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# Farm size, relative efficiency and agrarian policy in Côte d'Ivoire: profit function analysis of rice farms

Akinwumi A. Adesina<sup>a,\*</sup>, Kouakou K. Djato<sup>b</sup>

<sup>a</sup> *West Africa Rice Development Association, 01 BP 2551, Bouake, Cote d'Ivoire*

<sup>b</sup> *Centre Ivoirien de Recherches Economiques et Sociales, Abidjan, Côte d'Ivoire*

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## Abstract

This paper examines the relative economic efficiency of small and large rice farms in Côte d'Ivoire using a profit function approach. No differences in the relative economic efficiency of small and large farms were found. This conclusion is robust under alternative model specifications. Agrarian reforms directed towards further concentration of landholding for large farms in Côte d'Ivoire cannot be justified based on economic efficiency. Results show that access to credit and use of modern rice varieties significantly increase profits. To improve technical efficiency of rice farms, an accelerated program to provide information, credit, improved seeds and other inputs is needed. When all the farms (i.e. large and small) are taken together, there is evidence of allocative inefficiency. Strategies are needed to remove such management related inefficiencies in rice production either through the development of a better market price information system or effective farmer-oriented technical training programs by rice extension workers.

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## 1. Introduction

Agricultural policy makers in developing countries face difficult decisions in their choice of agrarian structure to achieve the dual goals of growth and equity in the agricultural sector (Dorner, 1972; Khan and Maki, 1979; Noronha, 1985; Lele and Agarwal, 1989; Deininger and Binswanger, 1995). Often, agrarian policies favor large farms under the presumption that they are more economically efficient than small farms (Dorner, 1972; Khan and Maki,

1979; Kydd and Christiansen, 1982; Lele and Agarwal, 1989; Kouadio and Pokou, 1991; Deininger and Binswanger, 1995). Several attempts have been made in Africa to encourage large scale farms. Examples include policies favoring collectivized agriculture that dominated production relations in Tanzania in the 1970s (McHenry, 1979); state-imposed tenure conversion arrangements in Kenya that led to further land consolidation, concentration and marginalization of small farms (Brokensha and Glazier, 1973; Njeru, 1978; Okoth-Ogendo, 1986); diversion of institutional credit to large farms in Kenya and Malawi (Kydd and Christiansen, 1982; Lele and Meyers, 1986); subsidization of land settlement, irrigation and mechanization costs in Nigeria (Lele et al., 1989); policy-induced land, labor and output market

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\* Corresponding author at: International Institute of Tropical Agriculture, Humid Forest Program, BP 2008, Yaounde, Cameroon.

interventions to favor large European farms over African smallholder farms in Kenya, Zimbabwe and South Africa (Deininger and Binswanger, 1995) or restrictive market differentiation that gave large farms legal rights to grow specific crops for export in Malawi (Christiansen and Kydd, 1987).

The presumed superior economic efficiency of large farms may, however, be illusory due to the high social costs of the preferential public policies that have maintained them. Experiences with most large-farm led agrarian reforms within dual farm size structures have been mixed (Lele and Agarwal, 1989; Collier et al., 1990; Bruce and Migot-Adholla, 1994). Deininger and Binswanger (1995) suggest that incorporating rent seeking behavior in the theory of production relations may explain the existence of such dual farm size structures in Kenya, Zimbabwe and South Africa. Policies that were used to reduce the 'reservation utility' of the African smallholder farms in these countries included restrictive land, labor and output market regulations. In the absence of these policy distortions, large European farms could not have been competitive with the African smallholder farms. Lele and Agarwal (1989) compared domestic resource costs for the production of coffee and tea in Kenya for large and smallholder farms. Their estimates showed a strong comparative advantage in smallholder production, and they argued that this possibly explains why the colonial government imposed restrictions on smallholder farms producing tea and coffee in Kenya. However, Lele and Agarwal (1989) and Deininger and Binswanger (1995) did not specifically test for economic (i.e. price and technical) efficiency differences between the large and small farms in their insightful analyses.

