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## Efficiency in agricultural production: the case of peasant farmers in eastern Paraguay

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### Abstract

This paper contributes to the productivity literature in developing country agriculture by quantifying the level of efficiency for a sample of peasant farmers from Eastern Paraguay. A stochastic efficiency decomposition methodology is used to derive technical, allocative and economic efficiency measures separately for cotton and cassava. An average economic efficiency of 40.1% for cotton and of 52.3% for cassava is found, which suggests considerable room for productivity gains for the farms in the sample through better use of available resources given the state of technology. Gains in output through productivity growth have become increasingly important to Paraguay as the opportunities to bring additional virgin lands into cultivation have significantly diminished in recent years. No clear strategy to improve farm productivity could be gleaned from an examination of the relationship between efficiency and various socioeconomic variables. One possible explanation for this finding is the existence of a stage of development threshold below which there is no consistent relationship between socioeconomic variables and productivity. If this is the case, then our results suggest that this sample of Paraguayan peasants are yet to reach such a threshold. Hence, improvements in educational and extension services, for example, would be needed to go beyond this threshold. Once this is accomplished, additional productivity gains would be obtained by further investments in human capital and related factors.

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### 1. Introduction

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers alike. It is no sur-

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prise, therefore, that considerable effort has been devoted to the analysis of farm level efficiency in developing countries. An underlying premise behind much of this work is that if farmers are not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing agricultural output (Belbase and Grabowski, 1985; Shapiro, 1983).

Most of the empirical literature dealing with farm efficiency in developing countries has been concerned exclusively with the measurement of technical efficiency. Studies of this type have been published for India, The Philippines, Sri Lanka, Nepal, Malaysia, Tanzania, Jamaica, Guatemala, and Brazil (Huang and Bagi, 1984; Kalirajan and Shand, 1985; Kalirajan, 1981, 1984; Lingard, Castillo and Jayasuriya, 1983; Kalirajan and Flinn, 1983; Ekayanake, 1987; Kalirajan and Shand, 1986; Shapiro and Müller, 1977; Rawlins, 1985; Phillips and Marble, 1986; Taylor and Shonkwiler, 1986). By focusing only on technical efficiency, these works have ignored the gains in output that could be obtained in the short run by also improving allocative efficiency.

There are only a few studies that go beyond the measurement of technical efficiency in developing country agriculture. These include the work by Taylor, Drummond and Gomes (1986), who analyzed technical and economic efficiency for a sample of Brazilian farmers; Bailey et al. (1989), who measured technical, allocative and scale inefficiency for a sample of Ecuadorean milk producers; and Ali and Chaudry (1990), who examined technical, allocative and economic efficiency for a sample of Pakistani crop farmers.

The purpose of this paper is to contribute to the efficiency literature in developing country agriculture by quantifying the level of technical, allocative and economic efficiency for a sample of peasant farmers from Eastern Paraguay. The relationship between efficiency and various socioeconomic characteristics of the peasants is also investigated. The remainder of this paper is organized into five sections. First, we present a brief background of the Paraguayan agricultural sector, followed by the analytical framework employed in

this study. The data and empirical model are discussed next, followed by a section containing the results and analysis. The last section offers some concluding remarks.

## 2. Background

The agricultural sector in Paraguay, as is often the case in less developed nations, has played a key role in this country's development strategy. An important component of this strategy was the availability of public lands which were distributed to settlers as a means of both absorbing a growing population and of increasing agricultural output (Nagel, 1991). These settlements, along with massive migration to Argentina during the 1950s and 1960s, delayed the process of rural to urban migration and eased the need for improving agricultural productivity (Nikiphoroff and Villagra, 1987).

In the late 1960s and through the 1970s, Paraguay experienced rapid economic growth resulting in part from favorable international commodity prices and, more importantly, from cash inflows stemming from the huge hydro-electric project in Itaipú (Evenson, 1988). According to the World Bank, the average annual rate of growth in Paraguayan agriculture during the 1965–80 period was a healthy 4.9%. By the late 1970s, however, the availability of public lands for agricultural use had diminished considerably, and the vast resources generated during the construction of the Itaipú project had failed to provide a lasting solution to the rising levels of unemployment and poverty (Nikiphoroff and Villagra, 1987).

