	

a Coefficients with \*, \*\*, \*\*\* are significant at 10%, 5%, and 1%, respectively.

function, the frontier production function is specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln Land_i + \beta_2 \ln Current_i + \beta_3 \ln Capital_i + \beta_4 \ln Labor_i + \beta_5 SYSTEM_i + V_i - U_i$$

The error term consists of two components: the  $V_i$  that captures the effects of random noise and the  $U_i$  intended to capture the effects of technical efficiency. The inefficiency may be expressed as:

$$\mu_i = \delta_0 + \delta_1 WATER_i + \delta_2 LOCATION_i + \delta_3 OWNER_i + \delta_4 SEASON_i$$

where  $\mu_i$  is the inefficiency measure of farmer  $i$ . SYSTEM can be treated as a variable that may create inefficiency. In this study, however, we use this dummy variable to control the difference in the frontier function of each sample system. The inclusion of this variable in the inefficiency function does not alter the results of our estimation. These two equations are estimated simultaneously by applying the maximum likelihood estimation method.

### Results of estimation

**Average production function:** The estimation results are presented in Table 6. It is worth mentioning that during the process of estimation, the inclusion of LOCATION contributes to the high value of R<sup>2</sup>. This clearly indicates the significant influence of

The regression results show that all the estimated coefficients of conventional inputs are with the expected signs and all of them, except for the coefficient of capital in Cavite, are statistically significant. It should be reminded that the production elasticities are equivalent to the functional shares of factor inputs under the assumption of competitive market equilibrium. For both the systems, the order of magnitude of the estimated production elasticities is exactly the same as for the factor shares presented in Table 5. In particular, we find close affinity between the production elasticity and factor share for land and labor.

Among the dummy variables, the coefficients of WATER, LOCATION and OWNER are statistically significant. As expected, farmers in the upstream of the systems attain significantly higher productivity than those in the downstream. The negative sign of OWNER indicates that the productivity of owner operators is significantly lower than tenant operators. It should be noted that this dummy variable seems to pick up the impact of the age of farm operators, rather than the tenure status *per se*. In both the systems, owner operators tend to be significantly older than tenant operators, lease holders and share tenants alike. The

coefficient of SEASON is also significant for Cavite and the pooled regression, suggesting the yield superiority of dry season. But this relation is not picked up for Mindoro. It should also be remarked that SYSTEM gives no significant coefficient in the pooled regression. This indicates that there is no productivity

The parameter  $\gamma$  is found to be highly significant, suggesting that technical inefficiency exists. The coefficients of the WATER and LOCATION dummies are estimated to be negative and significant for Mindoro and the pooled regression. The negative sign means that technical

**Table 7. Maximum likelihood estimates of the parameters of the stochastic frontier production function of rice farmers in Cavite and Mindoro 1999/2000<sup>a</sup>**

Variables		Cavite		Mindoro		Total	
		Coefficient	SE	Coefficient	SE	Coefficient	SE
Ln Land	$\beta_1$	0.246 ***	0.080	0.551 ***	0.071	0.432 ***	0.056
Ln Current	$\beta_2$	0.156 **	0.064	0.038	0.065	0.130 **	0.044
Ln Capital	$\beta_3$	0.190 **	0.085	0.089 *	0.055	0.102 **	0.066
Ln Labor	$\beta_4$	0.412 ***	0.091	0.247 ***	0.084	0.263 ***	0.088
SYSTEM	$\beta_5$					-0.073	0.088
Constant	$\beta_0$	1.007 *	0.524	0.836	0.237	1.009 ***	0.234
WATER	$\delta_1$	- 0.242	0.174	- 0.163 **	0.071	-0.171 ***	0.049
LOCATION	$\delta_2$	- 0.162	0.135	- 0.290 ***	0.099	-0.200 ***	0.053
OWNER	$\delta_3$	0.169 **	0.070	0.100	0.066	0.124 ***	0.045
SEASON	$\delta_4$	- 0.185	0.136	- 0.046	0.059	-0.085 **	0.042
Constant	$\delta_0$	0.659 ***	0.072	0.454	0.106	0.494 ***	0.084
Sigma-squared	$\sigma^2$	0.057 ***	0.015	0.069 ***	0.018	0.579 ***	0.009
Gamma	$\gamma$	0.999 ***	0.000	0.853 ***	0.081	0.792 ***	0.116
Mean Tech. Efficiency		<b>0.676</b>		<b>0.756</b>		<b>0.735</b>	
Log-likelihood Function		26.959		32.937		50.237	

a Coefficients with \*, \*\*, \*\*\* are significant at 10%, 5%, and 1%, respectively.

difference between the two systems, once differences in input levels are taken into account.

**Stochastic frontier production function:** The maximum likelihood estimates for the parameters of the stochastic frontier production function are presented in Table 7. A computer program, Frontier 4.1, created by Coelli (1996), is used for the estimation.

The results of the frontier production estimation show that all the coefficients of the conventional inputs are statistically significant with the expected sign and remarkably close to the respective factor shares, except for current input in Mindoro.