Previous studies in Asia have tested for relative efficiency differences by farm size, with conflicting results. Lau and Yotopoulos (1971) and Yotopoulos and Lau (1973) found that small wheat farms in the Indian Punjab were more economically efficient than large farms. In Pakistan, Khan and Maki (1979) found that large farms were more economically efficient than small farms. However, these results are at variance with those of Sidhu (1974) who found no evidence of differences in the relative economic efficiency or its components of technical and pricing efficiency, between small and large farms. The above suggests the need to avoid generalizations on what is

clearly a complex issue. Owing to major differences in agricultural and institutional settings, evidence from the aforementioned studies in Asia cannot be used directly for informing agrarian policy in Africa. However, there is a dearth of studies in Africa that test for relative economic efficiency (Saleem, 1988) by farm size in order to guide policy decision makers. Data limitations have largely precluded such analysis, most especially in West Africa (Lele and Agarwal, 1989). The objective of this paper is to test for relative economic efficiency differences between small and large rice farms in Côte d'Ivoire using the profit function approach. The purpose of this paper differs from that of Deininger and Binswanger (1995), in that while they focused on generating plausible hypotheses for the existence of dual farm size agrarian structures, our aim is to determine whether differences in economic efficiency by farm size exist in Côte d'Ivoire, the existence of dual farm size agrarian structure taken as given (Widner, 1993).

There is an on-going debate in Côte d'Ivoire on the types of institutional changes needed to stimulate rice production in the country (Coopération Française de Développement, 1993). With declining national rice self-sufficiency, Côte d'Ivoire has become the second largest importer of rice in West Africa (average of 284 200 t annually in 1988–1990) (West Africa Rice Development Association, 1993). This has again led some policy makers to argue in favor of increasing domestic production through the encouragement of large farms. The argument for such an approach is that it lowers extension and input distribution costs, and ensures easier and lower marketing costs with fewer producers. Although about 80% of rice farms in the country are smallholder farms, the government has over the years encouraged large farms through the importation and distribution of highly subsidized mechanized equipment, seed and chemical inputs. For example, the government established large, fully mechanized, and highly subsidized upland rice farms in the northern part of the country. The state has also given preferential tax exemptions for the import of large machinery (Kouadio and Pokou, 1991). The lack of empirical studies on the relative economic efficiency of large and small farms in Côte d'Ivoire makes it difficult for policy makers in Côte d'Ivoire to evaluate their agrarian policy for achieving growth and equity.

## 2. Empirical analysis

### 2.1. Empirical model

Using the output price as the numeraire, the normalized restricted profit function ( $\pi^*(q, Z)$ ) can be written in a generalized form as

$$\pi^*(q, Z) = F[X_1^*(q, Z), \dots, X_n^*(q, Z)] - \sum_{j=1}^m q_j X_j^*(q, Z) \quad (1)$$

where  $q_j$  represents the normalized factor prices,  $F$  is a well behaved production function,  $X$  is the vector of variable inputs and  $Z$  is the vector of fixed inputs used in the production process. Starting with any well specified normalized restricted profit function, direct application of Hotelling's–Shephard's Lemmas to the function yields the corresponding factor demand and output supply equations

$$\partial \pi^*(q, Z) / \partial q_j = -X_j^* \quad j = 1, \dots, m \quad (2)$$

Multiplying both sides by  $q_j / \pi^*$  gives a series of  $m$  factor share equations

$$\left[ \partial \pi^*(q, Z) / \partial q_j \right] = -X_j^* q_j / \pi^* = \alpha_j^* \quad j = 1, \dots, m \quad (3)$$

Eqs. (1) and (3) form a theoretical basis for the specifications of the empirical models. Following Lau and Yotopoulos (1971), the empirical specification of the system of equations of the normalized restricted profit function and the factor share equations is given as

$$\begin{aligned} \ln \pi^* &= \ln A^* + \delta_L^* D_L + \sum_{i=1}^2 \alpha_i^* \ln w_i + \sum_{i=1}^2 \beta_i^* \ln Z_i \\ &+ \beta_3^* R_3 + \phi_1 \text{EXT} + \phi_2 MV + \phi_3 \text{EDUC} \\ &+ \phi_4 \text{CRDT} + \epsilon_i - \frac{w_i X_i}{\pi^*} \\ &= \alpha_i^{*L} D_L + \alpha_i^{*S} D_S + \mu_i \quad i = 1, 2 \end{aligned}$$

where  $\pi^*$  is the normalized profit in FCFA (FCFA 520 = \$US1), defined as revenue less variable costs normalized by the price of paddy ( $p$ );  $A^*$  is the intercept;  $X_1$  is the number of man-days of labor