In the early 1980s, Paraguay entered a severe recession resulting in a negative one-percent growth in the gross national product (GNP). The annual average GNP growth rate between 1981 and 1986 was a meager 0.6% (BID, 1987). During this same period, the rate of growth in agriculture remained positive but dropped to an annual average of 2.0%. By comparison, the average annual population growth rates went from 2.8% in the 1965–80 period to 3.2% during the 1980–87 period (World Bank, 1989). This poor economic

performance, along with rapid population expansion and the dwindling supply of public lands suitable for cultivation, has made farm productivity growth a major policy issue in Paraguay (Nikiphoroff and Villagra, 1987).

### 3. Analytical framework <sup>1</sup>

We begin by assuming that the farm frontier production function can be written as:

$$Q = g(X_a; \beta) \quad (1)$$

where  $Q$  is the quantity of agricultural output,  $X_a$  is a vector of input quantities, and  $\beta$  is a vector of parameters. The technically efficient input vector  $X_t$ , for a given level of production ( $\bar{Q}$ ), is derived by solving simultaneously Eq. (1) and the input ratios  $X_i/X_t = k_i$  ( $i > 1$ ), where  $k_i$  is the ratio of observed inputs  $X_i$  and  $X_t$  at output  $\bar{Q}$ .

If the functional form of the production frontier is self-dual, for example Cobb–Douglas, then the corresponding cost frontier can be derived analytically and written in general form as:

$$C = h(P, Q; \gamma) \quad (2)$$

where  $C$  is the minimum cost associated with the production of  $Q$ ,  $P$  is a vector of input prices, and  $\gamma$  is a vector of parameters. By using Shephard's Lemma, we obtain:

$$\frac{\partial C}{\partial P_i} = X_i(P, Q; \Phi) \quad (3)$$

which is a system of minimum cost input demand equations. Substituting a firm's input prices and output quantity into the demand system in Eq. (3) yields the economically efficient input vector  $X_e$ . Given a farm's observed level of output, the corresponding technically and economically efficient costs of production are equal to  $X_t' \cdot P$  and to  $X_e' \cdot P$ , respectively, while the cost of the farm's

actual operating input combination is  $X_a \cdot P$ . These three cost measures are the basis for computing the following technical (TE) and economic (EE) efficiency indexes:

$$TE = (X_t' \cdot P) / (X_a' \cdot P) \quad (4)$$

and

$$EE = (X_e' \cdot P) / (X_a' \cdot P) \quad (5)$$

Following Farrell (1957), Eqs. (4) and (5) can be combined to obtain the allocative efficiency (AE) index:

$$AE = (EE) / (TE) = (X_e' \cdot P) / (X_t' \cdot P) \quad (6)$$

To empirically measure efficiency, we first estimate a stochastic production frontier and then use the approach introduced by Jondrow et al. (1982) to separate the deviations from the frontier into a random and an efficiency component. To show how this separation is accomplished, consider the stochastic production frontier:

$$Q = f(X_a; \beta) + \epsilon \quad (7)$$

where

$$\epsilon = v - u \quad (8)$$

is the composed error term (Aigner, Lovell and Schmidt, 1977; Meeûsen and van den Broeck, 1977). The two components  $v$  and  $u$  are assumed to be independent of each other, where  $v$  is the two-sided, normally distributed random error ( $v \sim N(0, \sigma_v^2)$ ), and  $u$  is the one-sided efficiency component with a half-normal distribution ( $u \sim |N(0, \sigma_u^2)|$ ). The maximum likelihood estimation of Eq. (7) yields estimators for  $\beta$  and  $\lambda$ , where  $\beta$  was defined earlier,  $\lambda = \sigma_u / \sigma_v$  and  $\sigma^2 = \sigma_u^2 + \sigma_v^2$ .