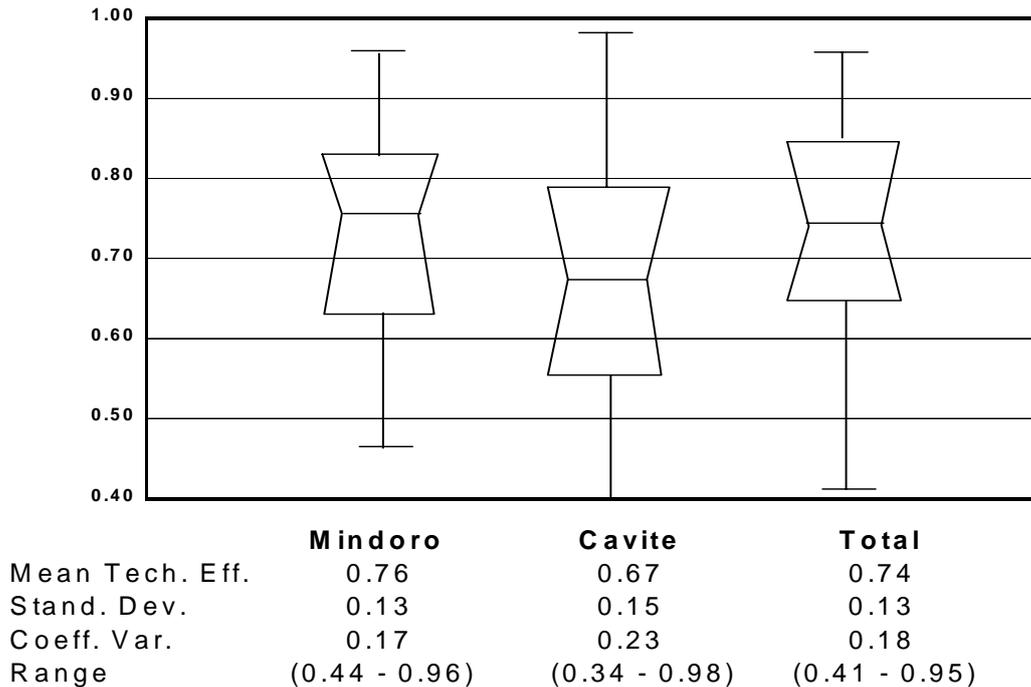
inefficiency (or the distance from the frontier function) is less, if the dummy variables are on. The results thus suggest that the availability of water is a critical determinant of technical inefficiency. Such results are consistent with earlier findings that the upstream farmers have higher rice yields than the downstream farmers in both systems.

In the pooled regression, OWNER and SEASON also give significant coefficients. The positive sign for the former indicates that the owner operators' technical efficiency is lower than tenant operators. Since this dummy is highly correlated with operators' age, as mentioned earlier, this fact may imply that

the technical efficiency becomes lower as farmers become very old. The negative coefficient for SEASON means that technical efficiency is higher in dry season than in wet season. It should be noted that in the process of estimation the age and educational level of farmers were included in the estimation of technical efficiency, but omitted since they yielded no significant result.

The mean technical efficiency of farmers in Mindoro is estimated to be 0.76, higher

estimated to be lower in the Mindoro system than in the Cavite system; in terms of the coefficient of variation, it is 17% in Mindoro and 23% in Cavite. As observed in Table 1, the farmers in the two systems share similar characteristics in many respects. With such similarity, the lower variation in technical efficiency among farmers coupled with the higher technical efficiency on average in Mindoro may infer the critical role of an IA in ensuring the more equitable distribution of



Note: The mortar-shape depicts 2-SD range around the mean.

**Figure 2. Technical efficiency distribution in Mindoro and Cavite 1999/2000**

than that in Cavite, which is 0.68. In the pooled estimation, the estimated mean of technical efficiency is 0.74; the average production function is located 26% below the frontier production function. Compared to the level of technical efficiency of 0.89 estimated for rice farmers in Nueva Ecija (Dawson et al 1991), the level of technical efficiency in our study systems is lower. More recent estimation by Gonzales et al (2004) gives the mean technical efficiency for rice farmers in irrigated areas in the Philippines of 0.67-0.75, the range of which tallies quite well with our estimates.

The distribution of sample farmers by the level of technical efficiency is shown in Figure 2. The variation in technical efficiency is

water among the IA members. On the other hand, the absence of an IA in Cavite might have resulted in the higher variation in and the lower mean level of technical efficiency.

## CONCLUSIONS

The estimation of production function for groups of rice farmers with and without an irrigators' association (IA) reveals that the availability of irrigation water is a critical determinant of the technical efficiency of individual farmers. It is found that the mean level of technical efficiency of farmers located in the irrigation system with an IA is higher than that of farmers located in the system without an IA. Likewise, the variation of

technical efficiency of farmers located in the system with an IA is lower than without an IA. These results suggest the critical role played by an IA in the O&M of irrigation systems and in ensuring the efficient and equitable distribution of water among farmers. Efficient and equitable distribution of scarce water in irrigation systems might be enhanced if an IA implemented rational water rotation as well as better maintenance

activities. Our study supports the hypothesis that the existence of an IA does affect the productivity of rice farming positively.

Certainly, there could be many factors that are not included in this study that affect the technical efficiency of farmers. In this sense, our evidence is circumstantial. Further study is necessary to single out the impact of an IA on the technical efficiency of farmers.

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