used including family and hired labor;  $w_1$  is the wage rate normalized by the price of output;  $w_2$  is the price of fertilizer normalized by the price of paddy;  $X_2$  is the quantity of fertilizer used;  $Z_1$  is the capital input and is the sum of costs of seeds, insecticides, herbicides, animal and mechanical power;  $Z_2$  is the land input, which is the net area sown to rice in hectares;  $D_L$  is a dummy variable taking on the value of unity for large farms;  $D_S$  is a dummy variable taking on the value of unity for small farms;  $R_1$  is a district dummy<sup>1</sup>. Other variables included in the profit function equation are use of improved rice varieties ( $MV$ ), whether or not the farmer is educated ( $\text{EDUC}$ : defined as having had at least 6 years of schooling, the least required for literacy in the country), contact with extension ( $\text{EXT}$ ) and access to credit ( $\text{CRDT}$ ). The inclusion of education in the profit function derives from the findings of earlier studies (Sidhu and Baanate, 1981; Jamison and Lau, 1982; Pudasaini, 1983) that education has a positive effect on profits, a result that indicates the existence of management related inefficiency (Ali and Byerlee, 1991). Inclusion of the extension variable in the profit function follows studies that have shown that extension contacts by farmers have a positive influence on their farm management ability and technical efficiency (Bindlish and Evenson, 1993). The use of modern varieties ( $MV$ ) is expected to have a positive effect on profits given the higher productivity potentials of these varieties (Sidhu, 1974).

It is assumed that the errors of the system of equations are additive with zero mean and finite variance. For the same farm, the co-variance of the error terms in these equations are non-zero, while the co-variance of error terms of any of the equations for different farms is assumed to be zero. Given these assumptions, and following previous studies (Yotopoulos and Lau, 1973; Sidhu, 1974; Saleem, 1988), Zellner's seemingly unrelated regression ( $\text{SUR}$ )

<sup>1</sup> Pooling of data across regions to enhance price variability in data sets has precedence in several of the studies on profit function applications (Lau and Yotopoulos, 1971; Tamin, 1979; Lau et al., 1979). As in previous studies we introduce a regional dummy variable.

method was used to estimate the system of equations in order to obtain asymptotically efficient parameter estimates. The efficiency of the estimates can be further improved by imposing appropriate restrictions on the parameters in the system of equations.

## 2.2. Data

Data used to estimate the model were collected from August 1992 to April 1993 from a sample of 410 rice farms in villages in three districts of northern Côte d'Ivoire, namely Touba (67 farms), Korhogo (216 farms) and Katiola (127 farms). This provided us with disaggregated micro-level data<sup>2</sup>. The definition of farm size has been variable in the efficiency literature, as what is considered 'large' or 'small' is relative depending on the agricultural system settings. In Pakistan agriculture, Khan and Maki (1979) classified large farms as those having 12.5 acres or over (i.e. 5 ha). Using Indian data, Yotopoulos and Lau (1973) and Sidhu (1974) classified 'large' farms as those with at least 10 acres (i.e. 4 ha). In this study, large farms were defined as farms that have at least 5 ha. In their study in northern Côte d'Ivoire, Kouadio and Pokou (1991) noted that average farm size of the large farms ranged from 5 to 28 ha, with a mean of 10 ha. To determine the robustness of conclusions from the initial analysis, we shall also examine the effects of re-defining the threshold for large farms to 10 ha. Sensitivity of the conclusions to alternate definitions of the threshold, although very important given the potential far-reaching implications of the results of farm efficiency tests, is rarely evaluated (Khan and Maki, 1979).

<sup>2</sup> The use of data from the districts also enhanced variability in the price data. We find the succinct argument of Sevilla-Siero (1991) (p. 125) highly relevant here: "[A]s soon as we bring into the analysis spatial considerations (and agriculture in most developing countries is par excellence a geographically dispersed activity) we see locational differences in farmgate prices....Thus depending on their location, farms will confront different constellations of output and input prices. Paradoxically, it is the wide geographic dispersion characteristic of developing country agriculture (and the geographic price variability occasioned by it) that renders feasible the estimation of profit functions therein".

## 3. Empirical results

### 3.1. Hypothesis testing

The estimated results of the profit function and factor share equations for the efficiency tests are given in Table 1. The parameter estimates all have the expected signs. The input prices all have the theoretically expected negative signs indicating that the estimated profit function is convex in input prices. The coefficient on capital input is positive as expected, which agrees with the finding of Khan and Maki (1979). In the model of Yotopoulos and Lau (1973), the coefficient on the capital variable was found to be negatively signed due to what the authors described as mis-specification of this variable. Although extension (EXT) and education (EDUC) positively influence profits, their effects are not significant. However, access to credit (CRDT) and use of modern varieties (MV) are positively related to profits and are generally significant.

Efficiency has three components: technical, allocative and economic. Technical efficiency can be defined as the ability to achieve a higher level of output, given a similar level of production inputs. Allocative efficiency defines the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to output value is equal to the factor cost. Economic efficiency combines technical and allocative efficiency. Technical and allocative efficiency are necessary, and when they occur together are sufficient conditions for achieving economic efficiency. In order to address the questions of relative efficiency discussed above, we carried out the following statistical tests:

H1: small and large rice farms have equal relative economic efficiency;

H2: there is equal relative price efficiency with respect to labor and fertilizer for small and large rice farms;

H3: there is equal relative technical and price efficiency for small and large rice farms;

H4: if either H1 or H2 is rejected, H4 tests for absolute price efficiency of the large farms;

H5: if either H1 or H2 is rejected, H5 tests for absolute price efficiency of the small farms;

H6: maintaining the hypothesis of equal relative price efficiency, this hypothesis tests for the absolute price efficiency of both large and small farms (i.e. as a group);

H7: this hypothesis tests for constant returns to scale in all factors of production.