Jondrow et al. (1982) have shown that the assumptions made on the statistical distributions of  $v$  and  $u$ , mentioned above, make it possible to calculate the conditional mean of  $u_j$  given  $\epsilon_j$  as:

$$E(u_j | \epsilon_j) = \sigma^* \left[ \frac{f^*(\epsilon_j \lambda / \sigma)}{1 - F^*(\epsilon_j \lambda / \sigma)} - \frac{\epsilon_j \lambda}{\sigma} \right] \quad (9)$$

where  $F^*$  and  $f^*$  are, respectively, the standard normal density and distribution functions, evaluated at  $\epsilon_j \lambda / \sigma$ , and  $\sigma^2 = \sigma_u^2 - \sigma_v^2 / \sigma^2$ . Therefore, Eqs. (7) and (9) provide estimates for  $u$  and  $v$  after replacing  $\epsilon$ ,  $\sigma$ , and  $\lambda$  by their estimates. If

<sup>1</sup> The model presented in this section is based on the stochastic efficiency decomposition approach presented by Bravo-Ureta and Rieger (1991), which is an extension of the model introduced by Kopp and Diewert (1982). For reviews of frontier function methodology, see Forsund, Lovell and Schmidt (1980) and Schmidt (1985–86).

$v$  is now subtracted from both sides of (7), we obtain:

$$Q^* = f(X_a; \beta) - u = Q - v \quad (10)$$

where  $Q^*$  is the firm's observed output adjusted for the statistical noise captured by  $v$ . Eq. (10) is the basis for computing the vector  $X_t$  and for algebraically deriving the cost frontier. Applying Shephard's Lemma to the cost frontier yields the minimum cost factor demand equations which, in turn, are used to obtain the vector  $X_e$ .

In closing this section, it is useful to point out that an important issue in stochastic frontier models is the distributional assumptions made for the one-sided error. Much of the literature to date, including this paper, has followed the half-normal distribution, as originally proposed by Aigner, Lovell and Schmidt (1977), despite the fact that more flexible distributions are available. One of the few papers that have examined the sensitivity of the efficiency results to distributional assumptions was published recently by Greene (1990), where he introduced a stochastic frontier specification that incorporates the Gamma distribution. After comparing several specifications, Greene (1990) concluded that, for his data, efficiency levels were essentially the same for the half-normal, truncated normal and exponential distributions while the Gamma model yielded higher efficiency<sup>2</sup>. In a review of new developments in frontier function methodology, Bauer (1990) argued that additional empirical as well as theoretical work is needed to arrive at a better understanding of the effects that alternative distributional assumptions have on efficiency.

#### 4. Data and empirical procedures

The data used in this paper come from a random sample of small-scale Paraguayan producers for the 1986–87 agricultural year collected in July, 1987. The sample is comprised of 148

peasant farms producing traditional food crops and cotton in Eastern Paraguay. The farms in the sample are located in the following eight districts: Caaguazú, Yhú, Eusebio, Ayala, Yaguarón, Pirayu, Villeta, and Ita<sup>3</sup>.

The analysis reported below focuses on the two most important crops grown in the study region, cotton and cassava, for which the data are most reliable. After deleting farmers not producing these crops and discarding incomplete records, we end up with 87 cotton producers and 101 cassava producers. A total of 57 farmers produced both crops. This latter group is referred to as the subsample.

The Cobb-Douglas functional form was used to fit separate stochastic production frontiers for cotton and cassava using maximum likelihood procedures. Despite its well known limitations, the Cobb-Douglas is chosen because the methodology employed requires that the production function be self-dual. It is also worth stating that this functional form has been widely used in farm efficiency analyses for both developing and developed countries<sup>4</sup>. Furthermore, in one of the very few studies examining the impact of functional form on efficiency, Kopp and Smith (1980) concluded "...that functional specification has a discernible but rather small impact on estimated efficiency" (p. 1058).

The use of the single-equation model depicted in Eq. (11) is justified by assuming that farmers maximize expected profits, as is commonly done in studies of this type (Zellner, Kmenta and Drèze, 1966; Kopp and Smith, 1980; Caves and Barton, 1990). The specific model estimated is:

$$\ln Y = \beta_0 + \beta_1 \ln R + \beta_2 \ln L + \beta_3 \ln M + \epsilon \quad (11)$$

where  $Y$  is annual total farm output of cotton or cassava (kg);  $R$  the area devoted to cotton or cassava production (ha);  $L$  family and hired

<sup>2</sup> It should be noted that several years ago Greene (1980) introduced the Gamma distribution in the context of a deterministic frontier model.

<sup>3</sup> For additional details concerning the data the interested reader is referred to Evenson (1988).