We tested the relevant hypotheses under the two alternative specification of the farm size threshold. H1–H5 were tested from the unrestricted model,

while H6 was tested with two parameter restrictions. For H7, four restrictions were imposed on the parameters. The test results are shown in Table 2. The results for the model variant for the case of the 5 ha threshold are discussed first. H1 cannot be rejected. This indicates that small and large farms have equal relative economic efficiency. H2 is rejected, suggesting that differences exist in the relative price efficiency between small and large farms. H3 is re-

Table 1

Joint estimation of profit function and factor share equations for rice farms, Côte d'Ivoire, 1993

Function/variable		Zellner's SUR method					
		Unrestricted		Two restrictions		Four restrictions	
		5 ha	10 ha	5 ha	10 ha	5 ha	10 ha
<i>Profit function</i>							
$A^*$	Constant	5.63 (6.82) ***	5.60 (6.73) ***	5.68 (6.82) ***	5.60 (6.73) ***	7.70 (9.70) ***	7.62 (9.57) ***
$\delta_L^*$	Large farm dummy	-0.22 (-0.34)	0.42 (1.61)	-0.48 (-0.73)	0.17 (0.87)	-0.59 (-0.82)	0.13 (0.61)
$\alpha_1^*$	Wage	-0.55 (-2.04) **	-0.51 (1.86) *	-0.56 (-2.04) **	-0.51 (-1.86) *	-1.16 (-6.17) ***	-1.15 (-6.10) ***
$\alpha_2^*$	Fertilizer price	-0.43 (-0.68)	-0.53 (-0.83)	-0.45 (-0.70)	-0.53 (-0.83)	-0.77 (-7.30) ***	-0.77 (7.26) ***
$\beta^*$	Capital	0.15 (2.90) **	0.15 (2.90) **	0.15 (2.86) **	0.15 (2.90) **	0.10 (1.99) **	0.11 (2.10) **
$\beta_2^*$	Land	0.69 (8.95) ***	0.68 (8.73) ***	0.69 (8.87) ***	0.68 (8.71) ***	0.73 (8.93) ***	0.72 (8.73) ***
$\beta_3$	Regional dummy	0.87 (1.31)	0.38 (1.95) *	0.87 (1.31)	0.38 (1.94) *	0.95 (1.31)	0.36 (1.80)
$\phi_1$	Extension	0.12 (0.44)	0.13 (0.45)	0.12 (0.45)	0.13 (0.47)	0.21 (0.69)	0.20 (0.69)
$\phi_2$	Improved variety adoption	0.41 (4.10) ***	0.40 (3.92) ***	0.41 (3.99) ***	0.40 (3.91) ***	0.31 (3.39) ***	0.30 (3.37) ***
$\phi_3$	Access to credit	0.17 (1.90) *	0.17 (1.90) *	0.17 (1.90) *	0.17 (1.90) *	0.13 (1.35)	0.13 (1.35)
$\phi_4$	Education	0.12 (1.31)	0.12 (1.30)	0.12 (1.30)	0.12 (1.30)	0.096 (0.92)	0.091 (0.88)
<i>Labor demand function</i>							
$\alpha_1^{*L}$	Large farm	-0.47 (-0.60)	-0.12 (-0.06)	-2.50 (-7.50) ***	-2.50 (-7.50) ***	-1.16 (-6.17) ***	-1.15 (-6.09) ***
$\alpha_1^{*S}$	Small farm	-2.90 (-8.0) ***	-2.59 (-7.6) ***	-2.50 (-7.50) ***	-2.50 (-7.50) ***	-1.16 (-6.17) ***	-1.15 (-6.10) ***
<i>Fertilizer demand function</i>							
$\alpha_2^{*L}$	Large farm	-0.32 (-0.88)	-0.17 (-0.21)	-1.26 (-8.63) ***	-1.26 (-8.60) ***	-0.77 (-7.30) ***	-0.77 (-7.30) ***
$\alpha_2^{*S}$	Small farm	-1.44 (-9.13) ***	-1.30 (-8.76) ***	-1.26 (-8.63) ***	-1.26 (-8.63) ***	-0.77 (-7.30) ***	-0.77 (-7.30) ***

<sup>a</sup> Values in parentheses are the corresponding *t*-values for the estimated parameters.

Asterisks indicate significance at the following levels: \*\*\* 1%; \*\* 5%; \* 10%.

jected, which is not surprising given the result of H2. H4 cannot be rejected for large farms, suggesting that large farms have absolute price efficiency. H5 is rejected for small farms. H6 is rejected, again not surprising given that H2 has been rejected. H7 is rejected.  $\beta_1^* + \beta_2^* < 1$  suggests that technology on the farms exhibits decreasing returns to scale. Next we discuss the results of the tests for the case where the farm size threshold was 10 ha. As for the 5 ha scenario above, H1 cannot be rejected, strongly supporting the above conclusion that small and large farms have equal relative economic efficiency. H2 cannot be rejected, suggesting that small and large farms have equal relative price efficiency. H3 cannot be rejected, indicating that small and large farms have equal relative technical and price efficiency. H4 cannot be rejected, but H5 is rejected, results which together appear to indicate that large farms have absolute price efficiency. H6 was rejected, indicating that as a group, there exists absolute price inefficiency among all rice farms in the sample. H7 is rejected, supporting the conclusion of decreasing returns to scale for the technology use on all the rice farms. When all the results are taken together, there is certainly evidence that when account is taken of differences in access to extension, use of modern varieties, credit and education, there are no differ-

ences in relative economic efficiency between small and large rice farms in Côte d'Ivoire.

### 3.2. Elasticity estimates and implications

An issue of central interest to policy makers is the responsiveness of output supply and factor demands to price policy, and how they are affected by investment and land policies (Lau and Yotopoulos, 1979). Such estimates are lacking for rice in Côte d'Ivoire. An advantage of the profit function approach is that it permits straightforward derivation of own-price and cross-price output supply and input demand elasticities. Indirect estimates of production elasticities were derived from identities which link the coefficients of the profit function and those of the production function. It has been noted that these indirect input elasticities, when compared with those obtained from the production function, have the distinct advantage of statistical consistency (Sidhu, 1974). These estimates of indirect elasticities are compared with direct elasticity estimates obtained from an estimated production function. All elasticities have the expected signs. The elasticity of rice output is highest for labor (0.408) followed by fertilizer (0.267), land (0.204) and capital (0.036).

To examine the output and factor demand respon-

Table 2

Tests of statistical hypotheses on efficiency differences between large and small farms, under alternative specification of farm size thresholds. Rice farms, Cote d'Ivoire, 1993

Hypotheses	Maintained 5 ha	Tested 10 ha	$\chi^2$ value		Critical value $\chi^2$ value
H1		$\delta_L^* = 0$	0.11	2.60	3.84 (1; 409)
H2		$\alpha_1^* L = \alpha_1^* S$ $\alpha_2^* L = \alpha_2^* S$	8.69	2.14	5.99 (2; 408)
H3		$\delta_L^* = 0$ $\alpha_1^* L = \alpha_1^* S$ $\alpha_2^* L = \alpha_2^* S$	9.11	2.89	7.81 (3; 407)
H4		$\alpha_1^* L = \alpha_1^* S$ $\alpha_2^* L = \alpha_2^* S$	0.03	0.12	5.99 (3; 407)
H5		$\alpha_1^* S = \alpha_1^* L$ $\alpha_2^* S = \alpha_2^* L$	33.3	27.72	5.99 (2; 408)
H6	$\alpha_1^* L = \alpha_1^* S$ $\alpha_2^* L = \alpha_2^* S$	$\alpha_1^* L = \alpha_1^* S$ $\alpha_2^* L = \alpha_2^* S$	25.43	25.94	5.99 (2; 408)
H7	$\alpha_1^* L = \alpha_1^* S$ $\alpha_2^* L = \alpha_2^* S$ $\alpha_1^* L = \alpha_2^* L$ $\alpha_2^* L = \alpha_1^* L$	$\beta_1^* + \beta_2^* = 1$	5.66	6.14	3.84 (1; 409)

siveness of rice farms, we derived output supply and variable-factor demand functions from the profit function as follows.