<sup>4</sup> Support for this statement can be found in the reviews of the empirical literature recently completed by Battese (1992) and by Bravo-Ureta and Pinheiro (1992).

Table 1  
Average production functions and stochastic production frontiers for cotton and cassava based on a sample of Paraguayan peasant farmers, 1987

Variable	Cotton ( $N = 87$ )			Cassava $N = 101$		
	Mean (SD)	Average function	Stochastic frontier	Mean (SD)	Average function	Stochastic frontier
Intercept	–	6.262 *** (0.323)	6.799 *** (0.365)	–	7.409 *** (0.399)	7.941 *** (0.466)
Land	1.74 (1.30)	0.698 *** (0.083)	0.684 *** (0.069)	0.91 (0.53)	0.746 *** (0.149)	0.712 *** (0.178)
Labor	91.37 (81.43)	0.212 ** (0.083)	0.196 ** (0.086)	47.05 (34.35)	0.335 *** (0.102)	0.355 *** (0.109)
Materials	65.96 (53.69)	0.007 (0.030)	0.014 (0.037)	15.57 (13.95)	0.045 (0.033)	0.061 (0.068)
$F$ -statistic model		63.8 ***	–		24.5 ***	–
$F$ -statistic CRTS		1.45	–		0.89	–
Quasi function coefficient		0.917	0.894		1.126	1.128
Adj. $R^2$		0.69	–		0.41	–
$\lambda$		–	2.12 ** (1.12)		–	1.74 * (1.10)
$\sigma^2$		–	0.69 (0.11)		–	0.93 (0.16)
Log likelihood		–	57.10		–	101.60

\*\*\*, Significant at the 0.01 level; \*\*, at the 0.05 level; \*, at the 0.10 level.

worker days used in cotton or cassava production;  $M$  value of materials including expenditures on draft animal services, seed, and other purchased inputs used for the production of cotton or cassava measured in thousands of Guaranies;  $\beta_i$  parameters to be estimated ( $i = 0, 1, 2, 3$ ); and  $\epsilon$  composed error term defined earlier. The explanatory variables included in the model are similar to those used in previous studies of developing country agriculture (Taylor, Drummond and Gomes, 1986; Taylor and Shonkwiler, 1986). A major difference is that we estimate separate production frontiers for two individual crops while most studies rely on estimates of total value product frontiers<sup>5</sup>.

<sup>5</sup> The production functions were initially estimated including District dummy variables to account for possible effects of location on the production structure of the farms in the sample. The null hypothesis that the parameters for the set of dummy variables was equal to zero could not be rejected for neither crop for both the OLS and the frontier models. Consequently, and as a way to simplify the analysis, the district dummy variables were dropped from the models.

## 5. Empirical results

Table 1 shows the maximum likelihood parameter estimates of the stochastic production frontier (Eq. 11) for cotton and cassava producers along with some descriptive statistics for the sample. For comparison, OLS estimates of average production functions are also shown. In general, the frontier estimates amount to a neutral upward shift of the average function. The function coefficient for cotton is close to 0.90 while the value for cassava is 1.13. These values are virtually unaffected by the estimator used. Based on restricted least squares regression, the hypothesis of constant returns to size cannot be rejected for either cotton or cassava. These results are consistent with the fact that all farms in the sample are relatively small. The largest number of hectares devoted to cotton production is six while the corresponding figure for cassava is three.

The dual cost frontier for cotton, derived analytically from the stochastic production frontier

Table 2

Frequency distribution of economic (EE) technical (TE) and allocative (AE) efficiency estimates for cotton and cassava based on a sample of Paraguayan peasant farmers, 1987

Level (%)	Cotton (N = 87)			Cassava (N = 101)		
	EE	TE	AE	EE	TE	AE
> 90	0 <sup>a</sup>	0	4	0	0	68
> 80 ≤ 90	0	6	23	0	7	22
> 70 ≤ 80	0	18	32	17	23	3
> 60 ≤ 70	5	22	10	19	23	6
> 50 ≤ 60	23	17	13	26	19	1
> 40 ≤ 50	20	9	4	18	14	1
> 30 ≤ 40	20	10	0	13	10	0
> 20 ≤ 30	16	4	1	6	4	0
> 10 ≤ 20	3	1	0	2	1	0
≤ 10	0	0	0	0	0	0
Mean (%)	40.67	58.24	70.12	52.26	58.67	88.94
Minimum (%)	15.19	19.21	24.33	15.65	17.86	42.31
Maximum (%)	66.94	84.95	91.66	78.24	83.14	99.70

<sup>a</sup> Number of farms.