Labor demand ( $X_L^*$ )

$$\ln X_L^* = \ln(-\alpha_1^*) + \ln A^* + (\alpha_1^* - 1)\ln w_1^{\wedge} + \alpha_2^*\ln w_2^{\wedge} + \delta_L^* D_L + \{1 - (\alpha_1^* + \alpha_2^*)\} \times \ln p + \beta_1^*\ln Z_1 + \beta_2^*\ln Z_2$$

Fertilizer demand ( $X_F^*$ )

$$\ln X_F^* = \ln(-\alpha_2^*) + \ln A^* + \alpha_1^*\ln w_1^{\wedge} + (\alpha_2^* - 1)\ln w_2^{\wedge} + \delta_L^* D_L + \{1 - (\alpha_1^* + \alpha_2^*)\}\ln p + \beta_1^*\ln Z_1 + \beta_2^*\ln Z_2$$

Output supply ( $Y_p^*$ )

$$\ln Y_p^* = \ln(1 - \sum \alpha_i^*) + \ln A^* + \sum \alpha_i^*\ln w_i^{\wedge} - (\sum \alpha_i^*)\ln p + \beta_1^*\ln Z_1 + \beta_2^*\ln Z_2$$

where  $w_i^{\wedge}$  and  $p$  are nominal money prices of the variable inputs and output (for details of derivations see Lau et al., 1979).

Output supply and input demand elasticity estimates were obtained under the two alternative speci-

Table 3  
Derived elasticity estimates for rice output supply's own-price and cross-price input elasticities: profit function results in Côte d'Ivoire and other countries

	Côte d'Ivoire	Thailand <sup>a</sup>	Taiwan <sup>b</sup>	India <sup>c</sup>
<i>Paddy</i>				
Price	0.98 (1.03)	0.89	1.25	0.58
Wage	-0.55 (-0.51)	-0.57	-0.98	-0.33
<i>Fertilizer</i>				
Price	-0.43 (-0.53)	-0.11	-0.23	-0.18
Land	0.69 (0.68)	0.54	0.93	0.95
Capital	0.15 (0.15)	0.45	0.07	0.05

Estimates for the 10 ha farm size model are in parentheses below the estimates for the 5 ha farm size specification.

<sup>a</sup> After Adulavidhaya et al. (1979).

<sup>b</sup> After Lau et al. (1979).

<sup>c</sup> After Duraisamy (1990).

Table 4

Fertilizer demand's own- and cross-price elasticities for paddy farms: profit function results in Côte d'Ivoire and other countries in Asia

	Côte d'Ivoire	Thailand <sup>a</sup>	Taiwan <sup>b</sup>	India <sup>c</sup>
<i>Paddy</i>				
Price	1.97 (2.03)	1.89	2.24	1.57
Wage	-0.55 (-0.51)	-0.57	-0.98	-0.33
<i>Fertilizer</i>				
Price	-1.43 (-1.53)	-1.11	-1.23	-1.18
Land	0.69 (0.68)	0.54	0.93	0.95
Capital	0.15 (0.15)	0.45	0.07	0.05

Estimates for the 10 ha farm size model are in parentheses below the estimates for the 5 ha farm size specification.

<sup>a</sup> After Adulavidhaya et al. (1979).

<sup>b</sup> After Lau et al. (1979).

<sup>c</sup> After Duraisamy (1990).

fications of farm size (i.e. under 5 ha and 10 ha), using the unrestricted parameter estimates. These elasticities, given in Tables 3–5, are compared with estimates obtained by previous studies on rice farms in Asia. The elasticity estimates from the two alternative model specifications are very similar, buttressing the robustness of the predicted estimates. The rice supply response to changes in paddy price is slightly inelastic (Table 3). The output supply elasticities with respect to land (0.69) and capital (0.15) indicate the output response of an average farm to increases in land and capital, holding wage rate (not quantity of labor) and fertilizer price (not quantity of fertilizer) constant. Increasing the amounts of land and capital will shift the marginal productivity curves of labor and fertilizer upwards. The implication is that, holding wage rate and fertilizer price constant, a 1% increase in amount of rice land will result in a 0.7% increase in rice output and a 1% increase in capital will result in a 0.2% increase in rice output. The inelastic own-price paddy supply elasticity, and the inelastic paddy supply elasticity with respect to the fixed factors, may be due to the lack of improved rice technologies which limits increases in land productivity. The highly elastic demand for fertilizer



Table 5  
Labor demand's own- and cross-price elasticities for paddy farms:  
profit function results in Côte d'Ivoire and other countries in Asia

	Côte	Thailand <sup>a</sup>	Taiwan <sup>b</sup>	India <sup>c</sup>
d'Ivoire				
<i>Paddy</i>				
Price	1.97 (2.03)	1.89	2.24	1.57
Wage	-1.55 (-1.51)	-1.57	-1.98	-1.33
<i>Fertilizer</i>				
Price	-0.43 (-0.53)	-0.11	-0.23	-0.18
Land	0.69 (0.68)	0.54	0.93	0.95
Capital	0.15 (0.15)	0.45	0.07	0.05

Estimates for the 10 ha farm size model are in parentheses below the estimates for the 5 ha farm size specification.