Table 3

Comparison of efficiency indexes from various studies using production frontiers

Author(s) <sup>a</sup>	Country	Product	TE	AE	EE
Ali and Chaudry	Pakistan	Crops	0.84	0.61	0.51
Bagi	United States	Crops	0.85	–	–
		Crops/Livestock	0.75	–	–
Bravo-Ureta and Rieger (1991)	United States	Dairy	0.83	0.85	0.70
Huang and Bagi	India	Multiproduct	0.90	–	–
Kalirajan	Philippines	Rice	0.63	–	–
Kalirajan and Flinn	Philippines	Rice	0.50	–	–
Kalirajan and Shand	Malaysia	Rice	0.65	–	–
Rawlins	Jamaica	Crops	0.73	–	–
Taylor and Shonkwiler	Brazil	Multiproduct	0.71	–	–
Taylor et al.	Brazil	Multiproduct	0.17	0.74	0.13
This study	Paraguay	Cotton	0.58	0.70	0.40
		Cassava	0.59	0.88	0.52

<sup>a</sup> For studies that report more than one value for a given efficiency index, a simple average is calculated and presented.

shown in Table 1, is <sup>6</sup>:

$$\ln C_A = -6.997 + 0.764 \ln P_R + 0.220 \ln P_L \\ + 0.016 \ln P_M + 1.118 \ln Q_A^* \quad (12)$$

and the dual cost frontier for cassava, derived in

a similar fashion, is:

$$\ln C_C = -6.228 + 0.631 \ln P_R + 0.315 \ln P_L \\ + 0.054 \ln P_M + 0.887 \ln Q_C^* \quad (13)$$

where  $C_A$  is per-farm costs of producing cotton;  $C_C$  per-farm costs of producing cassava;  $P_R$  rental price per hectare of land estimated at 80,000 Guaranies;  $P_L$  daily wage rate per worker estimated at 1,200 Guaranies;  $P_M$  price of materials set at 1.10 (since the quantity of materials applied

<sup>6</sup> For the analytical derivation of a Cobb–Douglas cost function from its dual production function, see Silberberg (1978, chapter 10) and/or Varian (1992, chapter 4).

is measured in 1000 Guaranies, using a price of 1.10 implies a cost of operating capital of 10%);  $Q_A^*$  annual total farm output of cotton in kilograms adjusted for any statistical noise as specified in Eq. (10) above; and  $Q_C^*$  annual total farm output of cassava in kilograms adjusted for any statistical noise as specified in Eq. (10) above.

The mean economic (EE), technical (TE) and

allocative (AE) efficiency indices computed for the 87 cotton producers, shown in Table 2, are 40.7, 58.2 and 70.1, respectively. The corresponding indices for the 101 cassava producers are 52.3, 58.7 and 88.9. Given that cotton is produced as a cash crop and cassava is produced primarily for direct consumption, it is interesting to compare the efficiency levels for these two crops. The null

Table 4  
Average economic (EE), technical (TE) and allocative (AE) efficiency indexes, and socioeconomic characteristics for Paraguayan peasant farmers