<sup>a</sup> After Adulavidhaya et al. (1979).

<sup>b</sup> After Lau et al. (1979).

<sup>c</sup> After Duraisamy (1990).

(Table 4) with respect to paddy price (1.97–2.03) indicates that increases in paddy prices would lead to significant increase in farmers' demand for fertilizers to intensify rice production. However, the highly elastic own-price elasticity of fertilizer demand (–1.43 to –1.53) suggests that increases in fertilizer prices would lead to substantial reduction in fertilizer usage. The estimated highly elastic labor demand elasticity (1.97–2.03) with respect to paddy price (Table 5) indicates that increases in paddy prices will lead to a substantial increase in labor absorption in the highly labor-intensive rice farms. Similarly, the highly elastic own-price labor demand elasticity (–1.6) indicates that exogenously enforced government intervention in the rural labor market to raise (lower) rural wage rates for agricultural labor above (below) the market determined rates would have major effects on the labor intensive rice production systems by creating major decline (increase) in labor absorption in rice production.

#### 4. Conclusions

In this paper we examined the relative economic efficiency of small and large rice farms in Côte

d'Ivoire using a profit function approach. We found no difference in the economic efficiency of small and large farms. This conclusion is robust under alternative model specifications. A number of agrarian policy implications for the rice sector of Côte d'Ivoire can be drawn from the findings. The most substantive is that agrarian reforms directed towards further concentration of landholding for large farms cannot be justified based on economic efficiency. Such programs can only be justified from the perspective of political considerations that often favor the elitist social class that control much of the large scale farms in Côte d'Ivoire (Widner, 1993). At times, the government has taken steps to mechanize rice production through direct land appropriation and re-distribution to form large scale farms. However, economic studies of large-scale fully mechanized rice projects in northern Côte d'Ivoire (i.e. Grand Travaux, Projet Soja) show very high economic losses (Berger et al., 1990). The preference for a large-farm led approach to rice production is a bias not supported by any evidence of superior economic efficiency of large farms.

Secondly, results show that within the dualistic farm size agrarian structure in Côte d'Ivoire, there exists evidence of absolute allocative inefficiency. Policy interventions are needed to remove such management related inefficiencies in rice production either through the development of a better market price information system or effective farmer-oriented technical training programs by rice extension workers.

Finally, results indicate that access to credit and use of modern rice varieties significantly increase profits. Several improved rice varieties are available in Côte d'Ivoire, but many farms do not have access to them because of poor seed distribution service, and ineffectiveness of the extension service. To improve technical efficiency of rice farms, a more accelerated program to provide information, credit, improved seeds and other inputs is needed. The recent establishment of a consolidated rural development agency (ONADER: Organization Nationale d'Appui au Développement Rural) will be instrumental in providing farmers access to these inputs. Our results strongly suggest that government policies on such farm support services should not be biased against smallholder rice farms.

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## References

- Adulavidhaya, K., Kuroda, Y., Lau, L.J., Lerttamrab, P. and Yotopoulos, P.A., 1979. A micro-economic analysis of the agriculture of Thailand. *Food Res. Inst. Stud.*, 27 (1): 79–86.
- Ali, M. and Byerlee, D., 1991. Economic efficiency of small farmers in a changing world: A survey of recent evidence. *J. Int. Dev.*, 3, 1: 1–27.
- Berger, L. et al., 1990. Etude de la filière riz. Rapport Final. Présidence de la République/Direction et contrôle des Grandes Travaux, Abidjan, Côte d'Ivoire.
- Bindlish, V. and Evenson, R., 1993. Evaluation of the performance of T and V extension in Kenya. World Bank Tech. Pap. 208, Africa Technical Department Series, The World Bank, Washington DC.
- Brokensha, D. and Glazier, J., 1973. Land reform among the Mbere of central Kenya. *Africa*, 43: 82–206.
- Bruce, J.W. and Migot-Adholla, S.E., 1994. Searching for land tenure security in Africa. Kendall/Hunt, Iowa, USA.
- Collier, P., Radwan, S., Wangwe, S. and Wagner, A., 1990. Labor and Poverty in Rural Tanzania. Ujamaa and Rural Development in the United Republic of Tanzania. Clarendon Press, Oxford.
- Christiansen, R.E. and Kydd, J.G., 1987. The political economy of agricultural policy formulation in Malawi, 1960–1985. Madia Paper, World Bank, Washington DC.
- Cooperation Française de Développement, 1993. Memorandum de la CFD sur la riziculture Ivoirien. Rapport de Mission, Avril.
- Deininger, K. and Binswanger, H.P., 1995. Rent seeking and development of large-scale agriculture in Kenya, South Africa, and Zimbabwe. *Econ. Dev. Cult. Change*, 43 (3): 493–522.
- Donner, P., 1972. Land Reform and Economic Development. Penguin, Harmondsworth, UK.
- Duraisamy, P., 1990. Technical and allocative efficiency of education in agricultural production: a profit function approach. *Indian Econ. Rev.*, 25 (1): 17–32.
- Jamison, D.T. and Lau, L.J., 1982. Farmer Education and Farm Efficiency. The Johns Hopkins University Press, Baltimore, MD.
- Khan, M.H. and Maki, D.R., 1979. Effects of farm size on economic efficiency: The case of Pakistan. *Am. J. Agric. Econ.*, 61 (1): 64–69.
- Kouadio, Y. and Pokou, K., 1991. Efficacité technique des petites et grandes exploitations agricoles dans le Nord de la Côte d'Ivoire. *Cah. Ivoiriens Rech. Econ. Sociale*, 1: 7–23.
- Kydd, J.G. and Christiansen, R.E., 1982. Structural change in Malawi since independence: consequences for a development strategy based on large-scale agriculture. *World Dev.*, May: 355–376.
- Lau, L.J. and Yotopoulos, P.A., 1971. A test for relative efficiency and application to Indian agriculture. *Am. Econ. Rev.*, 61: 94–109.
- Lau, L.J. and Yotopoulos, P.A., 1979. Summary and Conclusions. Food Research Institute Studies, Vol. XVII, No. 1, pp. 107–117.
- Lau, L.J., Lin, W. and Yotopoulos, P.A., 1979. Efficiency and technological change in Taiwan's agriculture. *Food Res. Inst. Stud.*, XVII: 23–50.
- Lele, U. and Agarwal, M., 1989. Smallholder and large-scale agriculture in Africa. Are there tradeoffs between growth and equity? Madia Discuss. Pap. No. 6, World Bank, Washington, DC, 20 pp.
- Lele, U. and Meyers, L.R., 1986. Agricultural development and foreign assistance: A review of World Bank's experience in Kenya, 1963 to 1986. Madia Paper, World Bank, Washington, DC.
- Lele, U., Oyejide, A.T., Bumb, B. and Bindlish, V., 1989. Nigeria's economic development, agriculture's role and World Bank assistance: Lessons for the future. Madia Paper, World Bank, Washington, DC.
- McHenry, D.E., Jr., 1979. Tanzania's Ujamaa villages: The implementation of a rural development strategy, Berkeley. Institute of International Studies, University of California.
- Njeru, E.H.N., 1978. Land adjudication and its implications for the social organization of the Mbere. Land Tenure Res. Pap. No. 73, University of Wisconsin.
- Noronha, R., 1985. A review of the literature on land tenure systems in Sub-Saharan Africa. Discuss. Pap. Rep. No. ARU 43, Agricultural and Rural Development Department, The World Bank, July 19.
- Okoth-Ogendo, H.W.O., 1986. The perils of land 'tenure' reform. In: J.W. Arntzen, L.D. Ngongco and S.D. Turner (Editors), Land Policy and Agriculture in Eastern and Southern Africa, United Nations University, Tokyo.
- Pudasaini, S.P., 1983. The effects of education in agriculture: evidence from Nepal. *Am. J. Agric. Econ.*, 65: 509–515.

- Saleem, S.T., 1988. Relative efficiency of cotton farms in Sudanese irrigated agriculture. *World Dev.*, 16 (8): 975–984.
- Sevilla-Siero, C.A., 1991. On the use and misuse of profit functions for measuring the price responsiveness of peasant farmers: A comment. *J. Dev. Stud.*, 27 (4): 123–136.
- Sidhu, S.S., 1974. Relative efficiency in wheat production in the Indian Punjab. *Am. Econ. Rev.*, 64 (4): 742–751.
- Sidhu, S.S. and Baanate, C.A., 1981. Estimating farm-level demand and wheat supply in the Indian Punjab using a translog profit function. *Am. J. Agric. Econ.*, 63: 237–246.
- Tamin, M., 1979. Micro-economic analysis of production behavior of Malaysian farms: Lessons from Muda. *Food Res. Inst. Stud.*, XVII: 87–98.
- West Africa Rice Development Association, 1993. *Rice Trends in Sub-Saharan Africa: Synthesis of Statistics on Production, Trade and Consumption of Rice*. WARDA.
- Widner, J., 1993. The origins of agricultural policy in Ivory Coast 1960–86. *J. Dev. Stud.*, 29 (4): 25–58.
- Yotopoulos, P.A. and Lau, L.J., 1973. Test for relative economic efficiency: Some further results. *Am. Econ. Rev.*, 63 (1): 214–223.