Variable	Cotton				Cassava			
	<i>N</i>	EE	TE	AE	<i>N</i>	EE	TE	AE
SIZE								
≤ 5 ha	26	38.5	56.2	69.5	37	54.7	59.6	91.9
> 5 ≤ 10 ha	43	41.8	60.0	69.4	44	50.8	57.6	87.8
> 10 ≤ 15 ha	7	41.8	58.3	73.6	10	49.4	60.2	82.5
> 15 ha	11	41.0	56.4	72.4	10	52.6	58.2	89.4
<i>F-value</i>		0.3	0.4	0.3		0.5	0.1	2.5 *
AGE								
≤ 40 years	14	41.7	60.7	69.3	14	49.7	56.7	87.4
> 40 ≤ 50 years	27	39.8	56.6	70.4	25	58.5	65.0	90.1
> 50 ≤ 58 years	23	42.3	61.4	68.4	31	48.6	54.4	89.1
> 58 years	23	39.5	55.6	72.0	31	52.1	58.7	88.6
<i>F-value</i>		0.2	0.7	0.3		2.1	2.3 *	0.2
EDUC								
≤ 1 year	11	34.6	48.7	70.8	12	59.8	65.5	90.8
> 1 ≤ 2 years	44	40.6	60.0	68.3	51	51.9	58.5	88.6
> 2 years	32	42.8	59.2	72.4	38	50.4	56.7	88.8
<i>F-value</i>		1.6	2.4 *	1.0		1.7	1.5	0.2
ASSIST								
0	76	40.2	57.5	69.3	93	52.4	59.0	88.6
1	11	44.0	63.2	70.2	8	50.8	54.9	92.6
<i>F-value</i>		0.8	1.2	0.1		0.1	0.5	1.1
CREDIT								
0	43	38.4	54.2	71.3	56	50.9	57.4	88.2
1	44	42.9	62.2	68.9	45	54.0	60.3	89.8
<i>F-value</i>		2.6	6.0 **	0.7		1.0	0.8	0.6
EXTEN								
0	74	40.8	58.4	70.2	86	52.7	59.4	88.4
1	13	40.2	57.1	69.8	15	50.0	54.3	92.3
<i>F-value</i>		0.2	0.1	0.1		0.4	1.4	1.8
EXHRS								
≤ 2000	32	41.7	56.3	74.5	49	48.6	54.2	89.4
> 2000 ≤ 2700	25	38.5	59.3	65.5	24	60.2	67.1	89.7
> 2700	30	41.3	59.5	69.4	28	51.9	59.2	87.5
<i>F-value</i>		0.5	0.4	3.5 **		4.8 **	5.9 ***	0.3

\*\*\*, Significant at 0.01 level; \*\*, at 0.05 level; \*, at 0.10 level.



hypothesis that the mean efficiency (EE, TE and AE) for both crops is equal, evaluated using *t*-tests, is accepted for TE and rejected for EE and AE. These findings are consistent for the overall sample as well as for the subsample of 57 farmers producing both crops. Therefore, we conclude that EE and AE are significantly higher in cassava production compared to cotton production, while no difference is found across the two crops for TE. In addition, correlation analysis for each efficiency measure between the two crops suggests a positive but weak association. The correlation coefficients are 0.12 for EE, 0.19 for TE, and 0.18 for AE.

For comparison purposes, Table 3 presents efficiency indices reported in various studies using data from several countries. It is interesting to note that our efficiency estimates tend to be lower than those reported by other researchers. A clear exception is the study by Taylor, Drummond and Gomes (1986), who reported technical and economic efficiency indexes much lower than those found in this study. Their measures were derived from a deterministic frontier which makes them very sensitive to outliers. In fact, Taylor and Shonkwiler (1986) applied a stochastic frontier on the same data as Taylor, Drummond and Gomes (1986) and found that, as shown in Table 3, technical efficiency increased from around 0.18 to 0.71<sup>7</sup>.

Several authors have investigated the relationship between efficiency and various socioeconomic variables using two alternative approaches<sup>8</sup>. One approach is to compute correlation coefficients or to conduct other simple non parametric analyses. The second way, usually referred to as a two-step procedure, is to first measure farm level efficiency and then to estimate a regression model where efficiency is expressed as a function of socioeconomic attributes. These analyses have been criticized by some who

argue that the socioeconomic variables should be incorporated directly in the production frontier model because such variables may have a direct impact on efficiency (Battese, Coelli and Colby, 1989). Kalirajan (1991) has recently defended this practice by contending that the socioeconomic attributes have a roundabout effect on production and, hence, should be incorporated into the analysis indirectly. Ray (1988) has argued that the two-step procedure is justifiable if one assumes that the production function is multiplicatively separable in what he calls discretionary and nondiscretionary inputs. The former inputs are those typically included in production function models while the latter are those commonly used to explain variations in efficiency. This controversy is relatively recent in the frontier literature and, thus, additional research will be required before a resolution is found.

Despite the controversy just mentioned, we still believe that it is useful to examine the possible relationship between efficiency and socioeconomic characteristics. For this purpose, we use Analysis of Variance (ANOVA) to investigate the association between EE, TE and AE, and the following seven socioeconomic characteristics: (1) SIZE, the total number of hectares in the farm unit; (2) AGE, given by the age of the household head; (3) EDUC, the number of years of schooling completed by the household head; (4) ASSIST, equal to 1 for those farmers that received technical assistance from a variety of sources, including private firms, the extension service, credit institutions, neighbors and/or family members, and zero otherwise; (5) CREDIT, equal to 1 for farmers that reported receiving credit and zero otherwise; (6) EXTEN, equal to 1 for farmers that reported having contacts with the extension service and zero otherwise; and (7) EXHRS, the number of extension field staff hours devoted to field extension work on each crop in the district where the farm is located.

The most striking conclusion that can be gleaned from the ANOVA results, shown in Table 4, is the lack of a consistent pattern of association between efficiency and socioeconomic characteristics. Some of these results, however, are consistent with findings reported by others who have

<sup>7</sup> For a detailed comparison of the impact of alternative estimators on mean technical efficiency levels, see Bravo-Ureta and Rieger (1990).

<sup>8</sup> For a review of several of these papers, see Bravo-Ureta and Pinheiro (1993).

studied the productivity of traditional farmers. For example, a weak association between efficiency, and education and extension has also been reported by Antiporta (1978) for The Philippines, and by Cotlear (1986) for Peru. In a recent paper, using data from Pakistan, Azhar (1991) lends further support to the notion "...that elementary education (4–5 years of schooling) does not have much effect on agricultural productivity" in traditional farm settings (p. 658)<sup>9</sup>. In our sample, around 50% of the peasants had two years of education or less, 30% had three years, and no farmer had more than five years.

The clearest pattern that emerges is for credit which is positively related to efficiency in five out of six cases. However, this positive relationship is statistically significant only in one of the six cases. By comparison, Lingard, Castillo and Jayasuriya (1983) also found evidence that credit had a positive impact on efficiency in their analysis of farmers in Central Luzon, in The Philippines.

Extension hours (EXHRS) exhibits the greatest number of significant relationships with efficiency – three out six cases. Despite this statistical significance, no clear-cut pattern emerges concerning the effect that EXHRS has on individual farm efficiency. Finally, the lack of association found between efficiency, and experience and farm size has also been reported by Kalirajan and Flinn (1983), Huang and Bagi (1984), Belbase and Grabowski (1985) and Lingard, Castillo and Jayasuriya (1983).

## 6. Concluding remarks

This paper uses a stochastic efficiency decomposition methodology to derive technical, allocative and economic efficiency measures for a sample of peasant farmers located in Eastern Paraguay. The analysis is performed separately for two crops – cotton and cassava. This analysis

shows an average economic efficiency of 40.1% for cotton and of 52.3% for cassava, which reveals that there is considerable room for improvement in the productivity of the farms in the sample. The results of this study suggest that this sample of peasant farmers could increase output and, thereby, household income through better use of available resources given the state of technology. Gains in output stemming from improvements in productivity are important to Paraguay considering that the opportunities to increase farm production by bringing additional virgin lands into cultivation have significantly diminished in recent years while at the same time population pressure has been on the rise.

An examination of the relationship between efficiency and various socioeconomic variables did not reveal a clear strategy that could be recommended to improve performance. One possible explanation for the lack of a consistent relationship between efficiency and socioeconomic indicators might be the existence of a stage of development threshold below which this type of relationship is not observed. If this is the case, then our results imply that this sample of Paraguayan peasants are yet to reach such a threshold. Consequently, our analysis suggests that policies to improve education and extension services, for example, would be needed in order to go beyond this threshold. Once this is accomplished, additional productivity gains would be obtained by further investments in human capital and related factors. It should be noted that this "threshold" argument has been advanced in the literature as a potential explanation for the absence of a relationship between a few years of education (5 or less) and agricultural output in traditional farm settings (Azhar, 1991; Moock, 1981, 1985).

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<sup>9</sup> For further discussion of this point, see Lockheed, Jamison and Lau (1981), Moock (1985), Lipton (1985) and Philipps and Marble (1986).

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